

Multi-level analysis of school characteristics, based on the Comprehensive School Health Framework, associated with physical activity in a large sample of Ontario and Alberta secondary school students

by

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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Doctor of Philosophy
in
Health Studies and Gerontology

Waterloo, Ontario, Canada, 2021

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

This thesis contains in part three manuscripts that have been submitted to peer-reviewed journals in collaboration with my dissertation committee members.

Exceptions to sole authorship are as follows:

Chapter 4: Pirrie, M., Carson, V., Dubin, J.A., & Leatherdale, S.T. (2021). A Comprehensive School Health approach to student physical activity: a multilevel analysis examining the association between school-level factors and student physical activity behaviours. Under review by the Journal of School Health (Manuscript ID: JOSH-09-21-RA-437).

Chapter 5: Pirrie, M., Carson, V., Dubin, J.A., & Leatherdale, S.T. (2021). School-level factors within Comprehensive School Health associated with the trajectory of moderate-to-vigorous physical activity over time: A longitudinal, multilevel analysis in a large sample of Grade 9 and 10 students in Canada. Submitted to the International Journal of Environmental Research and Public Health (Manuscript ID: ijerph-1462207).

Chapter 6: Pirrie, M., Carson, V., Dubin, J.A., & Leatherdale, S.T. (2021). Do school characteristics, using the Comprehensive School Health Framework, contribute to youth meeting national physical activity recommendations over time? Submitted to Health Promotion and Chronic Disease Prevention in Canada (Manuscript ID: 211021).

As lead author of these three chapters, I was responsible for conceptualizing the research questions and study designs, determining the required variables from the COMPASS cohort platform, carrying out the data analysis, drafting the manuscripts, and submitting to the journals. My committee members provided insight into the outcome definition, study design, analytic approach, and revisions of the draft manuscripts. Dr. Scott Leatherdale and Dr. Valerie Carson were instrumental in providing access to the COMPASS cohort data platform, a unique resource that was critical to being able to conduct these studies.

Under the supervision of Dr. Scott Leatherdale, I was the sole author of Chapters 1 through 3 and Chapter 7, which were not written for publication.

Abstract

Physical activity (PA) has many physical and mental health benefits, but only 24.4% of youth achieve the recommended minutes of moderate-to-vigorous PA (MVPA). Schools are an important context for changing modifiable health behaviours in youth and the Comprehensive School Health (CSH) framework outlines four inter-related components that schools can strengthen to facilitate better student health: social and physical environment; teaching and learning; partnerships and services; and healthy school policy. There has been no research identified that simultaneously evaluates all four components of CSH and their association with youth PA in a Canadian context. The objectives of this thesis were: (1) describe the prevalence of school-level factors within the CSH framework and their association with student PA (weekly MVPA and meeting the three PA recommendations) in a large sample of Ontario and Alberta secondary schools; (2) examine how youth MVPA changes over a three-year period, stratified by gender; (3) evaluate the school characteristics associated with preventing the decline in MVPA over time, guided by the CSH framework; (4) determine the proportion of students achieving all three PA recommendations at baseline who were still achieving them two years later; (5) determine the proportion of students not achieving all three PA recommendations at baseline who were achieving them two years later; and, (6) evaluate the school characteristics associated with achieving all three recommendations two years later for these two groups of students, stratified by gender. These objectives were met using student and school data from the COMPASS research platform, a large prospective cohort, and reported through a series of three manuscripts.

The first manuscript was a cross-sectional study of 37,397 students in Grades 9 to 12 from 80 schools in the 2015/2016 cycle of COMPASS. Using descriptive and multilevel regression analyses (2-level: students within schools), it examined the prevalence of school characteristics guided by the CSH framework and the association between these characteristics and student PA. While some school

characteristics were found to be nearly universal (e.g., presence of gymnasiums), many varied between schools, allowing for further analysis. School characteristics within all four pillars of CSH were significantly associated with PA for at least one student subgroup (gender/grade).

The second manuscript was a longitudinal study of 17,661 students from 78 schools in the 2013/2014, 2014/2015, and 2015/2016 cycles of COMPASS who were in Grade 9 or 10 in 2013/2014 and participated for at least two of the three years. Using multilevel regression analyses (3-level: repeated measures within students within schools), this manuscript examined the association between school characteristics within the CSH framework and slope of weekly MVPA minutes over time. Student MVPA declined significantly across the three years for both male and female students. The school's social environment, partnerships, and policies were associated with student MVPA over time, however the specific school factors and directions of associations varied by gender.

