A LONGITUDINAL STUDY ASSESSING THE RELATIONSHIP BETWEEN PARENTS' AND CHILDREN'S PHYSICAL ACTIVITY AND THEIR ADHERENCE TO 24-HOUR MOVEMENT GUIDELINES

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DEDICATION

To my mother, for your constant support and selfless sacrifices that has led me to become the person I am today. To my dearest sister, whose unwavering enthusiasm and unconditional faith in me has been my anchor of strength throughout this journey. And to my husband, my best friend, my greatest supporter for being a constant source of my inspiration. To all the yesterdays that brought me to this moment.

ABSTRACT

Previous research highlights the health benefits of engaging in moderate- to vigorous-intensity physical activity, minimizing screen time and getting optimal sleep. Although many studies have examined associations between parents' and children's movement behaviours, most were based on single behaviours despite these behaviours being interdependent.

Using data from the Active Transportation and Independent Mobility-2 study, we assessed the associations between parents' adherence to the 24-hour guidelines, perceived behavioural control (PBC) to support their child's movement behaviours, and children's adherence to the Canadian 24-hour movement guidelines. Canadian parents of 7- to 12-year-olds (N = 2257) were surveyed at baseline (December 2020) and were followed every 6 months until June 2022 (4 waves). Movement behaviours were assessed by parent report. The final model was adjusted for age and gender of both children and parents, household income, immigration status and study wave.

Our current study found that if a parent respondent met all the guidelines, their children were 1.51 times more likely to meet all three guidelines (95% CI=1.17, 1.93). Moreover, each unit increase in the PBC scale was associated with higher odds of the child meeting all three guidelines (OR=1.72; 95% CI=1.45, 2.03). Moreover, adherence decreased with each year of age (OR = 0.77, 95% CI = 0.72, 0.83) and was higher in Wave 2 (OR=1.32; 95% CI=1.04, 1.66), Wave 3 (OR=1.73; 95% CI=1.33, 2.25) and Wave 4 (OR=1.62; 95% CI=1.21, 2.18) vs. Wave 1.

The findings of this study provide preliminary evidence suggesting that children's adherence to the guidelines is significantly associated with both parent's adherence and their PBC. These findings suggest that family-based interventions should be implemented to support children's movement behaviours.

CONTRIBUTION OF AUTHORS

I would like to acknowledge the co-authors of the manuscript as well as the original researchers of the Active Transportation and Independent Mobility (ATIM-2) study. This thesis is based on data from the ATIM-2 study, and hence, it would not have been possible without the previous work of the original researchers.

Manuscript:

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LIST OF ABBREVIATIONS

PA – Physical activity

MVPA – Moderate- to vigorous-intensity physical activity

SES – Socioeconomic status

PBC – Perceived behavioural control

TPB – Theory of planned behaviour

COVID-19 – Coronavirus disease 2019

Chapter 1: LITERATURE REVIEW

Due to its detrimental effects on health, physical inactivity has been identified as an urgent public health priority (Kohl et al., 2012). It has been identified as the fourth major risk factor for premature death worldwide and it is associated with adverse health outcomes such as cardiovascular diseases, type II diabetes, and some cancers and disabilities (Lee et al., 2012). Unfortunately, an international survey suggests that 27.5% of adults across the globe do not meet the World Health Organization's physical activity (PA) guidelines of at least 75 minutes of vigorous-intensity PA or 150 minutes of moderate-intensity PA per week (Guthold et al., 2018; WHO, 2020). A national survey showed that 50.7% of Canadian children of age 6 to 11 years did not meet the Canadian 24-hour guideline (Statistics Canada, 2021). This could be an underestimation of the prevalence of physical inactivity given that it is based on self-reported PA, which is vulnerable to social desirability and recall biases (Chaput, 2020). Guthold et al. (2020) also reported that more than 80% of school-going adolescents globally did not meet current recommendations of at least one hour of moderate- to vigorous-intensity physical activity (MVPA) per day – including 85% of girls and 78% of boys. Furthermore, the World Health Organization (2020) guidelines recommend engagement in vigorous-intensity physical activity, as well as muscle- and bone-strengthening activities, at least three times per week, but prevalence studies rarely measure these additional guidelines. Sufficient PA is essential for child development and provides numerous health benefits for children and adolescents, including cardiometabolic health, motor skill development, bone density, emotional regulation and psychological health (Janssen et al., 2010; Saunders et al., 2016).

Physical inactivity increases the risk of obesity (WHO, 2021), and, at present, 30% of children aged 5-17 years in Canada have overweight or obesity (PHAC, 2017). Obesity is associated with an increased risk of cardiovascular diseases (mainly heart disease and stroke), musculoskeletal disorders (especially osteoarthritis) and some cancers (including endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon) (Reilly and Kelly, 2011). Children with obesity present a greater risk of breathing difficulties, fractures, hypertension, early markers of cardiovascular disease, insulin resistance and poorer mental health (WHO, 2021). Many individuals with obesity also struggle with issues related to their mood, self-esteem, quality of life and body image, which may even lead to suicidal ideation and attempts (Sarwar & Polonsky, 2016). Pediatric obesity is particularly concerning given that it tends to persist into adulthood (Simmonds et al., 2016).

The 24-hour movement guidelines. Notwithstanding the importance of accumulating at least 60 minutes of daily PA, movement behaviours during the remaining 23 hours of the day are also associated with many health outcomes (Saunders et al., 2016). To address this situation, Tremblay et al. (2016) proposed the first integrated 24-hour movement guidelines. These guidelines represent a new approach to health promotion by including several general recommendations for a healthy 24-hour period, encompassing recommendations on time spent in sleep, screen-based sedentary behaviour, and MVPA (Tremblay et al., 2016). These guidelines were notably informed by a systematic review showing that a good balance of movement behaviours is associated with multiple health benefits (Saunders et al., 2016). For example, children and youth who meet the 24-hour movement guidelines have more favourable body composition and lower cardiovascular disease risk factors (Carson et al., 2017). Data from the Canadian Health Measures Survey

show that, on average, 6–17-year-old Canadians spend 40% of their 24-hour period in sleep, 38% in sedentary time, 18% in light-intensity PA, and 4% in MVPA (Carson et al., 2016). Saunders et al. (2016) found that children and youth with a high sleep, high MVPA and low sedentary time combination have better physical health outcomes than children and youth with a low sleep, low MVPA and high sedentary time combination. Despite the evidence suggesting the benefits of increased PA, reduced sedentary behaviours, and adequate sleep, the prevalence of Canadian children and youth meeting the 24-hour movement recommendations was reported to be only 12.7% before the COVID-19 pandemic (Rhodes et al., 2019).

Accelerometry data from the 2007-2009 Canadian Health Measures Survey indicated that Canadian children and youth are spending an average of 8.6 hours per day being sedentary, or 62% of their waking hours (Colley et al., 2011). Evidence shows that, independent of PA levels, sedentary behaviours are associated with increased risk of cardio-metabolic diseases, all-cause mortality, and a variety of physiological and psychological problems (Carson et al., 2016; Tremblay et al., 2011). Studies show that even those who meet PA guidelines may not be protected against the health detriments of engaging in excessive sedentary time (Salmon et al., 2011; Mitchell & Byun, 2014). According to the Canadian 24-hour movement guidelines, recreational screen time should be no more than 2 hours per day for 5–17-year-olds (Tremblay et al., 2016). Sleeping between 9–11 h/night for children (ages 6–13 years) and 8–10 h/night for adolescents (ages 14–17 years) to maximize overall health and well-being is recommended by National Sleep Foundation (Hirshkowitz et al., 2015). Sleep disturbances can have detrimental effects on attention span, emotional health, immune function, and academic performance (Buckhalt,

2011). Insufficient sleep might increase the risk of cardiometabolic disease in both children and adolescents (Paruthi et al., 2016; Martinez-Gomez et al., 2011), and results in anxiety or mood swings (Basta et al., 2007). Although the ideal amount of sleep per night varies from person to person, sleep duration recommendations play an important role in informing public policies, guidelines, interventions, and parents and children or youth about healthy sleep behaviours (Matricciani et al., 2013).

Increasing MVPA and reducing time spent in sedentary behaviours has numerous benefits for both children and adults (Ross et al., 2020; Tremblay et al., 2016). In 2020, the Canadian Society for Exercise Physiology (CSEP) released the first ever 24-hour movement guidelines for adults aged 18-64. The 24-hour movement guidelines for adults recommend: 1) at least 150 minutes of MVPA per week; 2) 7 to 9 hours of good-quality sleep; 3) no more than 3 hours of recreational screen time; and 4) no more than 8 hours of sedentary time (Ross et al., 2020). The guidelines recognize that each of these movement behaviours is related to health and that they are codependent on each other (Chaput et al., 2014; Chastin et al., 2015). Many studies suggest that a variety of health outcomes, including all-cause mortality, adiposity, cardiometabolic biomarkers, and adult mental health are related to the time-use composition of healthy movement behaviours over the course of a full 24-hour day of an adult (Janssen et al., 2020; Rollo et al., 2020).

Rollo and colleagues (2022) found that while the majority of adults (80.8%) met at least one of the recommendations, just 7.1% met all of the criteria within the 24-hour movement guidelines. In addition, the adults who met overall guidelines had more favourable BMI, waist circumference, aerobic fitness scores, and triglyceride, insulin, C-reactive protein and serum glucose levels (Rollo et al., 2022). Moreover, adults with normal

weight, non-smokers and those who did not have any chronic illness were more likely to meet the guidelines (Rollo et al., 2022). Another study conducted during the COVID-19 pandemic found that only 9.1% of parents of 5- to 17-year-olds met the 24-hour guidelines (Rollo et al., 2023). and higher levels of outdoor play, university education, and Adults aged ≥45 years old, those who played outside more or had a university education were more likely to meet the guidelines (Rollo et al., 2023).

COVID-19. In March 2020, COVID-19 was declared as a global pandemic by the World Health Organization. As COVID-19 is highly contagious, governments of many countries and provinces enforced restrictions to limit the spread of the virus (Dawson, 2020). Public health measures included mandating the closure of many institutions, programs, facilities, and other community spaces as well as limitations on public use of community outdoor spaces. Couzin-Frankel et al. (2020) found that an estimated 1.5 billion children (aged 5–12 years old) and adolescents (aged 13–17 years old) transitioned to remote learning following school closures. The lifestyle activities of children and adolescents across the 24-hour day were greatly affected by public health measures (Bates et al., 2020). For instance, studies have reported increased engagement in sedentary behaviour (Margaritis et al., 2020; Vanderloo et al., 2020), disrupted sleep patterns (Lee, 2020; Becker & Gregory, 2020) and decreased opportunities for children and adolescents to engage in PA (Zenic et al., 2020; Moore et al., 2020; Guerrero et al., 2020). Increases in screen time and sedentary behaviours were observed in children compared to the pre-pandemic period (Li et al., 2021). Paterson et al. (2021) reported an increase in sleep duration with a decrease in the quality of sleep of children. A shift to both later bedtimes and waking times was found (Cellini et al., 2021). Such negative changes in movement

behaviours are particularly concerning given that people who are physically active are less likely to experience severe symptoms and hospitalizations from COVID-19 (Ezzatvar et al., 2022; Young et al., 2023). It is to be noted that there are limited studies looking into the potential benefits of physical activity during the COVID-19 pandemic, and as such, many factors about its application and particular treatment outcomes are still unclear, underscoring the need for further research.

Parent influence. Researchers have found that physical inactivity habits track better from childhood to adulthood than PA (Telama, 2009). Essentially, those who are physically inactive during childhood and adolescence will likely remain physically inactive in adulthood. In this context, it is crucial to promote healthy movement behaviours during childhood. Parents have an important role to play as they can influence their child's movement behaviours both directly and indirectly. Parents can influence their child's PA through different mechanisms, including direct modeling of PA, providing resources to perform PA, establishing or eliminating barriers to PA, and positively reinforcing children for participation in PA (Taylor et al., 1994). Furthermore, researchers have found that engagement in joint parent-child PA may also be an effective method for increasing activity levels of both parents and children (Dunton et al., 2012). Thus, the family is a potent target for interventions to increase children's PA, and it may help to prevent and improve the management of childhood obesity (Anderssen et al., 1992). Yao and Rhodes (2015) conducted a meta-analysis comprising of 112 studies which stated that parental modelling and support are weakly associated with children's physical activity ($r= 0.16$, 95% CI= 0.09-0.24), and there was a high degree of heterogeneity among the studies. Yet, modeling is just one of the ways through which parents can influence their children's PA. Although the

relationship between parents' and their children's PA is well established (Sallis et al., 1992), less is known about the relationship between parents' and children's adherence to 24-hour movement guidelines because until 2020, such guidelines did not exist for adults. Nevertheless, behaviour-specific studies show that parents can influence their children's sleeping habits, sedentary behaviours, and screen time (McDowall et al., 2017; Jago et al., 2011).

The theory of planned behaviour (TPB) is one of the most widely used psychosocial models of the factors influencing health-related behaviours, and it is demonstrated to be particularly effective in predicting physical activity (Ajzen, 1991; McEachan et al., 2011). In the TPB, perceived behavioural control (PBC) refers to the extent to which people believe they can control situations in which the behaviour is likely to be performed. In addition to predicting intention to engage in a behaviour, PBC can predict behaviour directly, independent from intention (Ajzen, 1991; Gauvin & Bélanger-Gravel, 2017). Studies have found that parents' PBC to support their child's movement behaviours is a significant predictor of these behaviours. For example, parental support for a child's health behaviour was found to be predictive of that behaviour, and the supported behaviours were explained by intention and perceived capabilities to support (Rhodes et al., 2019; Rhodes et al., 2020).

Research gaps. Although there have been many studies that examined the relationship between parents' and children's movement behaviours, almost all of them were based on single behaviours whereas PA, sleep and sedentary behaviours are interdependent. Furthermore, the lack of longitudinal data on parents' and children's movement behaviour patterns based on 24-hour guidelines suggest a gap in the literature.

Longitudinal data could allow us to examine if, for example, changes in parental adherence to movement behaviour guidelines are associated with changes in their child's adherence. To address these gaps, this study aimed to examine the associations between the movement behaviours of parents and children and their adherence with the Canadian 24-hour movement guidelines. Secondary data from a national longitudinal study that began during the second wave of the COVID-19 pandemic was used. It was hypothesized that parents' adherence to the 24-hour movement guidelines and PBC are associated with their child's compliance. If a positive association between children's compliance and the parents' compliance with the guidelines is found, the results could inform future family-based interventions. A significant effect of PBC would suggest a potential for interventions based on the theory of planned behaviour.

METHODS

Study design. This longitudinal study was based on the Active Transportation and Independent Mobility (ATIM)-2 study that examined the changes over time in movement behaviours and independent mobility among children and parents' compliance with the Canadian Society for Exercise Physiology's 24-hour movement guidelines among other variables (Larouche et al., 2023). A longitudinal study design was selected to conduct this study as it makes it possible to detect the pattern of changes in a sample population over the course of time. The study design allowed us to investigate the determinants of changes in movement behaviour patterns of both parents and children. This secondary analysis was carried out in the light of the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines.

Study Setting. In this study, approximately 2291 parents of children aged 7- to 12-year-olds across Canada were recruited. Data was collected by Léger, which is the largest Canadian-owned market research and analytics company. Data were collected with an online questionnaire that took about 15-20 minutes to complete and only parents were able to answer the questionnaire.

Participants

Eligibility Criteria. Parents with 7 to 12 years old children, living in Canada and able to complete the questionnaire in either English or French were eligible for the study. Parents had to answer yes to the following screening questions before beginning the survey: 1) Do you have a child aged 7 to 12 years? and 2) Do you agree to be invited again to participate in this study in 6, 12, and 18 months? If parents had more than one child in the target age range, they were asked to respond to the survey for their child whose name comes first alphabetically (Larouche et al., 2023). For participating in each survey, parents were compensated with $3 per wave which corresponds to Léger's usual practice. Participants who participated in all four survey waves received a $10 bonus.

Sources and methods of selection. The participants were recruited via Léger. An online panel including over 450,000 Canadians who volunteer to participate in online studies is regulated by Léger. Online panels such as Léger's are designed to provide a demographic representation of the target population (Göritz, 2007).

Sample Size. In this study, the compliance of parents and their children with the 24-hour movement guidelines was assessed based on whether they met all the guidelines. Because the adult sedentary behaviour guidelines include a recommendation for screen time (no more than 3 hours/day) and total sedentary time (no more than 8 hours/day),

adherence with sedentary behaviour guidelines was operationalized as meeting both recommendations (Rollo et al., 2022). Hence, both the exposure and outcome variables are ordinal in this scenario. A sample size calculation was performed with G*Power 3.1.9.7 (Düsseldorf, Germany) for repeated measures MANOVA, and the results were subsequently increased to account for the loss of power associated with the categorization of the outcome (Taylor et al., 2006). Based on the meta-analysis by Yao & Rhodes (2015), we assumed an effect size (Cohen's *f*) of 0.162. We assumed a moderate-to-large correlation among repeated measures (0.50). Based on these parameters, the formula indicates that 264 participants are needed. Depending on the distribution of the outcome, Taylor et al. (2006) estimated in a Monte Carlo simulation that when a continuous outcome is converted to a categorical variable with three to five categories, the required sample size increases by 11-227%. Assuming the upper end of this range, 599 participants would be required to achieve a power of 0.80 with an α of 0.05. In the present study, 708 parents completed the last follow-up.

