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Original Research

Outdoor Time is Not Associated with Metabolically Healthy Overweight and Obesity Phenotype in Canadian Children Aged 6-14 Years

BRITTANY V. RIOUX[†1,2], NEERU GUPTA[‡3], DANIELLE R. BOUCHARD[‡1,2], JAMES DUNBAR[†3], and MARTIN SÉNÉCHAL[‡1, 2]

[1]Cardiometabolic Exercise & Lifestyle Laboratory, Fredericton, NB, CAN; [2]Faculty of Kinesiology, University of New Brunswick, Fredericton, NB, CAN; [3]Department of Sociology, University of New Brunswick, Fredericton, NB, CAN

[†]Denotes graduate student author, [‡]Denotes professional author

ABSTRACT

International Journal of Exercise Science 13(2): 383-394, 2020. A large proportion of children living with obesity have favorable cardiometabolic profiles despite their adiposity levels, who are referred to as metabolically healthy overweight or obese (MHO). However, the contribution of active outdoor time to the MHO phenotype is unknown. The purpose of this study was to investigate the association between outdoor time and moderate-to-vigorous physical activity (MVPA) with the MHO phenotype. A cross-sectional analysis of overweight/obese children aged 6-14 (n = 386) from the Canadian Health Measures Survey was performed. Outdoor time was self-reported using five questions in relation to the school schedule to produce a computed score ranging from 0-25. MVPA was measured using accelerometers. The MHO phenotype was defined based on the absence of cardiometabolic risk factors: triglycerides, HDL-cholesterol, systolic and diastolic blood pressure, and glucose (MHO: 0 cardiometabolic risk factors). The proportion of children living with obesity with the MHO phenotype was 58.5%. No significant differences were observed between MHO and *non*-MHO according to outdoor time or MVPA ($p > 0.05$). Logistic regressions indicated that outdoor time was not significantly associated with the MHO phenotype (OR: 0.99, 95% CI = 0.92-1.06; $p = 0.694$), while MVPA was significantly associated with the MHO phenotype (OR: 1.41, 95% CI = 1.01-1.98; $p = 0.047$) after adjusting for confounders. We conclude that outdoor time is not associated with the MHO phenotype, even though Canadian children living with obesity are more likely to be MHO with greater amounts of MVPA, regardless of whether these activities are completed outdoors or not.

KEY WORDS: Physical activity, cardiorespiratory fitness, metabolic syndrome, exercise

INTRODUCTION

Childhood obesity is associated with an increased risk of adverse cardiometabolic health and a number of chronic conditions, including Type 2 diabetes, metabolic syndrome, cardiovascular diseases, and hepatic steatosis (10, 11, 17, 27). However, a subgroup of individuals living with overweight or obesity possess a healthy cardiometabolic risk factor profile and are termed metabolically healthy overweight or obese (MHO). Currently, there is no universal consensus as to which MHO definition should be used in clinical settings, nor as to which thresholds are clinically relevant to define individuals living with MHO. As a result, the prevalence of MHO in children is estimated to range between 6-68% (1, 2, 6, 24).

Interestingly, some data suggest that lifestyle behaviors, including physical activity (PA) and diet, may differ between MHO and *non*-MHO individuals. In fact, using the homeostatic model assessment of insulin resistance, Prince et al. found that reduced fat intake was associated with a 44% increase in the likelihood of being MHO in children (24). Although they observed, when using a comprehensive definition of MHO with cardiometabolic risk factors, that moderate-to-vigorous PA (MVPA) was the strongest predictor of MHO in children (24) among the PA variables measured. Similarly, a recent study suggests that individuals living with MHO take a greater number of steps per minute (118.2 versus 105.2 min; $p < 0.01$) and have less sedentary time (563.5 versus 593.0 min, $p = 0.02$) compared to *non*-MHO (8). Altogether, these results suggest that PA, and especially MVPA, is associated with a better cardiometabolic risk factor profile in children.

Although PA and modifiable risk factors are characteristics that have been found to lead to reduced cardiometabolic risk at a young age (9, 29), other data suggest the importance of the setting in which the PA is performed for improved health. A recently published *Position Statement on Active Outdoor Play* advocated that children who spent more time outdoors were more likely to be active, active at the right intensities, manage stressful situations, and have better social behavior in the presence of other children (20, 35). Moreover, a study reported that each additional hour spent outdoors per day was associated with seven more minutes of MVPA, 762 more steps, and 13 fewer minutes of sedentary time (13). Another study reported 10 minutes of increased MVPA for each hour spent outdoors in children between 5 and 6 years of age (14). In addition, children were about 2.5 times more likely to meet the Canadian Physical Activity Guidelines (CPAG) for each hour spent outdoors (13). This result is of great concern, as only 9.0% of children reach the CPAG of 60 minutes of daily MVPA (20) and only 42.5% of children and 7.5% of adolescents meet similar guidelines in the United States (18).