The third manuscript was a longitudinal study of 9,870 students in Grades 9 and 10, from 78 schools, who participated in both the 2013/2014 and 2015/2016 cycles of COMPASS. Using multilevel regression analyses (2-level: students within schools), this manuscript examined the association between school characteristics and achieving all three national PA recommendations after two years (≥ 60 min of MVPA daily, vigorous PA ≥ 3 days/week, strengthening activities ≥ 3 days/week). The analyses were stratified by student gender and baseline PA status. While some school-level variables were associated with higher odds of achieving the PA recommendations (e.g., access to equipment, public health partnerships, staff time for health), other school-level variables were associated with lower odds of achieving the PA recommendations (e.g., providing showers).

The findings of this dissertation support that modifiable school characteristics within the CSH framework are associated with student PA and can have an impact on the trajectory of student PA over time. With limited school resources and a need to improve student PA, these findings can inform schools of which improvements could have the greatest impact. Since there was no researcher-led

intervention and only naturally occurring variability between schools was examined, there is a greater chance that these changes could be replicated and sustained by schools, which could be supported by communities of practice. Finally, many opportunities for future research have been presented within the dissertation.

Acknowledgements

I acknowledge that the land on which I completed my degree is on the traditional territory of the Neutral, Anishinaabeg and Haudenosaunee peoples. The University of Waterloo is situated on the Haldimand Tract, the land promised to the Six Nations that includes six miles on each side of the Grand River.

First and foremost, I would like to sincerely thank my doctoral supervisor, Dr. Scott Leatherdale, for being an uplifting force throughout this endeavour. It was quite the journey with many ups and downs, but I am forever grateful for your calm and encouraging mentorship. You have made a lasting impression on my work as a researcher and my approach to life as an individual.

To my committee members, Dr. Valerie Carson and Dr. Joel Dubin, thank you for the many hours that you have spent reviewing iterations upon iterations of my documents, providing invaluable feedback, and always responding to my emails with words of encouragement.

To my husband, Adam, there is no way that I could have accomplished this without your continued support and patience. There were many, many nights and weekends spent in front of my laptop and you have never made me feel guilty for pursuing this dream.

To my dad, thank you for your unconditional love, even when you still aren't quite sure what it is that I do. And to my mom, you left this earth far too soon, but I will always remember the joy of reading and learning that you instilled in me from a young age.

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List of Abbreviations

AOR	Adjusted odds ratio
ANOVA	Analysis of variance
BMI	Body mass index
CHMS	Canadian Health Measures Survey
CI	Confidence interval
COMPASS	The COMPASS system (formerly, COMPASS represented ‘Cohort Study on Obesity, Marijuana use, Physical activity, Alcohol use, Smoking, and Sedentary behaviour’)
C _q	COMPASS student questionnaire
CSEP	Canadian Society for Exercise Physiology
CSH	Comprehensive School Health
ICC	Intraclass correlation
PA	Physical activity
PE	Physical education
Q	Question (with respect to the COMPASS questionnaires)
MBSA	Muscle and bone strengthening activity
MPA	Moderate physical activity
MVPA	Moderate-to-vigorous physical activity
SD	Standard deviation
SES	Socioeconomic status
SPP	School Policy and Practices questionnaire
VPA	Vigorous physical activity
Y	Year (with respect to the year of COMPASS data)

Chapter 1

Introduction

1.1 General Introduction

Physical activity (PA) has many physical and mental health benefits, such as better cardiovascular health, lower anxiety, and lower cancer risk (Brown et al., 2012; Strong et al., 2005; Warburton et al., 2006). Unfortunately, only 24.4% of youth in Canada achieve the national recommendation of at least 60 minutes of moderate-to-vigorous PA (MVPA) per day, on average (Roberts et al., 2017). It has been observed that PA declines for many individuals during adolescence (Allison & Adlaf, 1997; Dumith et al., 2011; Roberts et al., 2017; Sallis et al., 2000), especially for female students (Roberts et al., 2017), and that PA during adolescence significantly predicts PA during adulthood (Malina, 2001; Telama et al., 2005). Therefore, targeting the youth life stage and identifying factors that can help attenuate the noted decline in PA during this period may help improve the health of youth and ultimately reduce the burden of future chronic diseases (e.g., diabetes, cancer, cardiovascular diseases).