Data Collection. Using Léger's online platform, baseline data collection started in December 2020, and participants were invited to complete follow-ups every 6 months until June 2022. A total of four survey follow-up waves were conducted, and each took approximately 15-20 minutes to complete. Ethics approval was received from the University of Lethbridge's Human Participant Research Committee (#2020-097).

Measures

Outcome variable:

Movement behaviours of children. The questionnaire was used to assess children's PA level, sedentary behaviour and sleep duration (see Appendix A for exact questions). The

level of physical activity was assessed by asking about the amount of time engaged in MVPA and light-intensity PA in the previous week. Sedentary behaviour and sleep were assessed by asking questions about the amount of time spent on screen time and the amount of time spent sleeping, including the naps in the previous week, respectively. For each behaviour, parents reported the time in hours and minutes per day separately for weekdays and weekend days. They could also respond with a "don't know" option. Afterwards, this variable was dichotomized to determine if the children met all three guidelines (3 out of 3 met) or not (0-2 out of 3).

Exposure variable:

Movement behaviours of parents. Similar questions were used to assess the movement behaviours of parent respondents. Parents were asked about the amount of time they engaged in MVPA on both weekdays and weekend days. They were also asked about their amount of time spent on sedentary time and screen time during their leisure time. Lastly, they were asked about their amount of time of sleep including naps. Similar to children, parents reported the time in hours and minutes per day separately for weekdays and weekend days for each behaviour and could also use a "don't know" option. Afterwards, this variable was dichotomized to determine if the parent met all three guidelines (3 out of 3 met) or not (0-2 out of 3).

Covariates

Age, gender, immigration status of children, household income, parent's perceived behavioural control towards their child's movement behaviours, and study wave were chosen as the potential covariates for analyses.

Age. Age was considered as an important confounder as it can affect the level of PA throughout the lifespan of an individual. A synthesis of human and animal studies concluded that the age-related decline in PA is the most consistent finding in PA epidemiology (Sallis et al., 2000). A meta-analysis found that, on average, PA declines by ~7% per year during adolescence (Dumith et al., 2011). For these reasons, the age of children and parents was considered as confounder.

Gender. Gender is known to be a consistent correlate of PA in children and adults (Bauman et al., 2012; Guthold et al., 2020). For example, Guthold et al. (2020) found that the prevalence of insufficient PA was 7.1% higher in girls compared to boys, with a larger gender gap in high-income countries (11.8%). In Canada, the prevalence of insufficient PA among boys and girls was 72.5% and 82.4% in 2016 (Guthold et al., 2020). Therefore, the gender of both parent respondents and children was deemed to be an important covariate in this study.

Immigration status. According to Statistics Canada (2022), about 8.3 million or 23% of the total population of Canada were immigrants in 2021. A systematic review indicated that immigrant children were significantly more likely to be physically inactive and less likely to participate in sports than native children (Lacoste et al., 2020). In the questionnaire, parents were asked how long their child has lived in Canada, and there were four options: less than 2 years, 3 to 5 years, 6 years or more, and born in Canada. Given the relatively small number of immigrant children, this variable was dichotomized as immigrant vs. Canadian-born.

Household Income. Many studies have found an association between socioeconomic status (SES) and PA, whereby people of high SES are more physically

active than those of lower SES (Jenum et al., 2009; Trost et al., 2002). For example, a systematic review reported that nine out of eighteen studies found a significant relationship between household income and PA level (Gidlow et al., 2006). The cost associated with organized PA participation can be a significant barrier to PA (Ferreira et al., 2007). Hence, household income was deemed to be an important covariate in this study.

Parent's perceived behavioural control (PBC). Parents were asked about their PBC over their children's movement behaviour. For each movement behaviour, parents were asked if they were capable of and if they would have the opportunity to support the behaviour over the next week based on questions similar to Rhodes et al. (2019). Likert-type response options were provided for these items, ranging from strongly disagree (1) to strongly agree (5). For each behaviour, PBC was calculated by averaging the 2 items. A general PBC scale for movement behaviours was derived by averaging the 6 items. Given the ability of PBC to predict PA, it could reasonably act as a predictor of children's movement behaviours or a moderator of the association between parents' and children's movement behaviours. Moderation could happen if this association was significantly larger among parents who have a high PBC.

Study wave. Although a longitudinal study with only two points of data collection would provide more insights than a cross-sectional study, a true longitudinal design is crucial to understanding the evolution and change of natural and organizational phenomena (Ployhart & MacKenzie Jr, 2015). In this study, there were four points of data collection as data were collected every 6 months interval for two years. As the Bank of Canada COVID-19 stringency index was approximately 64.0, 57.6, 42.6, and 17.0 for the dates

corresponding to the 4 successive study waves, it was deemed important to control for study wave (Bank of Canada, n.d.).

Data Management and Quality Control. All electronic data received from this study are stored in a private folder on a password-protected computer. The files are password-protected and encrypted. Only the members of the research team had access to the data, and they were required to sign a confidentiality agreement with the Principal Investigator. The data will be stored for 7 years after the last publication of this study. After that, the data will be safely destroyed. The participants were also informed that Léger would safely destroy all data collected for the purpose of this study 6 months after study completion.

Participants will not be identified in any publication or presentation of this study. If the participants are willing, they can receive a copy of the results at the end of the study by contacting the Principal Investigator. A pre-test of the questionnaire was conducted with a separate bilingual sample of 60 parents of children of age 7-12 years. This helped to identify any potential problem with the questionnaire items and to determine the one-week test-retest reliability of the movement behaviour questions (see Appendix B). Based on the Landis and Koch (1977) cut-points, a moderate 1-week test-retest reliability was found for children's adherence to MVPA, screen time, the 24-hour guidelines and the number of guidelines met as well as parents' adherence to sedentary behaviour, MVPA and the number of guidelines met. A substantial test-retest reliability was found for both children's and parents' adherence to sleep guidelines (Kappa = 0.70 and 0.78, respectively). The movement behaviour questions were modified after the pre-test to standardize the response format and allow parents to report hours and minutes for each behaviour. We believe that

these modifications simplified the questionnaire, which should improve the psychometric properties of these questions.

Data Treatment

The sample was restricted to parents aged 20-64 years and children and parents identifying as either boy/man or girl/woman due to the minimal sample size requirements to carry analyses and in line with previous research on changes in PA associated with COVID-19 (Mitra et al., 2020; Moore et al., 2020). As a result, data from 33 of 2291 respondents at baseline was excluded. The annual household income was recategorized into four categories (CAD$39,999 or less; $40,000-99,999; $100,000 or more; and prefer not to answer). The latter category was used to retain as much participants as possible in the analyses; for example, 204 parents chose "prefer not to answer" at wave 1.

In the primary study, 20 multiply imputed datasets were computed in IBM SPSS version 27 (Armonk, New York) to address missing values. The logistic regression and predictive mean matching procedures were used to predict the missing data for categorical and continuous variables, respectively. To enhance the prediction of missing values, many auxiliary variables were used as predictors only in the models (Graham, 2009; Sterne et al., 2009). Appendix C illustrates the variables that were used in the imputation model and their role in the model.

Analysis Strategy

Sample Description. The data was analyzed using the statistical software IBM SPSS (version 27). All the variables were examined with descriptive statistics. Mean and standard deviation were calculated for continuous variables like age, MVPA, sedentary behaviour and sleep pattern. For categorical variables like gender and income, frequencies

and percentages were used. Data was visualized using cross-tabulations, forest plots and line diagrams.

Differences between participants reporting “don’t know” and those not reporting “don’t know” for children and parents’ movement behaviours were examined using chi square and t-tests. The same approach was used to compare characteristics of parent respondents who completed Wave 4 versus those who dropped out. Effect sizes for these differences was assessed using Cramer’s V for chi-square and Cohen’s d for t-tests. The cut-points suggested by Cohen (1988) were used to qualify effect size as trivial ($V<0.1$ or $d<0.2$), small (V between 0.1 and 0.29 and d between 0.2 and 0.49), medium (V between 0.3 and 0.49 and d between 0.5 and 0.79), or large ($V\geq0.5$ or $d\geq0.8$).

Regression Modeling. IBM SPSS was used for conducting statistical analyses. Generalized estimating equations (GEE) models with an autoregressive correlation matrix were used to control for the repeated measures of the same participants (Hanley et al., 2003). These models allowed us to retain participants with missing data for some survey waves in analyses. Since the primary exposure and outcome variables are binary in nature, binary logistic regression was used within the GEE framework to model the association between whether the parent respondents and their children met all the guidelines or not. Bivariate models were used to understand the association between all exposure variables and the number of guidelines met by the child. Next, multivariable models were conducted, including the covariates described earlier as fixed effects. An interaction term was built between the number of guidelines met by the parent and the parents’ PBC to support their child’s movement behaviours to test the hypothesis that PBC moderates the association between parents’ and children’s adherence to the guidelines. The Quasi-likelihood under

Independence Model Criterion (QIC) and the corrected Quasi-likelihood under Independence Model Criterion (QICC) were used to assess the goodness of fit between the models. The main analyses were performed with the multiply imputed data, but as a sensitivity analysis, the analyses were replicated with the complete case data, and any substantive differences in the direction and strength of associations was discussed.

Ethics Approval

The primary study protocol was approved by the University of Lethbridge's Human Participant Research Committee (#2020-097) in accordance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans. For the secondary analysis, ethics approval was sought from the Health Research Ethics Board at the University of Alberta.

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CHAPTER 2: MANUSCRIPT

Association between parents' and children's adherence with the 24-hour movement behaviour guidelines: A national longitudinal study

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Abstract

Background: Engaging in moderate- to vigorous-intensity physical activity while minimizing screen time and getting sufficient sleep is associated with numerous health benefits. Although many studies have examined associations between parents' and children's movement behaviours, most were based on single behaviours despite these behaviours being interdependent. This study aimed to examine the associations between parents' and children's adherence to the Canadian 24-hour movement guidelines.

Methods: Using a longitudinal study design, an online national survey was conducted with parents of 7- to 12-year-olds (N=2,257; 51.6% boys) in December 2020, and parents were invited for follow-up surveys every six months until June 2022 (4 waves). Movement behaviours of parents and children were assessed by parent report. Generalized estimating equations (GEE) were used to model the associations between parents' adherence to the guidelines, perceived behavioural control (PBC) to support their child's movement behaviours and children's adherence to the guidelines. The final model was adjusted for age and gender of both children and parents, household income, immigration status and study wave.

Results: If a parent respondent met all three guidelines, their children were 1.51 times more likely to meet all three guidelines (95% CI=1.17, 1.93). Each unit increase in the PBC scale was associated with higher odds of the child meeting all three guidelines (OR=1.72; 95% CI=1.45, 2.03). Moreover, adherence was higher in Wave 2 (OR=1.32; 95% CI=1.04, 1.66), Wave 3 (OR=1.73; 95% CI=1.33, 2.25) and Wave 4 (OR=1.62; 95% CI=1.21, 2.18) vs. Wave 1 and decreased with each year of age (OR = 0.77, 95% CI = 0.72, 0.83).

Conclusion: These findings support the importance of parental role-modelling and PBC to support their child's movement behaviours, suggesting that family-based interventions should be implemented to support children's movement behaviours.

Keywords: physical activity, sedentary behaviour, sleep, modelling, perceived behavioural control.

1. Introduction

Physical inactivity has been identified as the fourth major risk factor for premature death worldwide and it is associated with adverse health outcomes such as cardiovascular diseases, type II diabetes, and some cancers and disabilities.[1] Unfortunately, an international survey suggests that 27.5% of adults across the globe do not meet the World Health Organization's physical activity (PA) guidelines of at least 75 minutes of vigorous-intensity PA or 150 minutes of moderate-intensity PA per week.[2, 3] A national survey showed that 50.7% of Canadian children aged 6 to 11 years did not meet the PA guidelines of 60 minutes per day of moderate- to vigorous-intensity physical activity (MVPA).[4] This could be an underestimation of the prevalence of physical inactivity given that it is based on self-reported PA, which is vulnerable to social desirability and recall biases.[5] Sufficient PA is essential for child development and provides numerous health benefits for children and adolescents, including better cardiometabolic health, motor skill development, bone density, emotional regulation and psychological health.[6, 7]

Notwithstanding the importance of accumulating sufficient moderate- to vigorous-intensity PA, movement behaviours during the remaining 23 hours of the day are also associated with many health outcomes.[7] Evidence shows that independent of PA levels, excessive time spent in sedentary behaviours is associated with increased risk of cardio-metabolic diseases, all-cause mortality, and a variety of physiological and psychological problems.[8, 9] Moreover, sleep disturbances can have detrimental effects on attention span, emotional health, immune function, and academic performance.[10] Saunders et al. (2016) found that children and youth with a combination of high sleep,

high MVPA and low sedentary time have better physical health outcomes than children and youth with a low sleep, low MVPA and high sedentary time combination.[7] To address this situation, Tremblay et al. (2016) proposed the first integrated 24-hour movement guidelines for children and adolescents,[11] and the Canadian Society for Exercise Physiology (CSEP, 2020) released the first-ever 24-hour movement guidelines for adults aged 18-64 years.[12] The guidelines recognize that each of these movement behaviours is related to health and that they are codependent on each other.[13, 14] However, national studies suggest that 17.5% of Canadian children and adolescents and less than 10% of Canadian adults meet the 24-hour movement guidelines.[15-17]

In March 2020, COVID-19 was declared a global pandemic by the World Health Organization and, as it is highly contagious, governments of many countries and provinces enforced restrictions to limit the spread of the virus.[18, 19] Public health measures included mandating the closure of many institutions, programs, facilities, and other community spaces as well as limitations on public use of community outdoor spaces. The movement behaviours of children, adolescents and adults[20] across the 24-hour day were greatly affected by public health measures.[21] For instance, studies have reported increased engagement in sedentary behaviour and screen time, disrupted sleep patterns and decreased PA.[22-29]

Parents have an important role to play as they can influence their child's movement behaviours both directly and indirectly. Parents can influence their child's PA through different mechanisms, including direct modeling of PA, providing resources to perform PA, establishing or eliminating barriers to PA, and positively reinforcing children for participation in PA.[30] The theory of planned behaviour (TPB) is one of the most

widely used psychosocial models of the factors influencing health-related behaviours, and it is particularly effective in predicting physical activity.[31, 32] In the TPB, perceived behavioural control (PBC) refers to the extent to which people believe they can control situations in which the behaviour is likely to be performed. In addition to predicting intention to engage in a behaviour, TPB can predict behaviour directly, independent from intention.[31, 33] Studies have found that parental support for a child's health behaviour was predictive of that behaviour, and this association was explained by intention and perceived capabilities to support.[34, 35]

Although there have been many studies that examined the relationship between parents' and children's movement behaviours, almost all of them were based on single behaviours, whereas PA, sleep and sedentary behaviours are interdependent. The current study aimed to examine the associations between the movement behaviours of parents and children and their adherence with the 24-hour movement guidelines during the COVID-19 pandemic. It was hypothesized that parents' PBC to support movement behaviours and adherence to the 24-hour movement guidelines are associated with their child's adherence.

2. Methods

2.1 Study design and setting.

This study used data from a national longitudinal study that began in December 2020 and included follow-ups every 6-months until June 2022.[36] In total, 2291 parents of children aged 7- to 12-year-olds across Canada were recruited. Data were collected by Léger, which is the largest Canadian-owned market research and analytics company. The sample was selected to represent Canadian parents with children in the target age range

based on education and household income. A total of four survey waves were conducted, and each took approximately 15-20 minutes to complete. Participants received a $3 incentive for completing each survey and a $10 bonus if they completed all four surveys. Ethics approval was received from the University of Lethbridge's Human Participant Research Committee (#2020-097).

2.2 Participants.

Parents with 7 to 12 years old children, living in Canada and able to complete the questionnaire in either English or French were eligible for the study. Parents had to answer yes to the following screening questions before beginning the survey: 1) Do you have a child aged 7 to 12 years? and 2) Do you agree to be invited again to participate in this study in 6, 12, and 18 months? If parents had more than one child in the target age range, they were asked to respond to the survey for their child whose name comes first alphabetically.[37] Léger continued to apply the screening questions at the follow-ups; hence, children were excluded after turning 13. It was estimated that a sample of 599 participants at the last follow-up would be needed to achieve 80% power with an α of 0.05.

2.3 Measures.

2.3.1 Movement behaviour of parents and children. A questionnaire was used to assess both parents' and children's moderate- to vigorous-intensity PA, sedentary behaviour and sleep duration in the week preceding the survey (Appendix A). For each behaviour, parents reported the time in hours and minutes per day separately for weekdays and weekend days. They could also respond with a "don't know" option. Afterwards, this variable was dichotomized to whether they met all three guidelines or

not (0-2 out of 3). In a pilot-study conducted in November 2020, moderate 1-week test-retest reliability was found for children's adherence to MVPA, screen time, the 24-hour guidelines and the number of guidelines met as well as parents' adherence to sedentary behaviour, MVPA and the number of guidelines met (Kappa ranging from 0.45 to 0.59). Substantial agreement was found for both children's and parents' adherence to sleep guidelines (Kappa = 0.70 and 0.78, respectively).