No population-based study has yet investigated the association between outdoor time and the MHO phenotype. Therefore, to address this gap in the literature, this study was conducted to investigate the association between both the time spent outdoors with the MHO phenotype and the time spent in MVPA with the MHO phenotype in Canadian children using data from the Canadian Health Measures Survey (CHMS). It was hypothesized that 1) children who spent more time outdoors would be more likely to be MHO since they spend more time physically active compared to children who spent less time outdoors, and 2) children who spent time in MVPA had an increased likelihood of being MHO.

METHODS

Participants

A cross-sectional analysis of outdoor time and MHO was performed in children who participated in either Cycle 3 (January 2012-December 2013) or Cycle 4 (January 2014-December 2015) of the CHMS. Analyses were restricted to cycles 3 and 4 since they were the first survey rounds with outdoor time measurement available at the time of the analyses. The CHMS captures data from a random sample of Canadians aged 3 to 79 years living in private households. Residents of First Nations Reserves or Crown lands, the territories, certain remote regions, and full-time members of the Canadian Forces were excluded from the survey, which represents ~4% of the population. A multi-stage, cluster sampling strategy was used to identify sites across Canada where the data would be collected in each CHMS cycle. Ethical approval to conduct the repeated national survey was obtained from Health Canada's Research Ethics Board. The CHMS consists of a personal home interview including questions on a number of health-related topics, as well as a physical examination at a mobile examination center including such measurements as body composition, blood pressure, bone density, and vision. Children who were 14 years or older provided written informed consent, while younger children provided written assent in addition to written consent from a parent/legal guardian.

The samples for Cycles 3 and 4 included 11579 individuals, from which 8672 participants were excluded from the present analysis because they were below or above the target age range, 1993 participants were excluded because they were not considered living with overweight or obesity, and 528 participants were excluded due to missing data for the primary outcome measure (Figure 1). Thus, data presented here were restricted to a sub-sample of children aged 6 to 14 years (n = 386) who presented information for the primary outcome measure, primary exposure variable, and a minimum status of overweight [1 SD above body mass index (BMI) z-Score] based on age- and sex-specific percentiles from the World Health Organization (7). This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (19).

Protocol

Primary Exposure Variable, Outdoor Time: Outdoor time in the CHMS was self-reported during interviews performed in mobile examination centers. Although the sub-set of questions has not been validated yet, some strategies were put in place to minimize recall bias and maximize the quality of the measure. For example, for children under the age of 12, a parent or a legal guardian answered on their behalf, while children above this age answered for themselves. Outdoor time was examined using five questions among children attending school. Four specifications were based on different periods of the school day: before school, at school, after school, and after dinner. Interviews for weekday outdoor time involved predetermined questions such as: "during the past month, on an average school day, how much time did you usually spend outside?" Weekend outdoor time was assessed with a fifth question: "…when you did not go to school, for example, on the weekend, how much time did you usually spend outside?" *(33, 34)*. Responses to each question were categorized into the following groups: 0 min. (0); 1 to < 15 mins. (1); 15 to < 30 mins. (2); 30 to < 1 hour (3); 1 to < 2 hours (4); and ≥ 2 hours (5). Then, a score was computed for each participant ranging from 0-25 for overall outdoor time (hours/week).