When promoting health behaviour change, ecological theories describe the importance of targeting both the individual and their context. For youth, many of their waking hours are spent at school, making it a key context for influencing health behaviours, such as PA (C. L. Craig et al., 2001; Rainham et al., 2012; Strong et al., 2005). However, school-based interventions have traditionally had limited impact and are rarely continued post-intervention (Dobbins et al., 2009). A different approach is to study the school characteristics associated with higher levels of youth PA through a natural experiment (P. Craig et al., 2017; Leatherdale, 2018); that is, examining the real-world variance between schools (e.g., PA policies) and the impact that these differences have on youth PA.

This dissertation aims to identify school characteristics associated with youth PA based on the Comprehensive School Health (CSH) framework, which has four inter-related components: 1) social and physical environment; 2) partnerships and services; 3) teaching and learning; and 4) policy (Joint Consortium for School Health, 2016; Veugelers & Schwartz, 2010). This will be accomplished through a series of three studies. First, it will evaluate the prevalence of school characteristics within CSH across a large sample of secondary schools in Ontario and Alberta, the prevalence of PA among students attending these schools, and the association between the school factors within CSH and student PA outcomes in a cross-sectional sample. Next, it will evaluate whether school factors within the CSH framework are associated with changes in youth MVPA over time (i.e., the slope of MVPA). Finally, it will evaluate whether school factors within the CSH framework are associated with the odds of students meeting national PA recommendations after two years. Identifying school characteristics that are associated with greater PA will help inform interventions that can be realistically implemented and sustained in similar schools.

1.2 Significance of this Research

It is widely acknowledged that schools are a prime context for health-related interventions for youth, but there has been limited success in school-based interventions for PA thus far (Dobbins et al., 2009). The results of this dissertation will shed light on the school physical and social environments, policies, programs, and partnerships that are associated with higher PA among youth. Since these school features already exist in some schools, there is a greater likelihood that similar schools would be able to successfully adopt these features and improve PA among its students. As such, the work completed for this dissertation is expected to impact stakeholder decision-making with respect to the physical and social environments, policies, programs, and partnerships of Ontario and Alberta secondary schools.

Chapter 2

Literature Review

2.1 Overview

This chapter will present the current landscape of youth PA within Canada (Section 2.2), including the benefits of PA (Section 2.2.1), current PA guidelines (Section 2.2.2), a comparison of sedentary behaviour and PA (Section 2.2.3), challenges in measuring PA (Section 2.2.4), the current trends in PA observed among Canadian youth (Section 2.2.5), and its significance to public health (Section 2.2.6). Next, using the ecological model as a theoretical framework (Section 2.3.1), this chapter will review the individual-level (Section 2.3.1.1) and school-level factors associated with PA (Section 2.3.1.2), specifically focusing on the CSH Framework (Section 2.3.2). It will also present the benefits of using natural experiments in population health research (Section 2.3.3). Finally, it will identify gaps in the current literature that will be addressed by the objectives of the proposed dissertation (Section 2.4).

Multiple systematic reviews have already been conducted related to youth and PA; as such, this literature review will present the findings of those systematic reviews and, in addition, present relevant studies that were outside of the scope of those reviews, published after the reviews were conducted, or that reflect the Canadian context.

2.2 Youth Physical Activity in Canada

This dissertation focused on the youth demographic since this life stage has been identified as a critical period when PA declines sharply (Allison & Adlaf, 1997; Dumith et al., 2011; Roberts et al., 2017; Sallis, 2000; Sallis et al., 2000) and this is also a life stage that significantly predicts PA as an adult (Malina, 2001; Telama et al., 2005). National PA recommendations have been established within the *Canadian 24-Hour Movement Guidelines for Children and Youth* (Tremblay et al., 2016;

see Appendix A), however, it is estimated that only 30.9% of youth meet the MVPA recommendation (Statistics Canada, 2020), despite the numerous benefits of PA. The definition of youth used throughout this dissertation will align with the one used by the national PA recommendations, which is 12-17 years old.