2.3.2 Parent's perceived behavioural control (PBC). Parents were asked about their PBC over their children's movement behaviour. For each movement behaviour, parents were asked if they were capable of and if they would have the opportunity to support the behaviour over the next week based on questions similar to Rhodes et al.[38] Likert-type response options were provided for these items, ranging from strongly disagree (1) to strongly agree (5). For each behaviour, PBC was calculated by averaging the 2 items. A general PBC scale for movement behaviours was derived by averaging the 6 items.

2.3.3 Other potential covariates. Age and gender of both children and parents, household income, and immigration status were included as covariates given previous evidence suggesting that these variables are associated with PA in children and/or adults.[39-47] Detailed information on how all the covariates were assessed is provided in Appendix A.

Study wave was deemed to be an important covariate in this study given that the COVID-19 restrictions evolved through the study period. Specifically, the Bank of Canada COVID-19 stringency index was approximately 64.0, 57.6, 42.6, and 17.0 for the dates corresponding to the 4 successive study waves.[48]

The sample was restricted to parents aged 20-64 years and children and parents identifying as either boy/man or girl/woman due to the minimal sample size requirements to carry analyses and in line with previous research on changes in PA associated with COVID-19.[27, 49] As a result, data from 33 of 2291 respondents at baseline were excluded. The annual household income was recategorized into four categories (CAD$39,999 or less; $40,000-99,999; $100,000 or more; and prefer not to answer). The latter category was used to retain as much participants as possible in the analyses; for example, 204 parents chose “prefer not to answer” at wave 1. To address missing values due to selection of the “don’t know” option for movement behaviours, twenty multiply imputed datasets were computed in IBM SPSS version 27 (Armonk, New York). The logistic regression and predictive mean matching procedures were used to predict the missing data for categorical and continuous variables, respectively. To enhance the prediction of missing values, many auxiliary variables were used as predictors only in the models.[50, 51]

2.5 Analysis Strategy.

The data were analyzed using IBM SPSS (version 27). All the variables were examined with descriptive statistics. Mean and standard deviation were calculated for continuous variables, and for categorical variables, frequencies and percentages were used. The differences between participants reporting "don't know" for the movement behaviours and those not reporting "don't know" were examined using chi-square and t-tests. Generalized estimating equations (GEE) models with an autoregressive correlation matrix were used to control for the repeated measures of the same participants.[52] These models allowed us to retain participants with missing data for some survey waves in

analyses. Binary logistic regression was used within the GEE framework to model the association as the primary exposure and outcome variables were binary. The main analyses were performed with the multiply imputed data, but as a sensitivity analysis, the analyses were replicated with the complete case data, and any substantive differences in the direction and strength of associations were discussed. We found no evidence of multicollinearity among the predictor variables (VIF<1.5).

3. Results

Table 1 provides descriptive characteristics of the full sample, and with stratification by gender in the first survey (December 2020). About two-thirds of the parent respondents were women (64.5%) and the mean age of parents was 41.2 ± 7.6 years. On average, the children were 9.9 ± 1.7 years old, and just over half of the children were boys (51.6%). More than 80% of the children were born in Canada. Parents reported a higher PBC over their children's sleep time (4.1) than PA (4.0) and screen time (3.7), and the differences between the three behaviours were significant ($p<0.001$; see Supplementary Table 1). At baseline, 5.0% of parents and 9.9% of children met the 24-hour movement guidelines (Table 2). However, adherence to the guidelines was higher in subsequent follow-ups especially among parents. For example, at Wave 4 (June 2022), 31.9% of parents and 13.7% of children met the guidelines.

The differences between participants reporting "don't know" and those not reporting "don't know" for parents and children's 24-hour movement behaviours are provided in Supplementary Table 2 and 3. Younger parents (d = 0.11), parents of older children (d = 0.13), parents with lower income (V = 0.13) and lower PBC (d = 0.28) were more likely to report "don't know" for children's 24-hour movement behaviours. Younger

parents (d = 0.21), parents with lower income (V = 0.14) and lower PBC (d= 0.19) were more likely to report "don't know" for their 24-hour movement behaviours. Moreover, we compared the baseline characteristics between participants who dropped out and those who completed Wave 4 using the complete case data (see Supplementary Table 4 and 5). On average, parents who dropped out were younger ($p < 0.001$; Cohen's d = 0.242), had lower PBC ($p = 0.001$; Cohen's d = 0.128) and were less likely to meet the sedentary behaviour guideline ($p = 0.006$; Cohen's d = 0.066). Except for the age of parents, the effect size for all other variables was trivial.

Figure 1 and 2 shows the bivariate and multivariate analyses of the correlates of the number of guidelines met by the children based on the multiply imputed data. The bivariate models indicated that children whose parent respondent met all the guidelines were 1.57 times more likely to meet all three guidelines (95% CI = 1.23, 1.99). Each unit increase in parent's PBC was associated with higher odds that the child met the 24-hour movement guidelines (OR = 1.72; 95% CI = 1.45, 2.03). In addition, adherence was higher in Wave 2 to 4 vs. Wave 1, in younger children, and in children whose parent respondent were younger or identified as woman.

The multivariate analysis indicated that the odds of children meeting all three guidelines were 1.51 times higher if their parents met all the guidelines (95% CI = 1.17, 1.94). Moreover, each unit increase in the PBC scale was associated with higher odds of the child meeting all three guidelines (OR = 1.72; 95% CI = 1.45, 2.03). There was no interaction between parents' adherence to the guidelines and PBC ($p = 0.525$). Adherence was higher in Wave 2 (OR=1.32; 95% CI=1.04, 1.66), Wave 3 (OR=1.73; 95% CI=1.33, 2.25) and Wave 4 (OR=1.62; 95% CI=1.21, 2.18) vs. Wave 1 and decreased with each

additional year of age (OR = 0.77, 95% CI = 0.72, 0.83). Results were similar in the complete case model except that the odds of children's adherence to the guidelines did not differ between Waves 1 and 2 in complete cases (Supplementary Table 6). Children's odds of adhering to the 24-hour guidelines decreased with parents' age in both complete case and multiply imputed models, but in the latter, the association was not significant in the multivariate model.

When children were stratified by gender (Figure 3), the bivariate analysis indicated that boys were 1.76 times more likely to meet all the guidelines if their parents met all the guidelines (95% CI = 1.27, 2.47), but no association was found in girls. In the multivariate analysis (Figure 4), parents' adherence was associated with adherence for both boys (OR= 1.69; 95% CI= 1.16, 2.46) and girls (OR = 1.57; 95% CI = 1.06, 2.32). Results of the multivariate model were generally similar for boys and girls, except that parent age was associated with lower odds of adherence to the child guidelines in boys (OR = 0.97; 95% CI = 0.96, 0.99) while this difference was similar, but not significant in girls (p = 0.098). Boys and girls were more likely to meet the 24-hour movement guidelines during Wave 3 vs. Wave 1 while only girls were more likely to meet the guidelines during Wave 4.

4. Discussion

In this study, we examined the associations between Canadian parents' PBC and adherence with the 24-hour movement guidelines and their children's movement behaviours. Children whose parents met the adult guidelines were about 50% more likely to meet the 24-hour movement guidelines. Each unit increase in parent PBC was associated with a ~70% increase in the likelihood that their child met the 24-hour

movement guidelines and the effect of PBC was independent from the effect of parents' movement behaviours. Our results suggest that parents can influence their children's movement behaviours by both role modelling and encouragement.

Using a representative sample of Canadian parents of children aged 7 to 12 years, we found that children whose parents met all the 24-hour movement guidelines were 1.51 times more likely to meet the child guidelines. Consistent with our findings, previous research found that parents' PA and sedentary behaviour were substantially associated with their child's PA and sedentary behaviour.[53] Our study began in the second wave of the COVID-19 pandemic, and at each time point, the large majority of children and parents did not meet the 24-hour movement guidelines. At baseline, only 5.0% of parents and 9.9% of children across Canada met these guidelines. Our findings are consistent with a cross-sectional study indicating that only 9.1% of Canadian parents of children aged 5-17 met all the guidelines during the COVID-19 pandemic.[17] Similarly, a repeated cross-sectional survey revealed that only 4.8% of Canadian children met the 24-hour movement guidelines during the early stages of COVID-19 pandemic (April 2020) with similar adherence six months later.[54]

We found that the percentage of parents and children meeting the 24-hour guidelines increased in the follow-up surveys as the COVID-19 restrictions were gradually lifted, and this increase was larger among parents (Table 2). However, adherence remained low at all time points. A pre-pandemic study revealed that only 7.1% of Canadian adults aged 18 to 79 years met the combined 24-hour guidelines from 2007 to 2013.[55] Another study reported that about 17.5% of Canadian children and youth met the combined 24-hour movement guidelines between 2009 and 2013.[15] It is to be noted

that both of these studies used questionnaires as well as accelerometers for data collection. Collectively, these findings underscore the need for interventions to promote healthy movement behaviours.

Our current study delves into the interconnected dynamics of the movement behaviours of both parents and children and offers a comprehensive outlook unlike existing literature that mostly focuses on individual movement behaviours. Through direct involvement and role modelling, parents can have a significant impact on their children's PA behaviours, and these effects may persist throughout adolescence.[56] Previous research suggests that family interventions promoting parent and child co-participation in PA are more likely to increase physical activity in their children than just solely targeting children's participation.[57-59] For example, the globally recognized "Healthy Dads, Healthy Kids" program significantly improved health outcomes and behaviours in fathers and children.[60, 61] A similar intervention targeting mother-child dyads could be developed to promote movement behaviours in a more inclusive way.

Our results suggest a significant positive association between parents' PBC and their children's movement behaviour and this association was independent of parent's adherence to 24-hour movement guidelines, indicating that parents may be effective in supporting their child's movement behaviour even if they don't meet all guidelines. Our findings are consistent with previous research indicating that parents' PBC and co-participation are associated with MVPA in children.[34, 35, 62] A meta-analysis concluded that interventions aiming at goal setting and reinforcement are particularly effective in this context, where identifying a target (e.g., increase in steps per day), recording progress and rewarding achievements can increase motivation and in turn, lead to a

change in behaviour.[63] If the family spends time preparing for PA, this effect can be even stronger.[63] Such strategies could also help increase PBC for screen time which, on average, was significantly lower compared to other movement behaviours in our study.

We found that with each year increase in age, children were 23% less likely to meet the guidelines. This finding is consistent with a previous systematic review, which revealed that PA decreases significantly during adolescence.[39] More recent evidence suggests that the decline may start as early as the beginning of primary school.[64] The age of the parent respondent was also negatively associated with their children's adherence to the 24-hour movement guidelines, though the effect size was modest (a 2% decline in odds of meeting the guidelines for each year of age). This finding is consistent with previous research, which reported that children of younger parents were more active, slept more and used social media less.[27]

Our multivariable models indicated no significant association between child and parent gender and children's adherence to the 24-hour movement guidelines. In contrast, previous studies found that boys were more likely to meet these guidelines.[15, 26] These inconsistent findings may be associated with methodological differences in the assessment of movement behaviours and/or inclusion of different covariates.

There were no significant association between household income and children's compliance with the 24-hour movement guidelines. In contrast, a systematic review indicated that children belonging to a higher-income family tend to be more physically active.[65] Although no significant association was found with respect to adherence to the combined 24-hour guidelines, individual movement behaviours may still differ by income. In this study, we assessed household income as an indicator of socioeconomic

status since low income has been shown to be associated with lower access to opportunities for PA[66] and it could also affect screen time and sleep. Similarly, we found no association between the immigration status of the child and their adherence to the guidelines. In contrast, most studies included in a systematic review found that children from immigrant families are less active than native-born children, but the review did not consider other movement behaviours.[46] Future studies are needed to compare screen time and sleep between immigrants and non-immigrants.

The odds of children meeting the 24-hour guidelines increased significantly in Wave 2, 3, and 4, compared to Wave 1 (see Table 2 and Table 3). Notably, Wave 1 data collection was done in December 2020, during the second wave of the COVID-19 pandemic. During subsequent follow-ups, as the restrictions were gradually lifted, the odds of children meeting the 24-hour guidelines also increased. It is notable that Wave 1 and Wave 3 data were collected in December 2020 and December 2021, which suggests that differences between study waves do not only reflect seasonal differences. COVID-19 restrictions were the least severe at the last wave (June 2022), but still only 13.7% of children achieved the 24-hour movement guidelines compared to the 17.5% pre-pandemic estimate based on the Canadian Health Measures Survey.[15] These findings underscore the need for interventions to promote healthy movement behaviours and the need for policymakers to preserve opportunities for engaging in these behaviours when public health restrictions are adopted to address future pandemics

Strengths and Limitations.

Study strengths include the longitudinal design, the inclusion of four waves[67], and the relatively large nationally representative sample, which increases the generalizability of the findings.[68] Compared to previous research about children's health behaviour, our sample provided included a higher representation of fathers, and fathers were less likely to dropout.[69]

When interpreting the findings of the present study, several limitations should be considered. First, as the data was subjectively collected via a questionnaire it is vulnerable to social desirability and recall biases. Furthermore, attrition is a notable limitation in this study, and parents who dropped out were younger and had lower PBC. Due to the online survey approach, it was impossible to establish rapport with the participants, which may have contributed to the high attrition rate. However, 708 parents completed the last follow-up, which exceeded the required sample size. We found that parents who dropped out were younger, had lower PBC, and were less likely to meet the sedentary behaviour guideline. This introduce attrition bias, but the fact that the effect size of all these variables except parent age was trivial reduces concerns about the generalizability of the results. In addition, the validity of the questions used to assess movement behaviours is unknown, though similar questions were used in other national cross-sectional studies.[27,70] Except for sleep, the test-retest reliability of the questions on the 24-hour movement behaviours was relatively low, though these estimates should be interpreted with caution given that the test-retest assessment was conducted during the second wave of COVID-19 when provinces incrementally introduced more severe restrictions. Lastly, multiple imputation generates more precise estimates than complete

case analyses as they preserve the original sample size[71], but this enhanced power may increase the risk of type I error. This concern is reduced by the limited differences in findings between multiply imputed and complete case models (Supplementary Table 6).

5. Conclusion

We found a significant positive association between parents' and their child's adherence with the 24-hour movement guidelines. Moreover, parents' PBC to support their child's movement behaviours was positively associated with their child's adherence to the movement guidelines, independently from parents' behaviours. The results highlight the significance of parents as role models and supporters of their children's movement behaviours and have implications for interventions to support healthy movement patterns. These findings can help inform future research, interventions, policies, and educational strategies to encourage parents and children to adhere to the 24-hour movement guidelines.

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Contributions

FS contributed to the study conception, data analysis, methodology, visualization and writing the draft. RL contributed to study conception, data curation, funding acquisition, investigation, methodology, project administration, supervision, and manuscript review and editing. NBP and AFW contributed to study conception, supervision, and manuscript review and editing. MST, GF, MB, MBr and KG contributed to funding acquisition, investigation, methodology, and manuscript review and editing. All authors contributed to the manuscript writing and critically revised the manuscript for important intellectual content.

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Declaration of competing interest

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Table 1

Sample description of the whole population and stratified by gender.