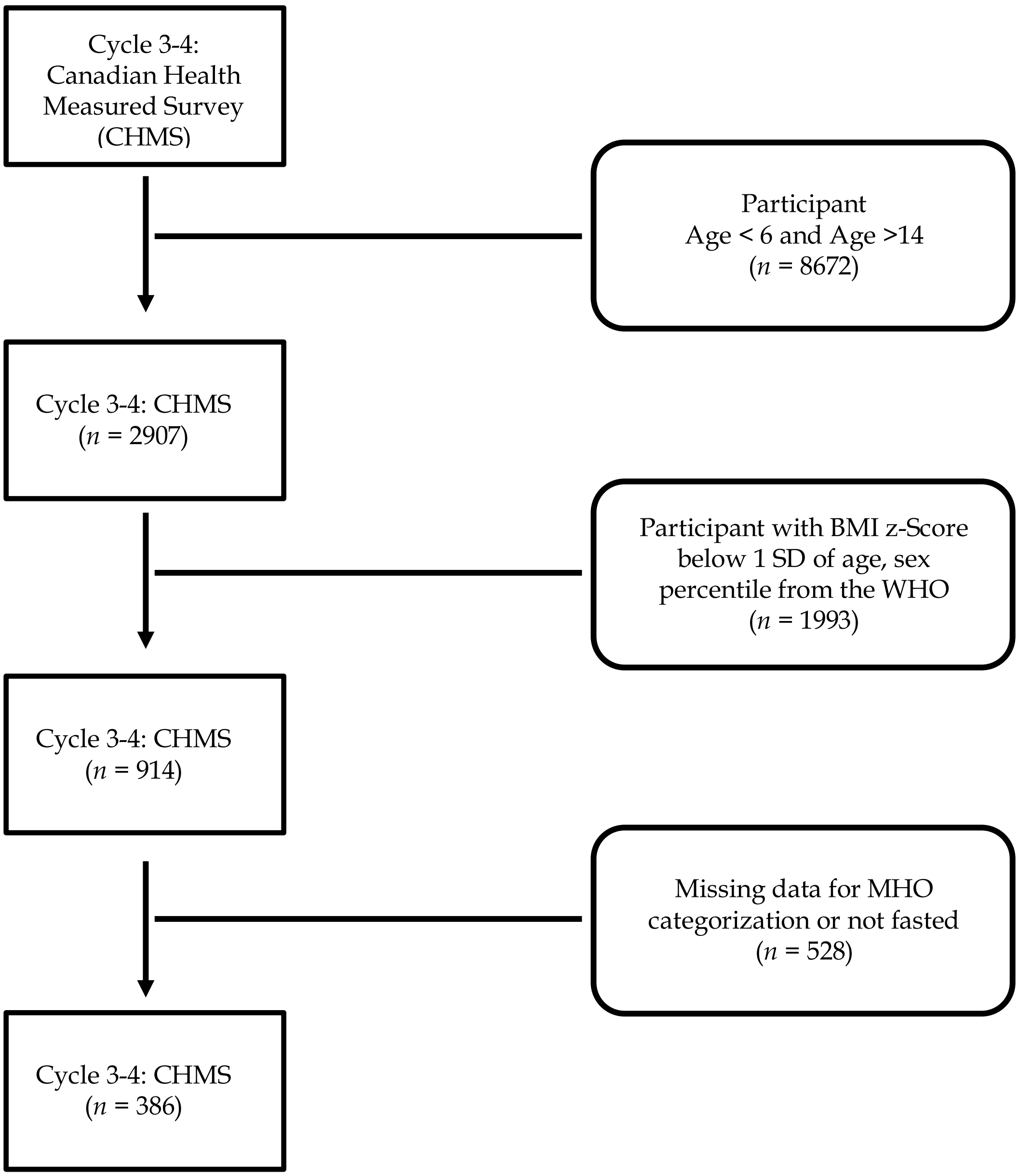

Figure 1. Flow chart.

Exposure Variable, Physical Activity: PA intensities (MVPA) were quantified in the CHMS using Actical accelerometers (Phillips-Respironics, Oregon, USA) which are recognized as a valid measurement tool for the PA of children (4). Following the visit at the mobile examination center, participants were asked to wear this device on an elasticized belt over their right hip for seven consecutive days during waking hours. Accelerometer data were considered valid if participants had ≥10 hours of wear time for at least four valid days (4). The cut-points used to determine PA intensity were based on accelerometer count ranges: less than 100 counts per minute = sedentary; 100 to < 1,535 counts per minute = light PA; and ≥ 1,535 counts per minute = MVPA (4).