2.2.1 Benefits of Physical Activity in Youth

PA is a vital component of youth health and wellbeing. Chronic diseases previously associated with adulthood, such as type 2 diabetes and cardiovascular diseases, are appearing more frequently in adolescents (Ball & McCargar, 2003; Menke et al., 2016; Pontiroli, 2004). In contrast, Strong et al. (2005) conducted a comprehensive review of over 850 articles and reported that higher levels of MVPA among school-aged children and youth is associated with many positive health outcomes, such as improved aerobic fitness, muscular strength, bone mineral density, lipid and lipoprotein levels, and lower adiposity. A meta-analysis of pooled data from the International Children's Accelerometry Database suggests that time spent in MVPA is associated with decreased waist circumference, systolic blood pressure, fasting triglycerides, and fasting insulin, which are known risk factors for chronic diseases (Ekelund et al., 2012). Beyond the physical benefits, MVPA is also associated with higher academic performance, lower anxiety, and fewer symptoms of depression (Strong et al., 2005).

Expanding on the work of Strong et al. (2005), Janssen and Leblanc (2010) reviewed the impact of PA quantity, intensity, and type on health outcomes among school-aged children and youth. The authors found a clear dose-response relationship between the quantity of PA and multiple health benefits, with the greatest risk reduction occurring in the first 60 minutes of MVPA (Janssen & Leblanc, 2010). Also, participation in MVPA showed a greater reduction in overweight and obesity when compared to light intensity PA. There is limited literature on the benefits of vigorous intensity PA specifically, since moderate and vigorous intensities are often combined as MVPA, but the

available research suggests that vigorous PA (VPA) may provide benefits beyond those observed with moderate intensity PA (Janssen & Leblanc, 2010). A Canadian study of 605 children and youth, aged 9 to 17 years old, measured PA via accelerometer and found that achieving more than 7 minutes of VPA daily was associated with significantly decreased odds of overweight (0.56, 95% CI 0.33-0.95) (Hay et al., 2012). The authors also reported a dose-response relationship as body mass index (BMI) z-score, waist circumference, and systolic blood pressure decreased and cardiorespiratory fitness increased across tertiles of VPA quantities; this pattern across tertiles was not observed within light or moderate PA intensities (Hay et al., 2012). These findings highlight the importance of VPA, not just moderate PA, for youth to achieve optimal health and the benefit of achieving greater quantities of VPA. Finally, the review by Janssen and Leblanc (2010) reported that activity type was important for some health outcomes. Specifically, improved bone mineral density was strongly associated with resistance exercise and high-impact activities, while decreased blood pressure was strongly associated with aerobic activity (Janssen & Leblanc, 2010).

Overall, research suggests that PA is a modifiable risk factor for chronic disease and that it is important for youth to participate in a variety of PA daily, including VPA and resistance exercise at least three days per week, in order to achieve optimal health during this life stage.

2.2.2 Physical Activity Recommendations

Recognizing the benefits of PA and the need to provide guidance, in 2002 the Canadian government collaborated with the Canadian Society for Exercise Physiology (CSEP) to establish PA guidelines for children and youth (6-14 years old) (Tremblay, Warburton, Janssen, et al., 2011). In 2011, these guidelines were updated to better reflect the research evidence available and to cover a larger age range, specifically targeting the school-aged population (Tremblay, Warburton, Janssen, et al., 2011). The updated guidelines suggested that all school-aged children (5-11 years) and youth (12-17 years), irrespective of gender, race, ethnicity, or socio-economic status (SES) should accumulate at least 60

minutes of MVPA daily (Tremblay, Warburton, Janssen, et al., 2011). This target is congruent with global recommendations provided by the World Health Organization (2010). The new Canadian guidelines also recommended VPA at least three days per week; muscle and bone strengthening activities at least three days per week; and that more daily PA provides greater health benefits. Unlike the 2002 guidelines, no reference is made to accumulating the 60 minutes of MVPA through smaller bouts of PA (e.g., 10 minutes in length) since the panel concluded that there is insufficient scientific evidence to support this recommendation for children and youth (Tremblay, Warburton, Janssen, et al., 2011).