Variable	Whole Sample n=2257		Boys n= 1165		Girls n=1092	
	Frequency (%)	**Mean (SD)**	**Frequency (%)**	**Mean (SD)**	**Frequency (%)**	**Mean (SD)**
Child age		9.9 (1.7)		9.9 (1.7)		9.9 (1.7)
Child gender						
Boys	1165 (51.6%)					
Girls	1092 (48.4%)					
Parent age		41.2 (7.6)		41.1 (7.4)		41.2 (7.3)
Parent gender						
Man	802 (35.5%)		438 (37.6%)		364 (33.3%)	
Woman	1455 (64.5%)		727 (62.4%)		728 (66.7%)	
Household income						
$39,999 or less	256 (11.3%)		132 (11.3%)		124 (11.4%)	
$40,000 to $99,999	1018 (45.1%)		532 (45.7%)		486 (44.5%)	
$100,000 or more	779 (34.6%)		393 (33.7%)		386 (35.3%)	
Prefer not to answer	204 (9%)		108 (9.3%)		95 (8.8%)	
Immigration status of children						
Born in Canada	1854 (82.1%)		961 (82.5%)		893 (81.8%)	
Born outside of Canada	403 (17.9%)		204 (17.5%)		199 (18.2%)	
Parents' PBC						
Physical activity		4.0 (1.0)		4.0 (1.0)		4.0 (1.0)

Sleep	4.1 (1.0)	4.1 (1.0)	4.0 (1.1)
Screen time	3.7 (1.1)	3.7 (1.1)	3.7 (1.1)
Combined	3.9 (0.9)	3.9 (0.9)	3.9 (0.9)

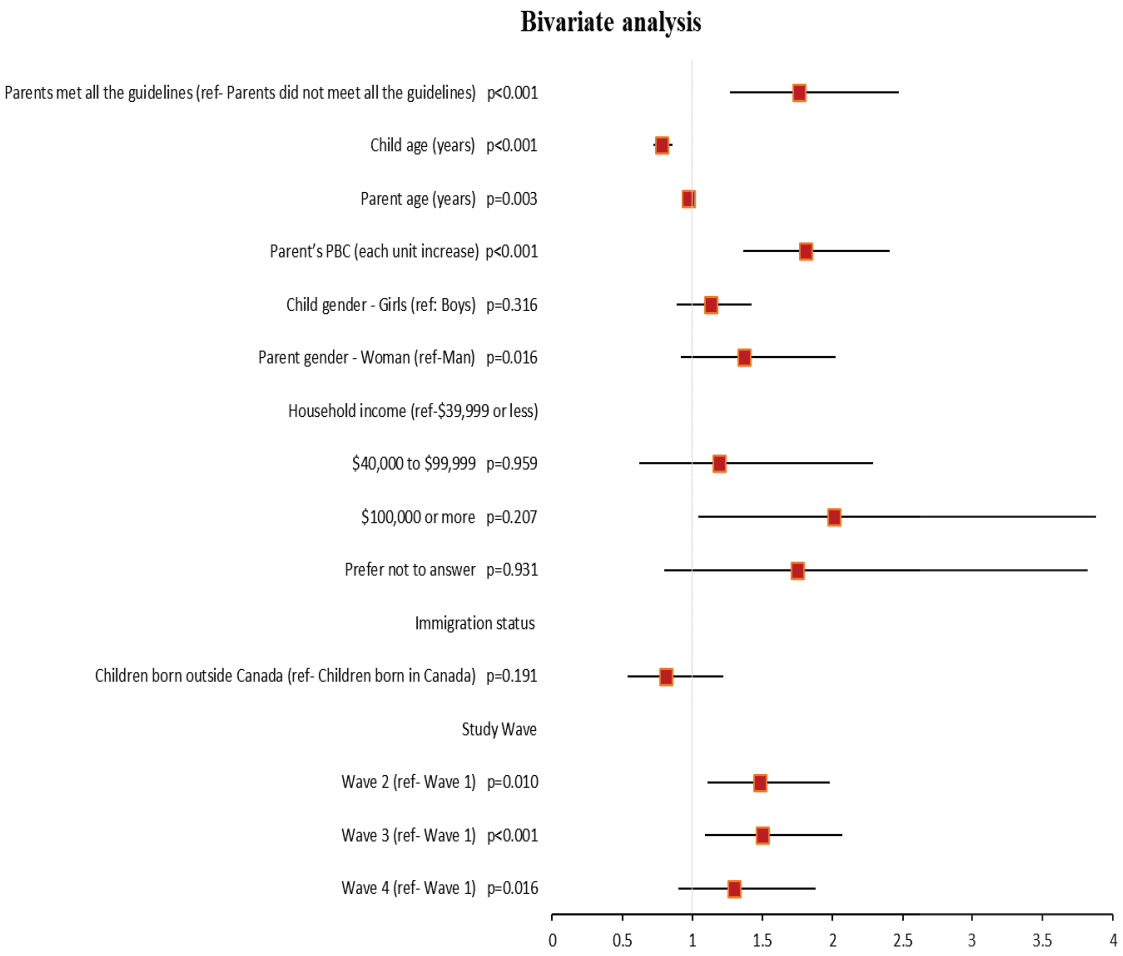
Note: Parent's perceived behavioural control (PBC) ranges from 1-5.

Table 2

Percentage of parents and children meeting the 24-hour guidelines during each study wave.

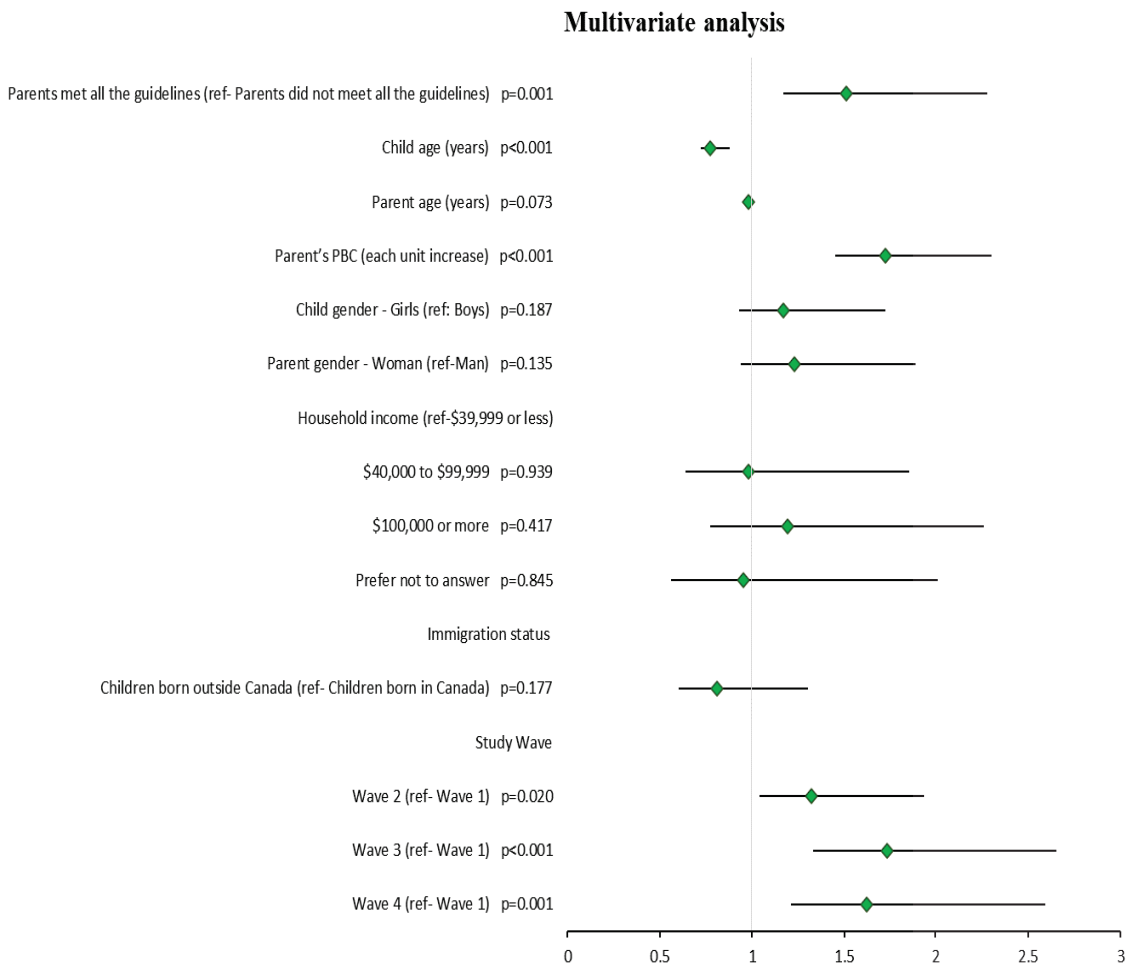
Variables	Wave 1 (%)	Wave 2 (%)	Wave 3 (%)	Wave 4 (%)
Parents	5.0	30.5	27.9	31.9
Fathers	5.4	32.4	24	27.4
Mothers	4.8	29.3	30.5	34.9
Children	9.9	13.0	16.2	13.7
Boys	9.0	13.6	14.1	11.9
Girls	10.9	12.3	18.7	36

Note: Wave 1 data were collected in December 2020 and subsequent waves were conducted every 6 months until June 2022.



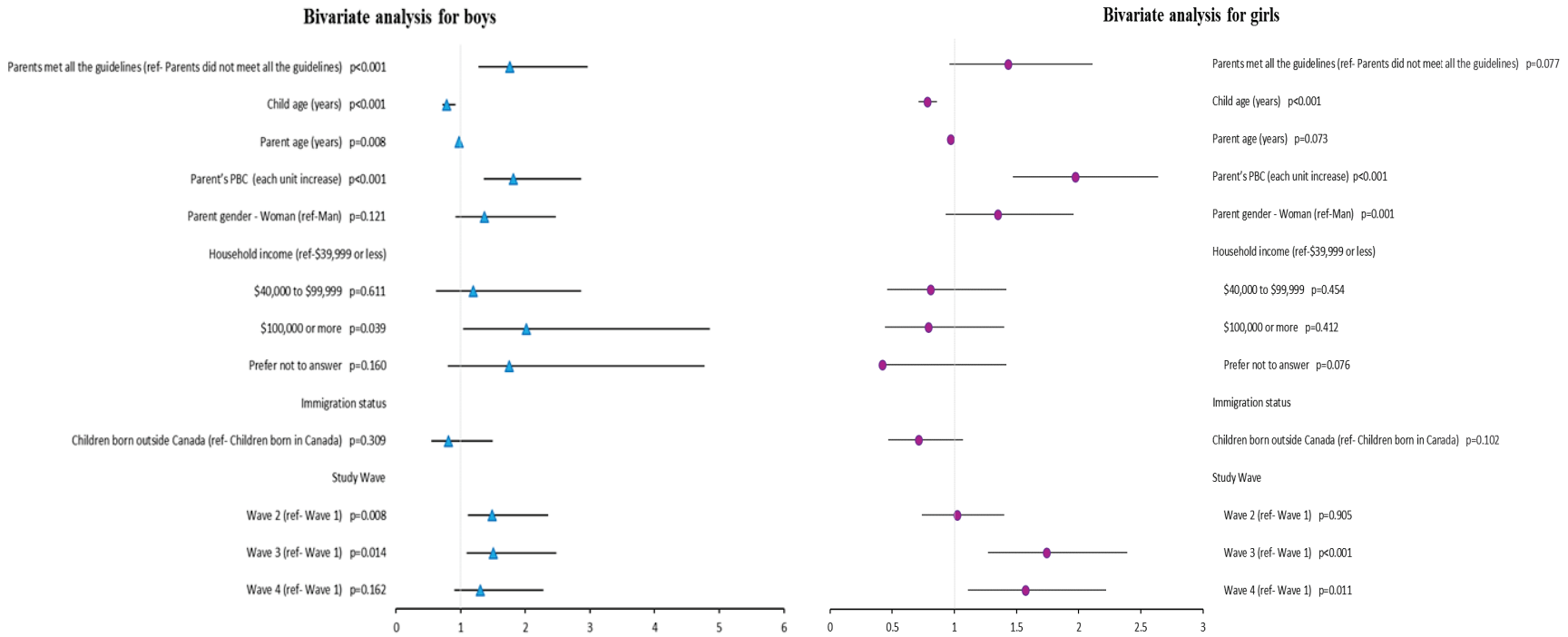
Note: CI: confidence intervals; OR: odds ratios; PBC: perceived behavioural control. For the bivariate model, the QIC and QICC were 2561.89 and 2559.77, respectively. Bolded p-values indicate statistical significance.

Figure 1: Bivariate analysis of the full sample.



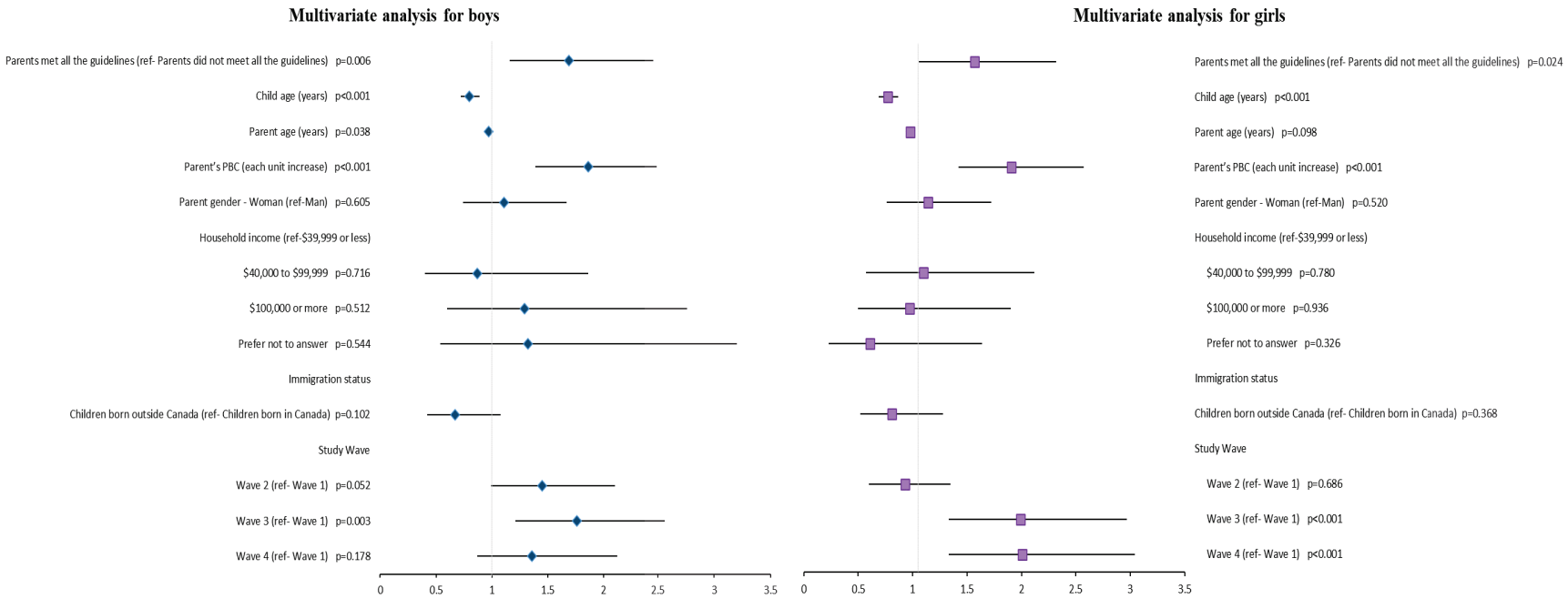
Note: CI: confidence intervals; OR: odds ratios; PBC: perceived behavioural control. For the multivariate model, the QIC and QICC were reduced to 2355.49 and 2347.56, respectively. Bolded p-values indicate statistical significance.

Figure 2: Multivariate analysis of the full sample.



Note: CI: confidence intervals; OR: odds ratios; PBC: perceived behavioural control. Bolded p-values indicate statistical significance. For boys, the QIC and QICC in the bivariate model were 1271.23 and 1269.65, respectively; and for girls, the QIC and QICC in the bivariate model were 1292.91 and 1290.35, respectively.

Figure 3: Bivariate analysis stratified by child gender.



Note: CI: confidence intervals; OR: odds ratios; PBC: perceived behavioural control. Bolded p-values indicate statistical significance. For boys, the QIC and QICC in the bivariate model were 1179.19 and 1173.68, respectively; and for girls, the QIC and QICC in the bivariate model were 1185.22 and 1178.95, respectively.

Figure 4: Multivariate analysis stratified by child gender.

Supplementary Table 1

Mean differences between parent's PBC for their child's screen time, PA and sleep.

Paired Variables	Mean Difference	95% Confidence Interval of the Difference		P-value	Cohen's d
		Lower	Upper		
PBC screen time - PBC PA	-0.3	-0.28	-0.32	**<0.001**	0.30
PBC screen time - PBC Sleep	-0.3	-0.33	-0.37	**<0.001**	0.31
PBC Sleep - PBC PA	0.1	0.05	0.02	**<0.001**	0.06

Note: PBC: perceived behavioural control; Cohen's D interpretation: d < 0.20 = trivial; d (0.2 - 0.49) = small; d between (0.5 - 0.79) = medium; and d ≥ 0.8 = large; Bolded p-values indicate statistical significance.

Supplementary Table 2

Differences between participants who reported "don't know" for children's 24-hour movement behaviours/their own 24-hour movement guidelines and those who reported their child's movement behaviours, based on continuous variables.

Variable	Mean-Don't Know	Mean-Reported	Mean difference	P-value	Cohen's d
Reported "don't know" for children's 24-hour movement:					
Child age	10.4	10.2	0.2	**<0.001**	0.13
Parent age	41.5	42.4	-0.9	**<0.001**	0.11
Parent's PBC	3.7	3.9	-0.2	**<0.001**	0.28
Reported "don't know" for their 24-hour movement:					
Child age	10.3	10.20	0.1	0.060	0.05
Parent age	41.1	42.60	-1.6	**<0.001**	0.21
Parent's PBC	3.8	4.0	-0.2	**<0.001**	0.19

Note: PBC: perceived behavioural control; Cohen's D interpretation: d < 0.20 = trivial; d (0.2 - 0.49) = small; d between (0.5 - 0.79) = medium; and d ≥ 0.8 = large; Bolded p-values indicate statistical significance.

Supplementary Table 3

Differences between participants who reported "don't know" for children's 24-hour movement behaviours/their own 24-hour movement guidelines and those who reported their child's movement behaviours, based on categorical variables.

Variable	Chi-squared	P-value	Cramer's V
Reported "don't know" for children's 24-hour movement:			
Child gender	1.41	0.230	0.01
Parent gender	0.67	0.410	0.01
Household income	91.85	**<0.001**	0.13
Immigration status	2.45	0.110	0.02
Study Wave	9.49	**0.020**	0.04
Reported "don't know" for their 24-hour movement:			
Child gender	2.45	0.110	**0.02**
Parent gender	2.77	0.090	**0.02**
Household income	107.05	**<0.001**	0.14
Immigration status	0.88	0.340	**0.01**
Study Wave	2.35	0.500	**0.02**

Note: Cramer's V interpretation: V < 0.10 = trivial; V (0.1 - 0.29) = small; V (0.3 - 0.49) = medium; and V ≥ 0.5 = large; Bolded p-values indicate statistical significance.