Primary Outcome Measure, Metabolically Healthy Overweight and Obesity Phenotype: In this analysis, the subset of children who had data collected in a fasted state were included. MHO and *non*-MHO were categorized using the following cardiometabolic risk factors: high-density lipoprotein (HDL)-cholesterol (mmol/L), triglycerides (mmol/L), glucose (mmol/L), and systolic and diastolic blood pressure (BP) (mmHg). Risk was determined by using the established ranges according to sex from the Canadian Laboratory Initiative on Pediatric Reference Intervals Project by The Hospital for Sick Children for the blood markers (32). Children received a score of 1 for each measure in which they fell outside of the established interval for the specific measure, while a score of 0 was given to those who fell within. Systolic and diastolic blood pressure is impacted by age, sex and height. Therefore, a multiple linear regression adjusted for age, sex, and height was performed from which standardized residuals were kept (5). Individuals with a BP residuals ≥ 90th percentile was considered at risk and were given a score of 1, while participants < 90^{th} percentile were given a 0. This value was added to the final computation to determine MHO status. MHO was defined as having a total score of 0 of all the above cardiometabolic risk factors – meaning they fell within the "healthy" range for each measurement. *Non*-MHO children had ≥ 1 cardiometabolic risk factor outside of the healthy range.

Potential Confounders: A wide body of literature suggests a number of sociodemographic indicators are associated with cardiometabolic risk factors and health outcomes (3, 16, 23, 25). In this analysis, age, sex, and total household income self-reported from the home interviews were included as a parsimonious set of potential confounders. As a common measure of socioeconomic status (SES), total household income was used to categorize children into coming from higher, middle, or lower income families. To control for anthropometric indicators of obesity, body weight was measured to the nearest 0.1 kg with a Mettler Toledo VLC with Panther Plus Scale Terminal (Mettler Toledo Canada, Mississauga, Canada). Height was obtained using a ProScale M150 stadiometer (Accurate Technology Inc., Fletcher, USA). BMI was calculated with the following formula: body weight (kg) / height (m^2). Absolute BMI (kg/m^2) was converted to a BMI z-Score by using representative age-and sex-specific normative data (7). Waist circumference was measured with a Gulick measuring tape (Fitness Mart, Gay Mills, USA) following the NIH guidelines (15).

Statistical Analysis

For the descriptive analyses, continuous and categorical variables are presented as means ± standard deviations and N (%), respectively. Independent t-tests and chi-square tests were used to quantify differences between MHO and *non*-MHO. Logistic regressions were performed to: 1) investigate the association between outdoor time and the MHO phenotype, 2) determine the odds of being MHO according to both high levels of time spent outdoors and in MVPA, and 3) determine whether the relationship held after further controlling for a number of sociodemographic and anthropometric confounders. Regression results are presented as odds ratios (OR) with associated 95% confidence intervals (CIs). Analyses were performed without the application of bootstrap weights for complex survey designs (26), mainly because of the highly limited sub-sample used against the total survey sample. Furthermore, the purpose of this study was not to estimate population parameters, but to analyze the associations in this sub-sample. Data management and statistical analyses were performed using SPSS version 20. The alpha-level to determine significance was set at $p \leq 0.05$.

RESULTS

The prevalence of children who were characterized with the MHO phenotype was 58.5% (Table 1). Significant differences were observed between MHO and *non*-MHO children for waist circumference and BMI z-Score ($p < 0.001$), while no such differences were observed for SES ($p > 0.05$). Significant differences were observed between MHO and *non*-MHO for each measure of the children's cardiometabolic profile (all $p \leq 0.001$), whereas children classified as MHO had a significantly better cardiometabolic profile. No differences were observed in MVPA, sedentary time, nor in outdoor time between MHO and *non*-MHO children (all $p > 0.05$).

Table 1. Characteristics of the sample.

General Characteristics	MHO (*n* = 226)	Non-MHO (*n* = 160)	*p*-value
Age (years)	10.2 ± 2.3	10.3 ± 2.2	0.771
Sex			
Females n (%)	110 (63.2)	64 (36.8)	0.092
Males n (%)	116 (54.7)	96 (45.3)	
Family Income Group			
Higher Income Brackets n (%)	52 (63.4)	30 (36.6)	
Middle Income Brackets n (%)	126 (56.5)	97 (43.5)	0.548
Lower Income Brackets n (%)	48 (59.3)	33 (40.7)	
Anthropometric Measures			
Weight (kg)	50.7 ± 15.8	54.0 ± 17.6	0.053
Waist Circumference (cm)	75.3 ± 10.6	80.0 ± 12.8	0.000
Body Mass Index (z-Score)	0.98 ± 0.95	1.3 ± 1.0	0.003
Physical Activity			
TSO Index (0-25)	11.8 ± 4.1	11.8 ± 3.9	0.999
Total Sedentary Time (mins/day)	503.3 ± 80.1	505.8 ± 77.7	0.788
Total MVPA (mins/day)	52.2 ± 26.5	47.9 ± 24.3	0.154
Cardiometabolic Risk Factors			
Systolic Blood Pressure (mmHg)	94.9 ± 5.9	103.5 ± 11.6	0.000
Diastolic Blood Pressure (mmHg)	60.6 ± 5.3	69.0 ± 12.0	0.000
Triglycerides (mmol/L)	0.92 ± 0.36	1.2 ± 0.70	0.000
Glucose (mmol/L)	4.7 ± 0.26	5.0 ± 0.43	0.000
HDL-cholesterol (mmol/L)	1.4 ± 0.30	1.3 ± 0.25	0.001