Recommendations to limit sedentary behaviour were intentionally omitted from the revised PA guidelines due to a lack of available evidence, at that time, to provide specific recommendations (Tremblay, Warburton, Janssen, et al., 2011). Subsequently, a systematic review examining sedentary behaviour and health among children and youth was conducted (Tremblay, LeBlanc, Kho, et al., 2011) and the first evidence-based *Canadian Sedentary Behaviour Guidelines for Children and Youth* were released (Tremblay, LeBlanc, Janssen, et al., 2011). The guidelines recommended that children and youth should limit recreational screen time to two hours or less per day and limit inactive methods of transport, extended time sitting, and time spent indoors (Tremblay, LeBlanc, Janssen, et al., 2011).

Finally, in 2016, CSEP released the *Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep* (Tremblay et al., 2016). This new guideline document maintains the same recommendations as the 2011 PA guidelines for MVPA, VPA, and muscle and bone strengthening activities, but these activities are now collectively referred to as the “Sweat” component of the 24-hour movement guidelines; sedentary behaviour recommendations have also remained the same. Light intensity PA and sleep were added to the document for a comprehensive set of guidelines that better represents the natural full day period

(24 hours) and to better communicate the relationship between these behaviours and their respective recommendations through an integrated guide (Tremblay et al., 2016). For the purpose of this dissertation, the term “national PA recommendations” will be used to specifically refer to the “Sweat” component of the *Canadian 24-Hour Movement Guidelines for Children and Youth* (see Appendix A); that is, an average of at least 60 minutes of MVPA daily, VPA at least three days per week, and muscle and bone strengthening activities at least three days per week (Tremblay et al., 2016).

2.2.3 Sedentary Behaviour and Physical Activity

Although sedentary behaviour and physical inactivity are often considered to be the same constructs, this is not accurate. “Sedentary behaviour” refers to the specific *behaviours* in which individuals engage during periods of low energy expenditure (e.g., television viewing) (Tremblay, LeBlanc, Janssen, et al., 2011), whereas “physical inactivity” specifically refers to the lack of measured movement (≤ 1.5 METS) (Mansoubi et al., 2015). Individuals can be classified as “sedentary,” which means they do not achieve the sedentary behaviour guidelines, and/or “physically inactive,” which means they do not achieve the PA guidelines (Tremblay et al., 2016; Tremblay, LeBlanc, Janssen, et al., 2011).

Sedentary behaviour and PA can co-exist (Marshall et al., 2002). Some youth who have high levels of sedentary behaviour also have low levels of PA (i.e., classified as sedentary and physically inactive), but there are also youth who have both high levels of sedentary behaviour and high levels of PA (i.e., classified as sedentary and physically active) (Marshall et al., 2002). In other words, time spent on sedentary behaviours does not directly take away from time to be active. Finally, there are different predictors of sedentary behaviour and PA (Marshall et al., 2002). As such, sedentary behaviour and PA are separate behaviours and sedentary behaviour was not evaluated in this dissertation.

2.2.4 Physical Activity Measurement

There are both objective and subjective tools commonly used by researchers to measure PA in daily living. Objective measures of PA, such as heart rate monitors and motion sensors demonstrate greater validity and reliability than subjective measures, such as self-reported questionnaires (Hills et al., 2014; Trost, 2001). Although objective measures can overestimate PA (e.g., heart rate monitors detecting increased heart rate due to non-PA contributors) or underestimate PA (e.g., pedometers or accelerometers that do not record all movements), there are objective measures that incorporate multiple physical measures simultaneously to more accurately assess PA (Hills et al., 2014). A major limitation to using objective measures is feasibility, especially with large research studies. The cost of the device and implementation, and the time required for data collection, can be prohibitive (Prince et al., 2008). In addition, objective PA measures are more invasive, have a higher participant burden, and require active consent, which is not ideal in a school setting since it can greatly impact participation rates and the ability to accurately report on that school's population (see Section 3.3 for more in-depth discussion on active versus passive consent). Therefore, while objective measures have better validity and reliability, they are not always the most appropriate tool for the research study (Prince et al., 2008).