Supplementary Table 4

Comparison of baseline characteristics between participants who dropped out and those who completed Wave 4, based on continuous variables.

Variable	Dropouts	Completers	p-value	Effect size
	Mean (SD)	Mean (SD)		
Child age	9.9 (1.7)	9.8 (1.7)	0.373	0.041
Parent age	40.6 (7.5)	42.4 (7.0)	**<0.001**	**0.243**
PBC-PA	4.0 (1.0)	4.1 (0.9)	**0.005**	0.128
PBC-sleep	4.0 (1.1)	4.1 (1.0)	**0.008**	0.121
PBC-screen time	3.7 (1.1)	3.9 (1.1)	**<0.001**	0.156
PBC-combined	3.9 (0.9)	4.0 (0.9)	**<0.001**	0.161

Note: Independent samples t-tests for continuous variables with Cohen's d as a measure of effect size. Cohen's D interpretation: $d < 0.20$ = trivial; d (0.2 - 0.49) = small; d between (0.5 - 0.79) = medium; and $d \geq 0.8$ = large; Cramer's V interpretation: $V < 0.10$ = trivial; V (0.1 - 0.29) = small; V (0.3 - 0.49) = medium; and $V \geq 0.5$ = large.

Supplementary Table 5

Comparison of baseline characteristics between participants who dropped out and those who completed Wave 4, based on categorical variables.

Variable	Dropouts	Completers	p-value	Effect size
	Frequency (%)	Frequency (%)		
Child gender			0.482	0.015
Boy	797 (51.1)	368 (52.7)		
Girl	762 (48.9)	330 (47.3)		
Parent gender			**0.008**	0.056
Man	526 (33.7)	276 (39.5)		
Woman	1033 (66.3)	422 (60.5)		
Household income ($)			0.230	0.044
≤39,999	184 (11.8)	72 (10.3)		
40,000-99,999	718 (46.1)	300 (43.0)		
≥100,000	522 (33.5)	257 (36.8)		
Prefers not to respond	135 (8.7)	69 (9.9)		
Immigration status			0.603	0.011
Born in Canada	1285 (82.4)	569 (81.5)		
Born outside Canada	274 (17.6)	129 (18.5)		
Child adherence to 24-hour guidelines				
Screen time			0.085	0.039
Yes	283 (21.4)	153 (25.0)		
No	1037 (78.6)	460 (75.0)		
MVPA			0.746	0.008
Yes	843 (69.8)	382 (69.1)		
No	364 (30.2)	171 (30.9)		
Sleep			0.069	0.041
Yes	714 (53.6)	258 (42.0)		
No	619 (46.4)	356 (58.0)		
Integrated guidelines			0.061	0.046
Yes	101 (9.0)	62 (11.9)		
No	1024 (91.0)	457 (88.1)		
Parent adherence to 24-hour guidelines				
Sedentary behaviour			**0.006**	0.066
Yes	496 (41.8)	266 (48.8)		

No	691 (58.2)	279 (51.2)		
MVPA			0.254	0.027
Yes	226 (18.5)	91 (16.3)		
No	993 (81.5)	467 (83.7)		
Sleep			0.219	0.028
Yes	801 (59.2)	391 (62.7)		
No	553 (40.8)	239 (37.9)		
Integrated guidelines			0.420	0.02
Yes	53 (4.7)	29 (5.7)		
No	1071 (95.3)	484 (94.3)		

Note: Chi-square tests for categorical variables with Cramer's V as estimate of effect size. Cramer's V interpretation: $V < 0.10$ = trivial; V (0.1 - 0.29) = small; V (0.3 - 0.49) = medium; and $V \geq 0.5$ = large.

Supplementary Table 6

Bivariate and multivariate analysis of the complete case data.

Variable	Bivariate			Multivariate		
	OR	95% CI	P-value	OR	95% CI	P-value
Parents met all the guidelines (ref- Parents did not meet all the guidelines)	1.59	1.23, 2.05	**<0.001**	1.64	1.25, 2.14	**<0.001**
Child age	0.80	0.75, 0.85	**<0.001**	0.78	0.72, 0.84	**<0.001**
Parent age	0.97	0.95, 0.99	**<0.001**	0.96	0.96, 0.99	**0.010**
Parent's PBC	1.89	1.53, 2.35	**<0.001**	1.87	1.52, 2.30	**<0.001**
Child gender - Girls (ref- Boys)	1.15	0.88, 1.48	0.308	1.22	0.94, 1.59	0.130
Parent gender - Woman (ref- Man)	1.36	1.03, 1.81	**0.032**	1.14	0.85, 1.53	0.387
Household income						
$40,000 to $99,999 (ref- $39,999 or less)	0.99	0.62, 1.58	0.971	1.00	0.61, 1.65	0.996
$100,000 or more (ref- $39,999 or less)	1.19	0.75, 1.87	0.472	1.11	0.67, 1.83	0.682
Prefer not to answer (ref- $39,999 or less)	1.00	0.55, 1.81	1.000	0.94	0.50, 1.78	0.845
Immigration status- Children born outside Canada (ref- Children born in Canada)	0.77	0.57, 1.03	0.076	0.74	0.54, 1.03	0.075
Study Wave						
Wave 2 (ref- Wave 1)	1.18	0.94, 1.48	0.160	1.18	0.91, 1.53	0.220
Wave 3 (ref- Wave 1)	1.62	1.29, 2.05	**<0.001**	1.88	1.44, 2.47	**<0.001**

Wave 4 (ref-Wave 1)	1.49	1.15, 1.92	**0.002**	1.69	1.25, 2.28	**<0.001**

Note: CI: confidence intervals; OR: odds ratios; PBC: perceived behavioural control; Bolded p-values indicate statistical significance.

CHAPTER 3: RESULTS

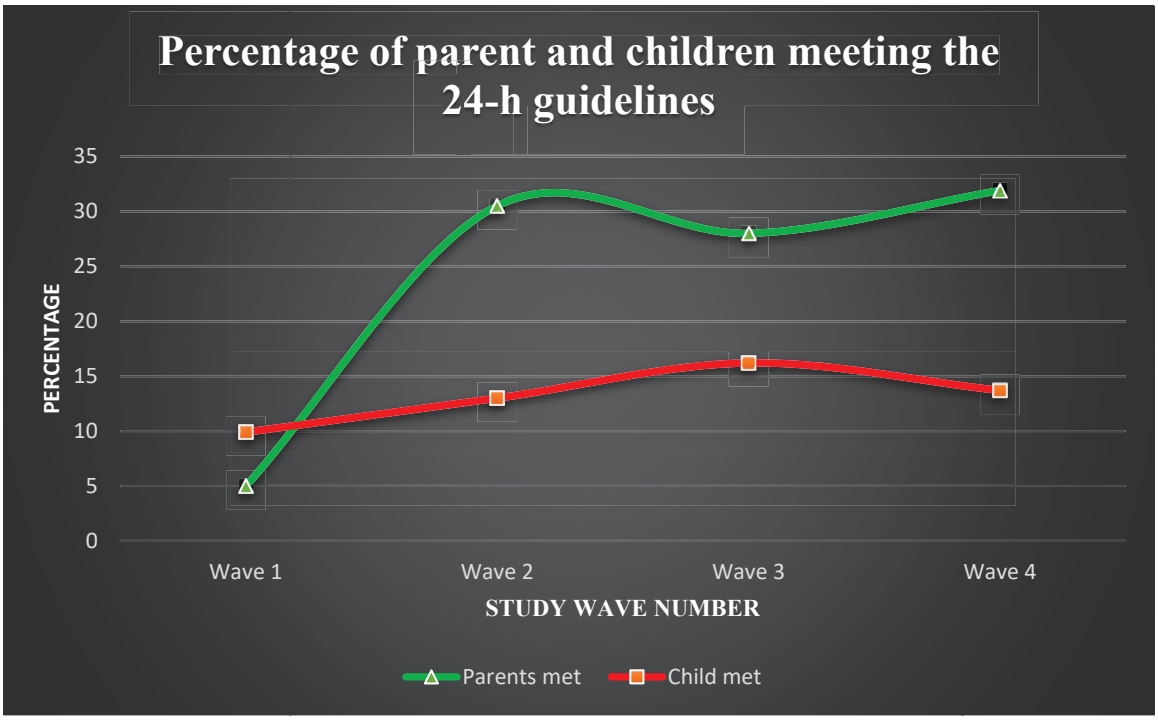
Table 3.1 provides descriptive characteristics of the full sample, and with stratification by gender in the first survey (December 2020). About two-thirds of the parent respondents were women (64.5%) and the mean age of parents was 41.2 ± 7.6 years. On average, the children were 9.9 ± 1.7 years old, and just over half of the children were boys (51.6%). More than 80% of the children were born in Canada. Furthermore, parents reported a higher PBC over their children's sleep time (4.1) than PA (4.0) and screen time (3.7), and the differences were significant ($p<0.001$; see Appendix D). The percentage of parents and children meeting the 24-hour guidelines was very low during the baseline data collection (5.0% and 9.9%, respectively). However, adherence to the guidelines was higher in subsequent follow-ups especially among parents, as shown in Figure 3.1. For example, at Wave 4 (June 2022), 31.9% of parents and 13.7% of children met the guidelines. In addition, adherence to the MVPA guidelines was higher in both parents and children in subsequent follow-ups (see Appendix E). We found no evidence of multicollinearity among the predictor variables (VIF<1.5).

Table 3.1: Sample description of the whole population and stratified by gender.

Variable	**Whole Sample n=2257**		**Boys n= 1165**		**Girls n=1092**	
	Frequency (%)	**Mean (SD)**	**Frequency (%)**	**Mean (SD)**	**Frequency (%)**	**Mean (SD)**
Child age		9.9 (1.7)		9.9 (1.7)		9.9 (1.7)
Child gender						
Boys	1165 (51.6%)					
Girls	1092 (48.4%)					

Parent age		41.2 (7.6)	41.1 (7.4)	41.2 (7.3)
Parent gender				
Man	802 (35.5%)		438 (37.6%)	364 (33.3%)
Woman	1455 (64.5%)		727 (62.4%)	728 (66.7%)
Household income				
$39,999 or less	256 (11.3%)		132 (11.3%)	124 (11.4%)
$40,000 to $99,999	1018 (45.1%)		532 (45.7%)	486 (44.5%)
$100,000 or more	779 (34.6%)		393 (33.7%)	386 (35.3%)
Prefer not to answer	204 (9%)		108 (9.3%)	95 (8.8%)
Immigration status of children				
Born in Canada	1854 (82.1%)		961 (82.5%)	893 (81.8%)
Born outside of Canada	403 (17.9%)		204 (17.5%)	199 (18.2%)
Parents' PBC				
Physical activity		4.0 (1.0)	4.0 (1.0)	4.0 (1.0)
Sleep		4.1 (1.0)	4.1 (1.0)	4.0 (1.1)
Screen time		3.7 (1.1)	3.7 (1.1)	3.7 (1.1)
Combined		3.9 (0.9)	3.9 (0.9)	3.9 (0.9)

Note: Parent's perceived behavioural control (PBC) ranges from 1-5.



Note: Wave 1 data were collected in December 2020 and subsequent waves were conducted every 6 months until June 2022.

Figure 3.1: Percentage of parents and children meeting the 24-hour guidelines during different survey waves.

Differences between participants who reported or did not report their movement behaviours.

Table 3.2 and 3.2 portrays the differences between participants reporting "don't know" and those not reporting "don't know" for children's 24-hour movement behaviours/parent's 24-hour movement guidelines for continuous variables respectively. Younger parents (d = 0.11), parents of older children (d = 0.13), parents with lower income (V = 0.13) and PBC (d = 0.28) were more likely to report "don't know". The proportion of parents reporting don't know varied by study wave, but the effect size was trivial (V=0.04). Although the percentage of parents reporting "don't know" decreased in Wave 2 versus Wave 1 (23.2% vs. 27.2%), the percentage gradually rose to 28.7% in Wave 4 (χ^2= 9.49, p < 0.023, V= 0.043). Younger parents (d= 0.21), parents with lower income (V= 0.14) and

lower PBC (d= 0.19) were more likely to report "don't know" for their 24-hour movement behaviours.

Table 3.2: Differences between participants who reported "don't know" for children's 24-hour movement behaviours/their own 24-hour movement guidelines and those who reported their child's movement behaviours, based on continuous variables.

Variable	Mean-Don't Know	Mean-Reported	Mean difference	P-value	Cohen's d
Reported "don't know" for children's 24-hour movement:					
Child age	10.4	10.2	0.2	**<0.001**	0.13
Parent age	41.5	42.4	-0.9	**<0.001**	0.11
Parent's PBC	3.7	3.9	-0.2	**<0.001**	0.28
Reported "don't know" for their 24-hour movement:					
Child age	10.3	10.20	0.1	0.060	0.05
Parent age	41.1	42.60	-1.6	**<0.001**	0.21
Parent's PBC	3.8	4.0	-0.2	**<0.001**	0.19

Note: PBC: perceived behavioural control; Cohen's D interpretation: d < 0.20 = trivial; d (0.2 - 0.49) = small; d between (0.5 - 0.79) = medium; and d ≥ 0.8 = large; Bolded p-values indicate statistical significance.

Table 3.3: Differences between participants who reported "don't know" for children's 24-hour movement behaviours/their own 24-hour movement guidelines and those who reported their child's movement behaviours, based on categorical variables.

Variable	Chi-squared	P-value	Cramer's V
Reported "don't know" for children's 24-hour movement:			
Child gender	1.41	0.230	0.01
Parent gender	0.67	0.410	0.01
Household income	91.85	**<0.001**	0.13
Immigration status	2.45	0.110	0.02
Study Wave	9.49	**0.020**	0.04
Reported "don't know" for their 24-hour movement:			
Child gender	2.45	0.110	**0.02**
Parent gender	2.77	0.090	**0.02**
Household income	107.05	**<0.001**	0.14
Immigration status	0.88	0.340	**0.01**
Study Wave	2.35	0.500	**0.02**

Note: Cramer's V interpretation: V < 0.10 = trivial; V (0.1 - 0.29) = small; V (0.3 - 0.49) = medium; and V ≥ 0.5 = large; Bolded p-values indicate statistical significance.

Moreover, we compared the baseline characteristics between participants who dropped out and those who completed Wave 4 using the complete case data (see Appendix F). On average, parents who dropped out were younger ($p < 0.001$ and Cohen's $d = 0.242$), had lower PBC ($p = 0.001$ and Cohen's $d = 0.128$) and were less likely to meet the sedentary

behaviour guideline (p = 0.006 and Cohen's d = 0.066). Except for the age of parents, the effect size for all other variables was trivial.

Association between parents' and their children's adherence to the 24-hour movement guidelines and other correlates

Table 3.4 shows the bivariate and multivariate analysis of the correlates of the number of guidelines met by the children based on the multiply imputed data. The bivariate model indicated that children whose parent respondent met all the guidelines were 1.57 times more likely to meet all three guidelines (95% CI = 1.23, 1.99). Each unit increase in parent's PBC was associated with higher odds that the child met the 24-hour movement guidelines (OR = 1.72; 95% CI = 1.45, 2.03). In addition, adherence was higher in Wave 2 to 4 vs. Wave 1, in younger children, and in children whose parent respondents were younger or identified as women. Children's gender, immigration status, and household income were not associated with children's adherence to 24-hour guidelines.

Table 3.4: Bivariate and multivariate analysis of the full sample.

Variable	**Bivariate**			**Multivariate**		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
Parents met all the guidelines (ref- Parents did not meet all the guidelines)	1.57	1.23, 1.99	**<0.001**	1.51	1.17, 1.94	**0.001**
Child age	0.79	0.74, 0.84	**<0.001**	0.77	0.72, 0.83	**<0.001**
Parent age	0.98	0.96, 0.99	**0.003**	0.98	0.97, 1.00	0.073
Parent's PBC	1.78	1.49, 2.12	**<0.001**	1.72	1.45, 2.03	**<0.001**

Child gender - Girls (ref- Boys)	1.13	0.89, 1.42	0.316	1.17	0.93, 1.48	0.187
Parent gender - Woman (ref- Man)	1.37	1.06, 1.78	**0.016**	1.23	0.94, 1.60	0.135
Household income						
$40,000 to $99,999 (ref- $39,999 or less)	0.99	0.65, 1.51	0.959	0.98	0.64, 1.51	0.939
$100,000 or more (ref- $39,999 or less)	1.31	0.86, 1.99	0.207	1.19	0.77, 1.84	0.417
Prefer not to answer (ref- $39,999 or less)	1.02	0.61, 1.72	0.931	0.95	0.56, 1.62	0.845
Immigration status - Children born outside Canada (ref- Children born in Canada)	0.82	0.62, 1.10	0.191	0.81	0.60, 1.09	0.177
Study Wave						
Wave 2 (ref- Wave 1)	1.31	1.07, 1.60	**0.010**	1.32	1.04, 1.66	**0.020**
Wave 3 (ref- Wave 1)	1.50	1.19, 1.89	**<0.001**	1.73	1.33, 2.25	**<0.001**
Wave 4 (ref- Wave 1)	1.38	1.06, 1.79	**0.016**	1.62	1.21, 2.18	**0.001**

Note: CI: confidence intervals; OR: odds ratios; PBC: perceived behavioural control. For bivariate model, the QIC and QICC were 2561.89 and 2559.77, respectively. For the multivariate model, the QIC and QICC were reduced to 2355.49 and 2347.56, respectively; Bolded p-values indicate statistical significance.