Note. Continuous data are presented as means ± SD, while categorical variables are presented as *n* (%); HDL = High Density Lipoprotein; TSO = Time Spent Outdoors; MVPA = Moderate-to-Vigorous Physical Activity.

Table 2 presents the results from the logistic regressions to predict MHO status according to outdoor time. Unadjusted analyses demonstrated that outdoor time was not significantly associated with being MHO (OR: 1.00, 95% CI [0.95, 1.06], p = 0.99). When adjusting the analysis for age, sex, SES, and obesity, outdoor time was not associated with being MHO. When accounting for an additional confounder, time spent in MVPA, outdoor time remained unassociated with the MHO phenotype. However, in this final model, MVPA emerged as a significant predictor of MHO. Children who performed more MVPA were more likely to be characterized as MHO (OR = 1.410, 95% CI [1.005, 1.978], $p < 0.05$), such that each additional 30 minutes spent performing MVPA was associated with a 41% increased likelihood of being MHO.

Table 2. Results from the logistic regressions to predict the odds of MHO according to outdoor time (unadjusted and adjusted).

Parameter	OR	95% CI		*p*-value
Model 1				
TSO Index (0-25)	1.000	.947	1.056	.999
Intercept	1.564	.797	3.070	.193
Model 2				
TSO Index (0-25)	1.002	.947	1.059	.957
Age (years)	.972	.879	1.076	.591
Female (%)	1.445	.921	2.269	.109
Higher Income Family (ref: Middle	1.237	.697	2.196	.468
Lower Income Family (ref: Middle	1.089	.621	1.909	.767
Obesity Status*	.579	.369	.910	.018
Intercept	2.053	.490	8.604	.325
Model 3				
MVPA (per 30 minutes)	1.410	1.005	1.978	.047
TSO Index (0-25)	.987	.924	1.054	.694
Age (years)	.984	.873	1.108	.787
Female (%)	1.832	1.069	3.139	.028
Higher Income Family (ref: Middle	1.305	.691	2.466	.412
Lower Income Family (ref: Middle	1.046	.521	2.102	.899
Obesity Status*	.749	.439	1.277	.288
Intercept	1.029	.179	5.903	.975

Note. Model 1= Outdoor time only; Model 2= Outdoor time, age, sex, SES, obese (WHO classification); Model 3= Outdoor time, age, sex, SES, obese (WHO classification) and MVPA; *Obese according to WHO Classification for Children. Study sub-sample includes only overweight and obese.

DISCUSSION

Our analysis aimed to examine the association between the time spent outdoors with the MHO phenotype, and the time spent performing MVPA with the MHO phenotype, using data collected from the CHMS. According to these results, Canadian school-aged children who spent more time outdoors were not found significantly more likely to be MHO. However, consistent with the literature, time spent performing MVPA was significantly associated with the MHO phenotype. These results suggest that increasing time spent in MVPA could lead to greater odds of being considered MHO among children living with overweight or obesity.

To the best of our knowledge, this cross-sectional analysis was the first to assess the impact of outdoor time for children living with MHO. Previous studies have suggested that outdoor time extends beyond the impact of PA itself, as outdoor play influences children's physical, emotional, social, and cognitive health (20, 35). For example, Larouche et al. observed a significant relationship between outdoor time and MVPA in children, such that each additional hour of outdoor time was associated with 7 to 10 additional minutes of MVPA (13, 14). Others have also reported similar associations (21, 31). In our analysis, children who had higher levels of MVPA had a greater likelihood of being MHO compared to those who performed less amounts. These results, however, did not depend on whether the PA was performed indoors or outdoors. We found that outdoor time was not associated with the odds of being MHO, and therefore was not impacted by cardiometabolic health. The limited number of available studies on this topic have found similar results, including Shaefer et al.'s investigation (31), which found no differences in obesity status nor in BP according to whether PA was performed outdoors or not. Elsewhere, in children aged 7-14 years old, outdoor time was not found to be related to the analyzed measures of cardiometabolic health ($p > 0.05$) (13). As children who spend more time outdoors have been reported to be more sufficiently active (35), and higher PA levels typically translate to better cardiometabolic health (9), it is surprising that outdoor time was not associated with the MHO phenotype. Many reasons might help understanding this result. It is possible that MHO individuals are generally more intensively active when outdoors without spending more overall time outdoors. Another potential reason might be related to the fact that there is currently no consistent definition of MHO used across clinical settings. As such, a comprehensive definition of MHO with thresholds for each cardiometabolic measure for children at all ages would be required to observe comparable and meaningful results with respect to outdoor time. Future research should focus on establishing a universal definition of the MHO phenotype. The present observed results may have also been impacted by the method by which outdoor time was measured. The CHMS relies on self-reported measures of the amount of time spent outdoors, without details on the types of outdoor play (e.g., structured, unstructured, or stationary activities). A valid and reliable method of assessing the duration, frequency, and types of outdoor time among children is required.

In accordance with our results, numerous studies demonstrate the importance of MVPA for children's cardiometabolic health (22, 30). For instance, Ekelund et al. observed better cardiometabolic risk factor profiles in children who spent a greater amount of time in MVPA (9). They found that MVPA was significantly and inversely associated with all tested cardiometabolic outcomes, including systolic BP, fasting insulin, triglycerides, and HDL-cholesterol, after adjusting for confounders. Consequently, the data suggest that those who reach lower levels of MVPA also have an increased risk of obesity. In an analysis of >6000 children, each decrease by 25 minutes of daily MVPA was associated with an increased risk of obesity, independently of sedentary time (OR: 0.49, 95% CI [0.44, 0.55], $p < 0.05$) (12). As demonstrated in our results, increasing time spent in MVPA also has positive benefits for those living with obesity who are MHO. Similarly, Prince et al. found that each 10-minute increase of MVPA was associated with a 22% increased likelihood of being MHO as defined by cardiometabolic risk factors (24). The findings from the current study suggest that each additional 30 minutes spent in MVPA translates to a 41% increased likelihood of being MHO

(OR: 1.410, 95% CI [1.005, 1.978], $p < 0.05$). Unfortunately, only a small portion of children achieve sufficient amounts of MVPA according to recommended guidelines (18, 20, 36). However, as the results demonstrate a clinically meaningful impact on children living with obesity, this may reinforce the importance of promoting time spent in MVPA.

Despite the novelty of the current study, there are limitations that must be addressed. First, this study is cross-sectional, which does not allow determinations of causality. Second, using a sub-sample of the CHMS limits our external validity. However, this strategy was used in order to allow inclusion of the primary outcome measure and exposure variable, which were not available for the entire sample. While the analysis pooled two rounds of survey data collection, the overall sub-sample size remained small. Third, the analyses were not performed applying survey sampling weights for complex survey designs; therefore, the results cannot be generalized to the whole Canadian population. Fourth, measures of outdoor time were not objectively measured, but were self-reported, either with or without confirmation from the child's parents depending on age. This creates a dependence on recall as well as possible social desirability bias. Fifth, the reliability and validity of the questions asked are currently unknown (14). Finally, the CHMS data capture was not designed to examine seasonality, which might have impacted our results since Canadian children tend to be less active during the colder winter months (37).

Despite such limitations, this study is strengthened by the inclusion of multiple cardiometabolic risk factors, which allows for a comprehensive definition of MHO. Furthermore, each of the survey samples obtained were taken during the fasted state. Although there is an abundance of definitions currently used to define metabolic health, a recent systematic review (28) reported that the most frequently used definition involves the same criteria used in the current study. This analysis is also strengthened by considering both key socioeconomic and anthropometric potential confounding variables. Lastly, to the best of our knowledge, this is the first study to examine the association between outdoor time and cardiometabolic risk factor clustering in Canadian children living with MHO.

In conclusion, based on these results, outdoor time was not associated with the odds of being classified with MHO among Canadian school-aged children living with overweight or obesity. However, time spent performing MVPA was significantly associated with the MHO phenotype. Each additional 30 minutes spent performing MVPA was associated with a 41% increased likelihood of possessing the MHO phenotype in children. These clinically relevant findings demonstrate the importance of promoting MVPA in children who wish to transition from an unhealthy *non*-MHO status to the healthy MHO phenotype, or in children living with overweight or obesity who wish to prevent metabolic abnormalities.

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