The multivariate analysis indicated that the odds of children meeting all three guidelines were 1.51 times higher if their parents met all the guidelines (95% CI = 1.17, 1.94). Moreover, each unit increase in the PBC scale was associated with higher odds of the child meeting three guidelines (OR = 1.72; 95% CI = 1.45, 2.03). There was no interaction between parents' adherence to the guidelines and PBC (p = 0.525). Moreover, adherence was higher in Wave 2 (OR=1.32; 95% CI=1.04, 1.66), Wave 3 (OR=1.73; 95% CI=1.33, 2.25) and Wave 4 (OR=1.62; 95% CI=1.21, 2.18) vs. Wave 1. Lastly, odds of adherence decreased with each additional year of age (OR = 0.77, 95% CI = 0.72, 0.83).

When children were stratified by gender (see Appendix G), the bivariate analysis indicated that boys were 1.76 times more likely to meet all the guidelines if their parents met all the guidelines (95% CI = 1.27, 2.47), but no association was found in girls. In the multivariate analysis, parents' adherence was associated with adherence for both boys (OR= 1.69; 95% CI= 1.16, 2.46) and girls (OR = 1.57; 95% CI = 1.06, 2.32). Results of the multivariate model were generally similar for boys and girls, except that parent age was associated with lower odds of adherence to the child guidelines in boys (OR = 0.97; 95% CI = 0.96, 0.99) while this difference was similar, but not significant in girls (p = 0.098). Boys and girls were more likely to meet the 24-hour movement guidelines during Wave 3 vs. Wave 1 while only girls were more likely to meet the guidelines during Wave 4.

In models with complete case data, parent's adherence to the guidelines was significantly associated with their child's adherence in both bivariate and multivariate analysis (see Appendix H). Furthermore, younger children and those whose parents were younger, identified as women, or had higher PBC had higher odds of adherence to the guidelines in both bivariate and multivariate analysis of complete case data. Children were

more likely to adhere to the 24-hour guidelines during Waves 3 and 4 versus Wave 1. Unlike the multiply imputed data, the odds of adherence to the guidelines did not differ between Waves 1 and 2 in complete cases. Children's odds of adhering to the 24-hour guidelines decreased with parents' age in both complete case and multiply imputed models, but in the latter, the association was not significant in the multivariate model.

CHAPTER 4: DISCUSSION AND CONCLUSION

Purpose

This longitudinal study aimed to assess the adherence of both Canadian parents and children with the 24-hour movement guidelines. It was hypothesized that children of parents who met the guidelines would be more likely to meet the child guidelines. It was also hypothesized that parent's PBC to support their children's movement behaviour would act as a predictor of their children's movement behaviours or a moderator of the association between parents' and children's movement behaviours. Consistent with our hypotheses, it was seen that parents' PBC and adherence to the guidelines were significantly related to their children's adherence. However, PBC did not moderate the association between parents' and children's adherence to the guidelines. While many previous studies have investigated the association between parent's and children's adherence to individual guidelines (Hughes et al., 2016; Matos et al., 2021; Varma et al., 2021), no previous longitudinal studies considered the combined 24-hour movement guidelines when assessing such associations. To our knowledge, this is the first longitudinal study examining the association between parents' and children's adherence to 24-hour movement guidelines. Our results suggest that parents can influence their children's movement behaviours by both role modelling and encouragement.

Association between parents' and children's adherence to the 24-hour movement guidelines:

Using a representative sample of Canadian parents of children aged 7 to 12 years, the present study found that children whose parents met all the 24-hour movement guidelines were 1.51 times more likely to meet the child guidelines. The effect size did not change markedly after controlling for parents' PBC, study wave, and potential

confounders. Consistent with our findings, previous research found that parents' PA and sedentary behaviour were substantially associated with their child's PA and sedentary behaviour (Garriguet et al., 2017). Furthermore, previous studies have shown that the parents' sleep hygiene and quality were significantly correlated with their children's sleeping patterns (Chehri et al., 2022). Therefore, consistent with the literature, our present study underscores the influence of parents as positive role models for their child's movement behaviours. Family-based interventions should be considered as they have previously been found to increase children's and parents' adherence to individual movement behaviours (Brown et al., 2016).

Our study began in the second wave of the COVID-19 pandemic, and at each time point, the large majority of children and parents did not meet the 24-hour movement guidelines. A cross-sectional study found that only 9.1% of Canadian parents of children aged 5-17 met all the guidelines during the 2nd wave of the COVID-19 pandemic (Rollo et al., 2023). Similarly, a national survey revealed that only 4.8% of Canadian children met the combined 24-hour movement guidelines during the early stages of the COVID-19 pandemic (April 2020) and found similar adherence six months later (Campbell et al., 2023). The present study found that 5.0% of parents and 9.9% of children across Canada met all the guidelines during baseline data collection. The percentage of parents and children meeting the 24-hour guidelines increased in the follow-up surveys as the COVID-19 restrictions were gradually lifted, and this increase was larger among parents (Figure 1). For example, at Wave 4 (June 2022), 31.9% of parents and 13.7% of children met the 24-hour movement guidelines. A pre-pandemic study revealed that only 7.1% of Canadian adults aged 18 to 79 years met the combined 24-hour guidelines from 2007 to 2013 (Rollo

et al., 2022). Another study in 2017 reported that about 17.5% of Canadian children and youth met the combined 24-hour movement guidelines between 2009 and 2013 (Roberts et al., 2017). It is to be noted that both of these studies used questionnaires as well as accelerometers for data collection. Hence, previous studies coupled with our current study suggest a poor adherence to the 24-hour movement guidelines in children and adults both before and during the pandemic.

The role of parents' perceived behaviour control for their children's movement behaviours

Our results suggest a significant positive association between parents' PBC and their children's movement behaviours. Furthermore, this association was independent of parent's adherence to 24-hour movement guidelines, indicating that parents may be effective in supporting their child's movement behaviours even if they do not meet all guidelines. In light of the theory of planned behaviour, parent's perceived behavioural control is the extent to which they believe that they can control the movement behaviour patterns of their children (Ajzen, 1991). Thus, our present study suggests that children are more likely to adhere to the recommendations if their parents have stronger beliefs in their ability to influence their child to adopt the behaviours. Our findings are also consistent with previous literature where it was seen that parent's PBC was significantly associated with their children's adherence to the Canadian 24-hour movement guidelines (Rhodes et al., 2019).

Additionally, Rhodes et al. (2019) also found that sleep had the highest PBC, followed by sedentary behaviour and light PA. Likewise, the current study found that parents perceived that they have greater control over their children's sleep patterns (see

Appendix D). Parents may perceive that they have a higher control over their children's sleep because compared to other movement behaviours, it is less complex and needs less supervision. Compared to sleep, parents' PBC was significantly lower for PA and, especially screen time. Screen time may be more difficult for parents to control, but previous randomized controlled trials focusing on reducing TV time have achieved small, but significant reductions in body mass index (Tremblay et al., 2011).

Overall, the significant association between parent's PBC and children's adherence to the 24-hour movement guidelines suggests that interventions aiming to support children's movement behaviours should focus on increasing parents' PBC. In light of the theory of planned behaviour, attitudes, subjective norms, and parental PBC towards their children's movement behaviour should be targeted. It may be advantageous to target PBC given that it can have a direct effect on behaviour (Ajzen, 1991). Interventions should include educational components for parents to better understand and control their child's screen time, PA, and sleep. Additionally, in order to help parents perceive attainable children's movement behaviours, resources should be made available to them to assist in developing measurable and achievable plans based on their regular life activities.

Age differences

The current study shows a significant association between children's age and adherence with the 24-hour movement recommendations. With each year increase in age, children were 23% less likely to meet the guidelines. This finding is consistent with a previous systematic review, which revealed that PA decreases significantly during adolescence (Dumith et al., 2011). More recent evidence suggests that the decline may start as early as the beginning of primary school (Reilly, 2016). In addition, it was also reported

that age-related decline is the most consistent finding in PA epidemiology (Sallis, 2000), indicating a need for interventions to promote sustained engagement in PA. Our findings suggest that such intervention should also focus on screen time and sleep.

The age of the parent respondent was also negatively associated with their children's adherence to the 24-hour movement guidelines, though the effect size was modest (a 2% decline in odds of meeting the guidelines for each year of age; Table 3.4). This finding is consistent with previous research, which reported that children of younger parents were more active, slept more and used social media less (Moore et al., 2020). However, the effect of parent age was no longer significant in our multivariable model (p=0.073). Hence, other variables included in the multivariate model (e.g., child age) may explain the association between parent age and children's adherence to the guidelines.

Gender differences

No significant association was found between the gender of children and their adherence to the 24-hour movement guidelines. In contrast, pre-pandemic data from the Canadian Health Measures Survey showed that boys had more MVPA and screen time than girls, and sleep did not differ in between genders (Roberts et al., 2017). In addition, Moore et al. (2020) found that a lower percentage of girls aged 5–11 years were engaging in sufficient PA compared with boys the same age during COVID-19 pandemic (April 2020), but girls spent more time on social media and sleep than boys. Discrepancies between studies may be associated with methodological differences in the assessment of movement behaviours and/or COVID-19 restrictions in place at the time of data collection.

Although the multivariate model revealed no significant association between parents' gender and their children's adherence to the guidelines, the bivariate model

suggested a significant association. The bivariate model portrayed mothers as having greater odds of influencing their children's adherence with the guidelines than fathers, and hence was consistent with prior research (Lloyd et al., 2014). However, this association was no longer significant when other factors came into play in the multivariate model.

Other socio-demographic factors

The present study did not find any significant association between household income and children's adherence with the 24-hour movement guidelines in both bivariate and multivariate models. In contrast, a systematic review indicated that household income and PA are significantly associated, where children belonging to a higher-income family tend to be more physically active (Sallis et al., 2000). Although no significant association was found with respect to adherence to the combined 24-hour guidelines, individual movement behaviours may still differ by income. Previous research showed that families with low incomes tend to be the least physically inactive, with a substantial correlation found between family income and PA (U.S. Department of Health and Human Services, 1996). In this study, we assessed household income as an indicator of socioeconomic status since low income has been shown to be associated with lower access to opportunities for PA and it could also affect screen time and sleep (Panter et al., 2008). Nonetheless, household income is one of the components of socioeconomic status, and as such, it is necessary to evaluate other socioeconomic disparities that may act as a barrier to equitable access to resources and influence children's adherence with movement guidelines.

The present study did not find any significant association between the immigration status of the child and their adherence to the guidelines. However, this finding was inconsistent with a previous systematic review which highlighted that children from

immigrant families are less likely to participate in PA than native-born children (Lacoste et al., 2020). However, the previous systematic review did not consider screen time and sleep. Future studies are needed to compare screen time and sleep between immigrants and non-immigrants.

Study wave

Study wave was significantly associated with children's adherence to the movement guidelines (see Figure 1 and Table 3.4). The odds ratio of children meeting the 24-hour guidelines were 1.32, 1.73 and 1.62 in Wave 2, Wave 3 and Wave 4 respectively, compared to Wave 1. This finding was consistent in both bivariate and multivariate analyses. Notably, Wave 1 data collection was done in December 2020, during the second wave of the COVID-19 pandemic. During subsequent follow-ups, as the restrictions were gradually lifted, the odds of children meeting the 24-hour guidelines also increased. It is notable that Wave 1 and Wave 3 data were collected in December 2020 and December 2021, which suggest that the effect of study wave does not only reflect seasonal differences. COVID-19 restrictions were the least severe at the last wave (June 2022), but still only 13.7% of children achieved the 24-hour movement guidelines compared to the 17.5% pre-pandemic estimate based on the Canadian Health Measures Survey (Roberts et al., 2017).

Limitations and strengths of the study

Limitations

When interpreting the findings of the present study, several limitations should be considered. First, as the data was subjectively collected via a questionnaire it is vulnerable to social desirability and recall biases. Social desirability bias refers to the tendency of

participants to choose responses they believe are more socially desirable or acceptable rather than choosing responses that are reflective of their true thoughts or feelings. This tendency results in the over-reporting of responses that are socially desirable and the under-reporting of those responses that are deemed to be socially less desirable (Grimm, 2010). For example, participants might have over-reported PA and under-reported sedentary behaviour for themselves and their children. However, this bias may have been reduced by using an online self-administered survey, as participants did not have any direct contact with the researchers. Recall bias is also possible because participants were asked to report their movement behaviours over the week preceding the survey.

In addition, our study found that younger parents, parents of older children, parents with lower income and PBC were more likely to report "don't know" for their children's movement behaviours. A UK-based study found that parents from various ethnic backgrounds living in England lacked awareness of PA recommendations and considered school to be the main provider for children's PA (Trigwell et al., 2015). Hence, additional efforts may be needed to raise parental awareness about the importance of healthy movement behaviours.

Furthermore, attrition is a notable limitation in this study. Attrition results in a loss of power due to the decrease in sample size and might cause bias in findings (Deeg, 2002). However, about 708 parents completed the last follow-up, which was more than the estimated participant number (599) required to achieve a power of 0.80 with an α of 0.05. Comparing the baseline characteristics between participants who dropped out and those who completed Wave 4, we found that parents who dropped out were younger, had lower PBC, and were less likely to meet the sedentary behaviour guideline. This introduces

attrition bias, but the fact that the effect size of all these variables except parent age was trivial reduces concerns about the generalizability of the results. Lastly, multiple imputation generates more precise estimates than complete case analyses as they preserve the original sample size, but this enhanced power may increase the risk of type I error (Austin et al., 2021). This concern is reduced by the limited differences in findings between multiply imputed and complete case models (Appendix H).

Lastly, the validity of the questions on movement behaviours is unknown, though they are similar to questions used in other national surveys conducted during the pandemic in Canada (Moore et al., 2020, 2021). Except for sleep, the test-retest reliability was modest during the pilot-study conducted just before Wave 1 (see Appendix B). These reliability estimates should be interpreted with caution given that the test-retest assessment was conducted during the second wave of COVID-19 when provinces incrementally introduced more severe restrictions. Thus, differences in parents' responses in the test-retest reliability study may reflect both measurement error and actual behaviour change.

Strengths

A major strength of this study was the longitudinal design. To our knowledge, this is the first study that investigated the association between parents' and children's adherence to the Canadian 24-hour movement guidelines longitudinally, which made it possible to examine changes over time during the COVID-19 pandemic. The inclusion of four waves is also a strength, as prior research suggests that four or more waves of data collection can effectively capture different rates of change across the study period in a non-linear model (Hopwood et al., 2022). Moreover, the percentage of men involved in our study is about twice higher than in a systematic review of studies focusing on obesity-related behaviours

in children and youth (Davison et al., 2016) and they were more likely than mothers to remain in the study at Wave 4 (see Appendix F).

Another important strength of this study was the relatively large nationally representative sample at baseline. The participants for this study were recruited via Léger. As mentioned earlier, online panels such as Léger's are designed to provide a demographic representation of the target population (Göritz, 2007). This increases the generalizability of the findings of the current study (Christensen, 2001).

Recommendations for future research

Based on the findings, observed strengths and limitations of this study, several recommendations should be considered for further research in this field. While the present study included parents who could answer the questionnaire in either English or French, future research should recruit parents who are only comfortable in answering questionnaires in other languages as well. This would facilitate inclusion of refugees and recent immigrants speaking neither official language. Additionally, future research in this area should also use device measures such as accelerometers along with questionnaires to provide more accurate data on movement behaviours of both parents and children (Marasso et al., 2021). This was not possible in the present study due to budgetary constraints.

More research is required to examine the effectiveness of interventions aiming to promote healthy movement behaviours. Based on our findings, future interventions targeting families should be implemented in an effort to increase PA and sleep, and decrease sedentary behaviour in parents and children. More research is also needed to understand the mechanism(s) underlying the association between parents' PBC and their children's adherence to the 24-hour movement guidelines. This could provide insights into effective

intervention strategies. Lastly, longer longitudinal studies could explore if the association between parent and child movement behaviours persists over time, for example from childhood to adolescence and adulthood.

Recommendations for practice and policies

Transportation policy can play a key role in boosting parents' and children's physical activity by providing neighbourhoods that encourage active commuting and family-oriented activities. Policy interventions aiming at supporting public transit via ticketing reforms (e.g., discounted season tickets and free university bus services) can significantly increase PA (Brockman & Fox, 2011). In Japan, a policy requiring that schools be located within walking distance has been credited as a key contributor to the fact that 98.3% of children engage in active travel to school (Mori et al., 2012). Moreover, previous empirical evidence indicates that financial incentives for active travel might be a strategy for promoting healthier lifestyle choices (Martin et al., 2012). Hence, policies could be aimed at providing financial incentives or subsidies to families who use active means of transportation. This may include tax credits for buying bicycles, incentives for walking or biking to school, or savings on public transportation for families.

The current study found a significant association between parents' and children's adherence to the 24-hour movement guidelines. Through direct involvement and role modelling, parents can have a significant impact on their children's PA behaviours, and these effects may persist throughout adolescence (Norton et al., 2003). A systematic review highlighted that enjoying time spent together, picking up new skills, and improving confidence—using PA as the vehicle for such change might resonate more to families who do not currently meet recommended PA guidelines (Brown et al., 2016). A meta-analysis

found that family PA interventions can help to foster family cohesion and organization, particularly among families with children in the early school years (Rhodes et al, 2023). Previous literature underscores the need for enhancing parental knowledge to increase the PA level in their children (Bentley et al., 2012). In this regard, ParticipACTION, a not-for-profit organization, launched the "Think Again" campaign to increase awareness among parents, specifically mothers, about their children's lack of physical activity and encourage them to get their children active. Gainforth et al. (2016) found that awareness of the campaign led to parents having greater knowledge of physical activity guidelines, higher intention to help their child meet them, and engaging in more parental support behaviours. As such, interventions should provide parents with knowledge and skills to support their child's movement behaviours.

The current study found that the odds of children meeting the 24-hour guidelines increases with each unit increase in parent's PBC. Previous research indicates that parents' PBC and co-participation are associated with MVPA in children (Doggui et al., 2021). Consistent with this, the positive association between parent's PBC and children's adherence to the guidelines in the present study suggest that interventions aiming to support child's movement behaviours should focus on increasing parent's PBC. In this regard, Bandura (2004) explained that self-efficacy plays a crucial role in acquiring health behavioural practices, as even after having the knowledge of lifestyle contributors to health, individuals with low self-efficacy will not take any action to change their health behaviour. As a result, interventions should be targeted at increasing parents' self-efficacy so that they can positively influence their children's movement behaviours. A meta-analysis indicated that interventions aiming at goal setting and reinforcement are particularly

effective in this context, where identifying a target (e.g., increase in steps per day), recording progress and rewarding achievements can increase motivation and in turn, lead to a change in behaviour; and, if the family spends time preparing for PA, this effect can be even stronger (Brown et al., 2016). Our study found that parents had the least PBC for their child's screen time. This may be because many parents strive to address the balance between adequate screen time and daily life (Chong et al., 2023). Hence, interventions should be targeted to educate parents about effectively incorporating movement behaviours into daily routines or at least interrupting long periods of sitting in front of screens. Lastly, interventions should also encourage parent's and children's co-participation in healthy movement behaviours. Previous research suggests that family interventions promoting parent and child co-participation in PA are more likely to improve health behaviours in their children than just solely targeting children's participation (Lee et al., 2010; Rhodes & Lim, 2018; Rodrigues et al., 2018). In this context, the globally recognized "Healthy Dads, Healthy Kids" program significantly improved health outcomes and behaviours in fathers and children (Morgan et al., 2011; Morgan et al., 2019). A similar intervention targeting mother-child dyads could be developed to promote movement behaviours in a more inclusive way..

Our study underlines the potential for a decrease in adherence to 24-hour movement guidelines as children grow older. Previous research has found that lack of PA enjoyment is one of the reasons behind the age-related decline in PA (Haas et al., 2021). We recommend targeting more age-appropriate and engaging activities for children in school, emphasizing the pursuit of fun activities, sports or exercise that cater to different interests. In this regard, a non-profit organization in Quebec, FitSpirit, offers a girls-only intervention

to encourage teenage girls aged 12 to 17 years old to be physically active throughout their lives by offering a unique set of tools and resources for schools. Previous research revealed that meeting individual and combined recommendations within the Canadian 24-hour movement guidelines is associated with improved perceived quality of life and health, PA self-efficacy and healthier BMI was achieved in a sample of FitSpirit participants (Guimarães et al., 2021). Hence, creating similar interventions for children of all genders within the school setting might encourage the children to adhere to the 24-hour movement guidelines more, and thereby increasing their PA self-efficacy and perceived quality of life and health.

Lastly, the current study found that parents' PBC over their children's movement behaviour was comparatively lower for screen time than for PA and sleep. In this context, a previous systematic review has indicated that interventions aiming to reduce screen time can result in improvements in PA, reduced inactivity and better sleeping patterns (Ramsey Buchanan et al., 2016). A meta-analysis highlighted that clinic-based interventions focusing on children aged 6 to 12 years and their parents attending regular meetings with a dietitian and children participating in regular physical activity sessions can significantly decrease the screen time of both parents and their children (Schmidt et al, 2012). Hence, clinic-based interventions could be implemented to educate parents about the effects of excessive screen time on children's health, providing useful advice, tools, and techniques for parents to effectively limit their children’s screen time.

CONCLUSION

The overarching aim of this study was to determine the association between parents and their children's adherence to the Canadian 24-hour movement guidelines during the COVID-19 pandemic. Children whose parent respondent adhered to the adult guidelines were about 50% more likely to meet the child guidelines. Parents' PBC to support their child's movement behaviours was positively associated with their child's adherence to the movement guidelines, independently from parents' behaviours. The results highlight the significance of parents as role models and supporters of their child's movement behaviours and have implications for interventions to support healthy movement patterns. These findings can help inform future research, interventions, policies, and educational strategies that will empower Canadian children to adhere to the 24-hour movement guidelines.

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APPENDICES

Appendix A – Parent questionnaire

Appendix B – Pilot-test results – 1-week test-retest reliability

Appendix C – Multiple imputation model

Appendix D – Differences between parent's PBC for their child's screen time, PA and sleep

Appendix E – Percentage of children and parents meeting individual guidelines

Appendix F – Comparison of baseline characteristics between participants who dropped out and those who did not

Appendix G – Bivariate and multivariate analysis stratified by gender

Appendix H – Bivariate and multivariate analysis of complete case data

APPENDIX A

Parent Questionnaire

- This questionnaire should take about 20 minutes to complete.
- Please answer the questions as per the situation today to the best of your knowledge.
- Your answers will be made anonymous and kept confidential.

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1. Has anyone in your household been diagnosed with COVID-19 within the last two weeks?
   - □ No
   - □ Yes
   - □ No, but we are awaiting test results

2. Was your household under a self-isolation or quarantine order in the last week (i.e., not allowed to leave the house, due to travel or other potential exposure to COVID-19)?
   - □ No
   - □ Yes
   - □ We are self-isolating without being ordered

3. In which province or territory do you live?
   - □ British Columbia
   - □ Alberta
   - □ Saskatchewan
   - □ Manitoba
   - □ Ontario
   - □ Quebec
   - □ New Brunswick
   - □ Nova Scotia
   - □ Prince Edward Island
   - □ Newfoundland
   - □ Northwest Territories
   - □ Yukon
   - □ Nunavut

The following questions ask about your child's movement behaviours in the last week. If you have more than one child who is aged 7-12, please think about the child whose name is first alphabetically.

4. What is your child's first name? _____

5. Was [insert child's name] school open in the last week?
   - □ Yes
   - □ No – go to question 6

6. How did [insert child's name] attend school last week?
   - □ In person
   - □ Online
   - □ Blended (a mixture of in person at school and online)

7. Were school buses for [insert child's name] school running in the last week?
   - □ Yes
   - □ No
   - □ Not applicable

8. Was [insert child's name] affected by any of the following conditions in the last week? Please select all responses that apply.
   - □ Flu or cold
   - □ Asthma
   - □ Injury
   - □ Other. Please specify:

   _____

9. How would you describe your current level of concern regarding COVID-19?
   - □ Not concerned
   - □ Somewhat concerned
   - □ Very concerned

10. How old is [insert child's name] ? _____ years

11. What gender does [insert child's name] identify as?
   - □ Boy
   - □ Girl
   - □ They identify as [SPECIFY]
   - □ I'd rather not say

12. Does [insert child's name] have a diagnosed disability or chronic condition?
   - □ Yes [specify]
   - □ No

13. In which country was [insert child's name] born?
   _____

14. How many years has [insert child's name] lived in Canada?

□ They were born in Canada
□ 2 years or less
□ 3 to 5 years
□ 6 years or more

15. What is the 6-digit postal code of [insert child's name] primary residence?

_____

□ Prefer not to respond

16. What type of home is [insert child's name] primary residence?

□ Low rise Apartment/Condo
□ High rise Apartment/Condo
□ Townhouse
□ Semi-detached house
□ Detached house
□ Something else [SPECIFY]

17. Please specify the number of adults and children in your household.

_____ adults (18 years or older)
_____ children (less than 18 years)

18. Does your family have a dog or dogs?

□ Yes
□ No

19. On average, how many total hours and minutes per day did your child watch TV, use the computer, social media and play inactive video games during their free time over the last week?

Weekdays (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know
Weekend (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

The next questions relate to physical activity…

Moderate-to-vigorous physical activity is any activity that increases your heart rate and makes you get out of breath some of the time. Examples include sports, swimming, soccer, hockey, running, or cycling. Light physical activity is physical activity that does not result in sweat production or shortness of breath. Examples include mild stretching, playing with animals, and leisurely walking.

20. In the last week, how many hours and minutes did your child usually spend in moderate-to-vigorous physical activity in a 24-hour period?

Weekdays (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know
Weekend (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

21. In the last week, how many hours and minutes did your child usually spend in light physical activity in a 24-hour period?

Weekdays (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know
Weekend (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

22. In the last week, how many hours and minutes did your child usually spend sleeping in a 24-hour period (including naps but excluding time spent resting while awake)?

Weekdays (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know
Weekend (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

23. On a typical **weekday** during the past week, how much time did your child spend playing outdoors (choose only one answer):
    - □ None at all
    - □ Less than 1 hour
    - □ 1 to less than 2 hours
    - □ 2 to less than 3 hours
    - □ 3 to less than 4 hours
    - □ 4 to less than 5 hours
    - □ 5 hours or more

24. On a typical **weekend day** during the past week, how much time did your child spend playing outdoors (choose only one answer):
    - □ None at all
    - □ Less than 1 hour
    - □ 1 to less than 2 hours
    - □ 2 to less than 3 hours
    - □ 3 to less than 4 hours
    - □ 4 to less than 5 hours
    - □ 5 hours or more

25. On a typical day, the MAIN part of your child's journey TO school is made by…
    - □ Walking
    - □ Bicycle
    - □ Bus, train, streetcar, subway, or boat/ferry
    - □ Car, motorcycle, or moped

□ Other. Please specify: _____
□ Not applicable; my child attends school at home

26. On a typical day, the MAIN part of your child's journey FROM school to home is made by…
    □ Walking
    □ Bicycle
    □ Bus, train, streetcar, subway, or boat/ferry
    □ Car, motorcycle, or moped
    □ Other. Please specify: _____
    □ Not applicable; my child attends at home

27. Is your child allowed to walk or bike home from school on their own when schools are open?
    □ Yes
    □ No

28. When going to places other than school that are *within walking distance*, is your child taken there or allowed to go on their own?
    □ Usually goes on their own
    □ Usually taken
    □ Varies

29. Is your child allowed to cross main roads on their own?
    ***Please note**: This question is included for all parents. Please answer even if the answer seems obvious.*
    □ YES
    □ NO

30. Is your child usually allowed to go out *on their own* after dark?
    □ YES
    □ NO

31. a) Does your child have a bicycle?
    □ YES
    □ NO – go to question 35

    b) Is your child allowed to cycle on main roads on their own?
    □ YES
    □ NO

32. Is your child usually allowed to travel on local buses on their own (other than a school bus)?
    □ YES
    □ NO

□ Not Applicable – There are no local buses in our neighbourhood

33. How far from home is your child allowed to roam on their own? *(Only tick <u>one box</u>)*
    - □ They are not allowed out on their own
    - □ Less than a 5 minute walk away from home
    - □ Within a 5-15 minute walk from home
    - □ More than a 15 minute walk from home

34. How far from home is your child allowed to roam on their own with friends and/or siblings (unaccompanied by an adult)? *(Only tick <u>one box</u>)*
    - □ They are not allowed out on their own
    - □ Less than a 5 minute walk away from home
    - □ Within a 5-15 minute walk from home
    - □ More than a 15 minute walk from home

35. Does your child have a mobile phone?
    - □ YES
    - □ NO

36. Please indicate how much you agree or disagree with each of the following statements.

Statement	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
a. I am capable of supporting my child's physical activity over the next week					
b. I will have an opportunity to support my child's physical activity over the next week					
c. I am capable of restricting my child's screen time to no more than 2 hours per day over the next week					
d. I will have an opportunity to restrict my child's screen time to no more than 2 hours per day over the next week					
e. I am capable of supporting my child's sleep over the next week					
f. I will have an opportunity to support my child's sleep over the next week					

37. Do you agree or disagree with the following statements about your neighbourhood?

Statement	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
a. People around my neighbourhood are willing to help their neighbours.					
b. This is a close-knit neighbourhood.					
c. People in my neighbourhood can be trusted.					
d. People in my neighbourhood generally don't get along with each other.					
e. People in my neighbourhood do not share the same values, attitudes or beliefs.					

38. Please select the answer that best applies to your neighbourhood.

Statement	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree
a. There is so much traffic along nearby streets that it makes it difficult or unpleasant for my child to walk (alone or with someone) in our neighbourhood.				
b. The speed of traffic on most nearby streets is usually slow (50 km/h or less).				
c. Most drivers go faster than the posted speed limits in our neighbourhood.				
d. There is a high crime rate in our neighbourhood.				
e. The crime rate in our neighbourhood makes it unsafe for my child to go on walks (alone or with someone) at night.				

f. I am worried about letting my child play outside alone around my home (e.g., yard, driveway, apartment common area) because I am afraid of them being taken or hurt by a stranger.				
g. I am worried about letting my child be outside with a friend around my home because I am afraid my child will be taken or hurt by a stranger.				
h. I am worried about letting my child play or walk alone or with friends in my neighbourhood and local streets because I am afraid my child will be taken or hurt by a stranger.				
i. I am worried about letting my child be alone or with friends in a local or nearby park because I am afraid my child will be taken or hurt by a stranger.				

39. Would you allow your child to do the following activities?

Questions	Yes	No
a. Would you let your child jump down from a height of 3-4 metres?		
b. Would you allow your child to play chase (or tag) with other children?		
c. Would you trust your child to play by themselves without constant supervision?		
d. Would you let your child go head first down a slippery slide?		
e. Would you allow your child to continue playing if they get a few scrapes during play?		
f. Would you let your child have lots of challenges when they play at home?		
g. Would you let your child use a hammer and nail unsupervised?		
h. Would you let your child climb up a tree within your reach?		
i. Would you let your child walk barefoot across a floor after broken glass had been swept up?		
j. Would you let your child walk on slippery rocks close to water?		
k. Would you allow your child to play-fight other children with sticks?		
l. Would you encourage your child to try new things that involve some risk?		
m. Would you allow your child to engage in “rough and tumble” play?		
n. Would you let your child play near the edge of steep cliffs?		

o. Would you allow your child to play in the bush or forest out of your sight?		
p. Would you let your child experience minor mishaps if what they are doing is lots of fun?		
q. Would you let your child run close to an open fire?		
r. Would you let your child swim in the ocean close to the shore while you were watching from the beach?		
s. Would you allow your child to continue playing if there is the potential they may break a bone?		
t. Would you let your child play in a backyard unsupervised?		
u. Would you allow your child to climb a rock wall that goes straight down to the water?		
v. Would you wait to see if your child could manage challenges on their own before getting involved?		
w. Would you let your child climb as high as they want to in trees?		
x. Would you allow your child to ride a bicycle down a steep hill at full speed?		
y. Would you trust your child to play safely?		
z. Would you allow your child to use a sharp knife?		
aa. Would you let your child play in a backyard supervised?		
ab. Would you let your child balance on a fallen tree more than 2 metres above the ground?		
ac. Would you encourage your child to take some risks if it means having fun during play?		
ad. Would you allow your child to climb up a tree beyond your reach?		

CHANGE IN MOVEMENT AND PLAY BEHAVIOURS

The World Health Organization (WHO) declared COVID-19 as a pandemic on March 11, 2020. For the following questions, we would like you to consider how your child's behaviours changed as a result of COVID-19 and related restrictions.

40. Compared to before the COVID-19 outbreak and related restrictions, my child walks, bikes or uses other active means of transportation (e.g., scooter, skateboard or rollerblades) to go from place to place…
    - □ A lot less
    - □ A little less
    - □ About the same
    - □ A little more
    - □ A lot more

41. Compared to before the COVID-19 outbreak and related restrictions, my child's independent mobility (e.g., their amount of freedom to move around in our neighbourhood without adult supervision) is…
    - □ A lot less
    - □ A little less
    - □ About the same
    - □ A little more
    - □ A lot more

42. Using the scale below, please select the number that best describes **how much distress** your child has been experiencing over the past week, including today.

    0 (No Distress) → 10 (Extreme Distress)

The following questions are about you:

43. How old are you? _____ years

44. What gender are you?
    - Man □
    - Woman □
    - Other, specify: □ _____
    - Prefer not to answer □

45. What is your current employment status?
    - Working full time □

Working part time □

Self-employed / freelance work □

Student □

Homemaker □

Unemployed □
Retired □
I can't work because of COVID-19 □
Prefer not to answer □

46. What is the last year of education that you have completed?
□ Elementary (7 years or less)
□ High school, general or vocational (8 to 12 years)
□ College (pre-university, technical training, certificate, accreditation or advanced diploma (13-15 years))
□ University certificates and diplomas
□ University Bachelor (including classical studies)
□ University Master's degree
□ University Doctorate (PhD)
□ Prefer not to answer

47. What is the last year of education that your partner has completed (if applicable)?
□ Elementary (7 years or less)
□ High school, general or vocational (8 to 12 years)
□ College (pre-university, technical training, certificate, accreditation or advanced diploma (13-15 years))
□ University certificates and diplomas
□ University Bachelor (including classical studies)
□ University Master's degree
□ University Doctorate (PhD)
□ Prefer not to answer

48. Among the following categories, which one best reflects the total **income**, before taxes, of all the members of your household in the last year?
□ $19,999 or less
□ Between $20,000 and $39,999
□ Between $40,000 and $59,999
□ Between $60,000 and $79,999
□ Between $80,000 and $99,999
□ $100,000 or more
□ Prefer not to answer

49. Does your household own or lease an automobile?

□ No □ Yes, 1 automobile □ Yes, 2 or more automobiles

50. In the last week, how many hours and minutes did you usually spend sleeping in a 24-hour period (including naps but excluding time spent resting)?

Weekdays (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

Weekend (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

51. In the last week, how many hours and minutes did you usually spend sedentary (e.g., sitting or reclining) in a 24-hour period?

Weekdays (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

Weekend (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

52. In the last week, how many hours and minutes did you usually spend in front of screens during your leisure time in a 24-hour period (e.g., watching TV and videos, playing video games, browsing the web, texting, etc.)?

Weekdays (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

Weekend (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

53. In the last week, how many hours and minutes did you spend engaging in moderate-to-vigorous physical activity in a 24-hour period?

Weekdays (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

Weekend (per day) _____ Hours (Cap at 23) AND _____ Minutes (Cap at 59) – Don't know

54. On a typical day, the MAIN part of your journey TO work is made by…

□ Walking
□ Bicycle
□ Bus, train, streetcar, subway, or boat/ferry
□ Car, motorcycle, or moped
□ Other. Please specify: _____
□ Not applicable; I work from home or do not work

55. On a typical day, the MAIN part of your journey FROM work to home is made by…

□ Walking
□ Bicycle
□ Bus, train, streetcar, subway, or boat/ferry
□ Car, motorcycle, or moped
□ Other. Please specify: _____
□ Not applicable; I work from home or do not work

Thank you very much for your help ☺

APPENDIX B
Pilot-test results – 1-week test-retest reliability

Table 1: Children's adherence to movement behaviour guidelines

Variables	Kappa	% Agreement
Screen time	0.59	81.4
MVPA	0.56	79.2
Sleep	0.70	84.9
Number of guidelines met	0.45 (weighted kappa = 0.76)	60.4
Meeting all guidelines	0.56	92.5

Table 2: Parents' adherence to movement behaviour guidelines

Variables	Kappa	% Agreement
Sedentary behaviour (both total sedentary behaviour and screen time)	0.55	77.4
MVPA	0.46	86.8
Sleep	0.78	90.6
Number of guidelines met	0.49 (weighted kappa = 0.55)	67.9
Meeting all guidelines	0.37	94.3

APPENDIX C

Multiple imputation model

Table 3: Multiple imputation model for children and parents' movement behaviours.

Variable name	Variable label	Role	Used data for all waves
Wave1_Q2	Household under COVID isolation in the last week	Predictor	Yes
Wave1_Q3	Geographical region	Predictor	No
Wave1_Q9	Concern COVID	Predictor	Yes
Wave1_Q10	Child age	Predictor	No
Wave1_Q11	Child gender	Predictor	No
Wave1_Q12	Child has a disability	Predictor	No
Wave1_Q14	Time since the child has lived in Canada	Predictor	No
Wave1_Q16	Type of home	Predictor	No
Wave1_Q18	Household has dogs	Predictor	No
Wave1_Q39	Child has a mobile phone	Predictor	No
Wave1_Q46	Child level of distress	Predictor	Yes
Wave1_Q47	Age of parent respondent	Predictor	No
Wave1_Q48	Gender of parent respondent	Predictor	No
Wave1_Q49	Parent employment	Predictor	No
Wave1_Q52	Household income	Predictor	No
Wave1_Q53	Vehicle ownership	Predictor	No

ChildScreenWeekdays	Child screen time on weekdays (min/day)	Predictor/Target	Yes
ChildScreenWeekends	Child screen time on weekdays (min/day)	Predictor/Target	Yes
ChildMVPAweekdays	Child MVPA on weekdays (min/day)	Predictor/Target	Yes
ChildMVPAweekends	Child MVPA on weekdays (min/day)	Predictor/Target	Yes
ChildLPAweekdays	Child LPA on weekdays (min/day)	Predictor/Target	Yes
ChildLPAweekends	Child LPA on weekdays (min/day)	Predictor/Target	Yes
ChildSleepWeekdays	Child sleep on weekdays (min/day)	Predictor/Target	Yes
ChildSleepWeekend	Child sleep on weekdays (min/day)	Predictor/Target	Yes
ParentScreenWeekdays	Parent screen time on weekdays (min/day)	Predictor/Target	Yes
ParentScreenWeekend	Parent screen time on weekdays (min/day)	Predictor/Target	Yes
ParentMVPAweekdays	Parent MVPA on weekdays (min/week)	Predictor/Target	Yes
ParentMVPAweekend	Parent MVPA on weekdays (min/week)	Predictor/Target	Yes
ParentSEDweekdays	Parent sedentary time on weekdays (min/day)	Predictor/Target	Yes
ParentSEDweekend	Parent sedentary time on	Predictor/Target	Yes

	weekdays (min/day)		
ParentSleepWeekdays	Parent sleep on weekdays (min/day)	Predictor/Target	Yes
ParentSleepWeekend	Parent sleep on weekdays (min/day)	Predictor/Target	Yes
TempMax	Average max temperature in the week before the survey	Predictor	Yes
Precipitation	Average max temperature in the week before the survey	Predictor	Yes
ALEClass	Canadian Active Living Environment (Can-ALE) class	Predictor	Yes
ModeToSchool	Travel mode to school	Predictor	Yes
OutdoorTime	Outdoor time	Predictor	Yes
ModeToWork_P	Travel mode to work (parent)	Predictor	Yes

Note: Only baseline data were used for sociodemographic variables in order to simplify the multiple imputation model and achieve convergence. For the movement behaviour variables, the weekday and weekend values were imputed separately.

APPENDIX D

Differences between parent's PBC for their child's screen time, PA and sleep

Table 4: Mean differences between parent's PBC for their child's screen time, PA and sleep.

Paired Variables	Mean Difference	95% Confidence Interval		P-value	Cohen's d
		Lower	Upper		
PBC screen time - PBC PA	-0.3	-0.28	-0.32	**<0.001**	0.30
PBC screen time - PBC Sleep	-0.3	-0.33	-0.37	**<0.001**	0.31
PBC Sleep - PBC PA	0.1	0.05	0.02	**<0.001**	0.06

Note: PBC: perceived behavioural control; Cohen's d interpretation: $d < 0.20$ = trivial; d (0.2 - 0.49) = small; d between (0.5 - 0.79) = medium; and $d \geq 0.8$ = large.

APPENDIX E

Percentage of children and parents meeting individual guidelines

Table 5: Percentage of children and parents meeting individual guidelines at each wave

	If the children met individual guidelines				If the parents met individual guidelines			
Variables	**Wave 1**	**Wave 2**	**Wave 3**	**Wave 4**	**Wave 1**	**Wave 2**	**Wave 3**	**Wave 4**
MVPA	69.6	76.7	77.5	80.1	17.8	82.9	78.1	80
Sleep	55.0	53.2	50.3	51.2	60.1	63.8	51.4	52.6
Sedentary Behaviour	22.6	24.5	29.2	28.4	44.0	50.0	29.9	29.1

APPENDIX F

Comparison of baseline characteristics between participants who dropped out and those who did not

Table 6: Comparison of baseline characteristics between participants who dropped out and those who completed Wave 4, based on continuous variables.

Variable	Dropouts	Completers	p-value	Effect size
	Mean (SD)	Mean (SD)		
Child age	9.9 (1.7)	9.8 (1.7)	0.373	0.041
Parent age	40.6 (7.5)	42.4 (7.0)	**<0.001**	**0.243**
PBC-PA	4.0 (1.0)	4.1 (0.9)	**0.005**	0.128
PBC-sleep	4.0 (1.1)	4.1 (1.0)	**0.008**	0.121
PBC-screen time	3.7 (1.1)	3.9 (1.1)	**<0.001**	0.156
PBC-combined	3.9 (0.9)	4.0 (0.9)	**<0.001**	0.161

Note: Independent samples t-tests for continuous variables with Cohen's d as a measure of effect size. Cohen's D interpretation: $d < 0.20$ = trivial; d (0.2 - 0.49) = small; d between (0.5 - 0.79) = medium; and $d \geq 0.8$ = large; Cramer's V interpretation: $V < 0.10$ = trivial; V (0.1 - 0.29) = small; V (0.3 - 0.49) = medium; and $V \geq 0.5$ = large.

Table 7: Comparison of baseline characteristics between participants who dropped out and those who completed Wave 4, based on categorical variables.

Variable	Dropouts	Completers	p-value	Effect size
	Frequency (%)	Frequency (%)		
Child gender			0.482	0.015
Boy	797 (51.1)	368 (52.7)		
Girl	762 (48.9)	330 (47.3)		
Parent gender			**0.008**	0.056
Man	526 (33.7)	276 (39.5)		
Woman	1033 (66.3)	422 (60.5)		
Household income ($)			0.230	0.044
≤39,999	184 (11.8)	72 (10.3)		
40,000-99,999	718 (46.1)	300 (43.0)		
≥100,000	522 (33.5)	257 (36.8)		
Prefers not to respond	135 (8.7)	69 (9.9)		
Immigration status			0.603	0.011
Born in Canada	1285 (82.4)	569 (81.5)		
Born outside Canada	274 (17.6)	129 (18.5)		
Child adherence to 24-hour guidelines				
Screen time			0.085	0.039
Yes	283 (21.4)	153 (25.0)		
No	1037 (78.6)	460 (75.0)		
MVPA			0.746	0.008
Yes	843 (69.8)	382 (69.1)		

No	364 (30.2)	171 (30.9)		
Sleep			0.069	0.041
Yes	714 (53.6)	258 (42.0)		
No	619 (46.4)	356 (58.0)		
Integrated guidelines			0.061	0.046
Yes	101 (9.0)	62 (11.9)		
No	1024 (91.0)	457 (88.1)		
Parent adherence to 24-hour guidelines				
Sedentary behaviour			**0.006**	0.066
Yes	496 (41.8)	266 (48.8)		
No	691 (58.2)	279 (51.2)		
MVPA			0.254	0.027
Yes	226 (18.5)	91 (16.3)		
No	993 (81.5)	467 (83.7)		
Sleep			0.219	0.028
Yes	801 (59.2)	391 (62.7)		
No	553 (40.8)	239 (37.9)		
Integrated guidelines			0.420	0.02
Yes	53 (4.7)	29 (5.7)		
No	1071 (95.3)	484 (94.3)		

Note: Chi-square tests for categorical variables with Cramer's V as estimate of effect size. Cramer's V interpretation: V < 0.10 = trivial; V (0.1 - 0.29) = small; V (0.3 - 0.49) = medium; and V ≥ 0.5 = large.

APPENDIX G

Bivariate and multivariate analysis stratified by gender

Table 8: Bivariate analysis stratified by child gender.

Variable	Boys			Girls		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
Parents met all the guidelines (ref- Parents did not meet all the guidelines)	1.76	1.27, 2.47	**<0.001**	1.43	0.96, 2.11	0.077
Child age	0.78	0.72, 0.86	**<0.001**	0.78	0.71, 0.86	**<0.001**
Parent age	0.97	0.95, 0.99	0.008	0.97	0.95, 0.99	**0.012**
Parent's PBC	1.81	1.36, 2.41	**<0.001**	1.97	1.47, 2.64	**<0.001**
Parent gender - Woman (ref- Man)	1.37	0.92, 2.02	0.121	1.35	0.93, 1.96	**0.001**
Household income						
$40,000 to $99,999 (ref- $39,999 or less)	1.19	0.62, 2.29	0.611	0.81	0.46, 1.42	0.454
$100,000 or more (ref- $39,999 or less)	2.01	1.04, 3.88	**0.039**	0.79	0.44, 1.40	0.412
Prefer not to answer (ref- $39,999 or less)	1.75	0.80, 3.82	0.160	0.42	0.46, 1.42	0.076
Immigration status - Children born outside Canada (ref- Children born in Canada)	0.81	0.54, 1.22	0.309	0.71	0.47, 1.07	0.102
Study Wave						
Wave 2 (ref- Wave 1)	1.48	1.11 1.98	**0.008**	1.02	0.74, 1.40	0.905
Wave 3 (ref- Wave 1)	1.50	1.09 2.07	**0.014**	1.74	1.27, 2.39	**<0.001**
Wave 4 (ref- Wave 1)	1.30	0.90, 1.88	0.162	1.57	1.11, 2.22	**0.011**

Note: CI: confidence intervals; OR: odds ratios; PBC: perceived behavioural control.

Table 9: Multivariate analysis stratified by child gender.

Variable	Boys			Girls		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
Parents met all the guidelines (ref- Parents did not meet all the guidelines)	1.69	1.16, 2.46	0.006	1.57	1.06, 2.32	**0.024**
Child age	0.80	0.72, 0.89	**<0.001**	0.77	0.69, 0.87	**<0.001**
Parent age	0.97	0.96, 0.99	**0.038**	0.98	0.95, 1.00	0.098
Parent's PBC	1.86	1.39, 2.49	**<0.001**	1.91	1.42, 2.57	**<0.001**
Parent gender - Woman (ref- Man)	1.11	0.74, 1.67	0.605	1.14	0.76, 1.72	0.520
Household income						
$40,000 to $99,999 (ref- $39,999 or less)	0.87	0.40, 1.86	0.716	1.10	0.57, 2.12	0.780
$100,000 or more (ref- $39,999 or less)	1.29	0.60, 2.76	0.512	0.973	0.50, 1.90	0.936
Prefer not to answer (ref- $39,999 or less)	1.32	0.54, 3.20	0.544	0.61	0.23, 1.64	0.326
Immigration status - Children born outside Canada (ref- Children born in Canada)	0.67	0.42, 1.08	0.102	0.81	0.52, 1.28	0.368
Study Wave						
Wave 2 (ref- Wave 1)	1.45	0.99, 2.10	0.052	0.93	0.60, 1.35	0.686
Wave 3 (ref- Wave 1)	1.76	1.21, 2.56	**0.003**	1.99	1.33, 2.97	**<0.001**
Wave 4 (ref- Wave 1)	1.36	0.87, 2.12	0.178	2.01	1.33, 3.04	**<0.001**

Note: CI: confidence intervals; OR: odds ratios; PBC: perceived behavioural control.

APPENDIX H

Bivariate and multivariate analysis of the complete case data

Table 10: Bivariate and multivariate analysis of the complete case data.

Variable	Bivariate			Multivariate		
	OR	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
Parents met all the guidelines (ref- Parents did not meet all the guidelines)	1.59	1.23, 2.05	**<0.001**	1.64	1.25, 2.14	**<0.001**
Child age	0.80	0.75, 0.85	**<0.001**	0.78	0.72, 0.84	**<0.001**
Parent age	0.97	0.95, 0.99	**<0.001**	0.96	0.96, 0.99	**0.010**
Parent's PBC	1.89	1.53, 2.35	**<0.001**	1.87	1.52, 2.30	**<0.001**
Child gender - Girls (ref- Boys)	1.15	0.88, 1.48	0.308	1.22	0.94, 1.59	0.130
Parent gender - Woman (ref- Man)	1.36	1.03, 1.81	**0.032**	1.14	0.85, 1.53	0.387
Household income						
$40,000 to $99,999 (ref- $39,999 or less)	0.99	0.62, 1.58	0.971	1.00	0.61, 1.65	0.996
$100,000 or more (ref- $39,999 or less)	1.19	0.75, 1.87	0.472	1.11	0.67, 1.83	0.682
Prefer not to answer (ref- $39,999 or less)	1.00	0.55, 1.81	1.000	0.94	0.50, 1.78	0.845
Immigration status- Children born outside Canada (ref- Children born in= Canada)	0.77	0.57, 1.03	0.076	0.74	0.54, 1.03	0.075
Study Wave						
Wave 2 (ref- Wave 1)	1.18	0.94, 1.48	0.160	1.18	0.91, 1.53	0.220
Wave 3 (ref- Wave 1)	1.62	1.29, 2.05	**<0.001**	1.88	1.44, 2.47	**<0.001**

Wave 4 (ref-Wave 1)	1.49	1.15, 1.92	**0.002**	1.69	1.25, 2.28	**<0.001**

Note: CI: confidence intervals; OR: odds ratios; PBC: perceived behavioural control.