In contrast, subjective measures of PA (i.e., PA questionnaires) have limited validity and reliability (Leatherdale et al., 2014; Shephard, 2003), but they have considerable advantages for large studies (Prince et al., 2008). Although bias can be problematic for one-time assessments and previous studies have found that youth over-report PA when using self-report measures compared to objective measures (Leatherdale et al., 2014; McMurray et al., 2004), there are methods to manage this bias. It is expected that the bias would always be in the same direction and have similar magnitude, which means it can be controlled for in longitudinal study designs that analyse scores over time. For cross-sectional study designs, individuals can be categorized as having low, moderate, or high levels of PA

using one standard deviation below and above the mean as the cut-off points for low and high levels of activity, respectively. This approach has been used in school-based PA studies (e.g., Hobin et al., 2010) and is effective when analysing a cohort at a single point in time since it effectively changes the absolute values captured on the self-report survey to a relative measure. However, this approach collapses a continuous outcome into categories, which loses information, reduces statistical power, and introduces new potential sources of biases (Altman & Royston, 2006).

In this dissertation, both cross-sectional and longitudinal study designs were used. For the cross-sectional study, instead of categorizing the outcome, it was decided to maintain the continuous outcome as reported and simply acknowledge the limitation of self-reported PA biases (i.e., overestimation) within the text. By providing the actual values as collected, it also facilitates comparison across studies that used the same standard questions and are likely to have a similar degree of self-report bias. As describe above, for the longitudinal studies this potential bias was less of a concern since it is expected that the direction and magnitude of bias would be similar over time and respondents were being compared against their own previous measures.

2.2.5 Physical Activity Trends

Despite the recommendations, many Canadian youth do not meet the national PA recommendations (Statistics Canada, 2020). According to the 2017 Canadian Community Health Measures Survey (CHMS), which objectively measured PA with accelerometers, only 43.6% of males and 17.0% of females, aged 12 to 17 years, attained an average of 60 minutes of MVPA daily (Statistics Canada, 2020). This has been a modest improvement since the CHMS previously reported that 38% of males and 14.7% of females achieved an average of 60 minutes of MVPA daily in 2013 (Statistics Canada, 2020).

Another national PA recommendation is that youth participate in VPA at least three days a week, but there is no specified number of minutes (Tremblay et al., 2016). According to the 2007-

2009 CHMS, 51% of children and youth participated in less than 5 minutes of VPA in an entire week and only 6% achieved at least 10 minutes of vigorous activity at least three days a week (Colley et al., 2011). In addition, 97% of MVPA occurred in the moderate intensity range. However, Colley et al. (2011) cautions that VPA may be underestimated due to the high cut-point used (6,500 counts per minute), which is based on a single study and is much higher than the cut-point used for adults (3,962 counts per minute). Other studies have provided very different cut-points for VPA in children, ranging from 4,000 to 8,200 counts per minute (Colley et al., 2011; Mattocks et al., 2007; Puyau et al., 2002; Troiano et al., 2008). The proportion of students achieving the VPA recommendation was not included in more recent reports by Statistics Canada, which have since focused only on respondents meeting the MVPA recommendation.

Finally, it is recommended that youth participate in muscle and bone strengthening activities (e.g., resistance or other high-impact exercise) at least three days per week. Although the systematic review by Janssen and Leblanc (2010) found studies supporting the health benefits of resistance and other high impact exercises for improving bone and muscle strength, there were no articles found in the research literature or information in the Statistics Canada resources regarding the prevalence of this type of exercise among Canadian youth.

2.2.6 Significance of PA to Public Health

The low prevalence of youth meeting the national PA guidelines is a major public health concern. Research indicates that PA levels decline with age throughout adolescence (Dumith et al., 2011; Sallis, 2000), with significant decreases around 15-16 years of age (Sallis, 2000) and younger for females (Dumith et al., 2011). As presented in Section 2.2.1, there are substantial physical and mental health benefits for youth who participate in PA, reducing risk factors for chronic diseases, such as hypertension and diabetes, during their youth (Strong et al., 2005; Warburton et al., 2006). In addition, PA during adolescence is significantly correlated with adult PA behaviour and health

(Malina, 2001; Telama et al., 2005). Since active youth are more likely to be active adults, this leads to many health benefits, including reduced risk of some cancers, cardiovascular disease, stroke, diabetes, and falls (Malina, 2001; Warburton et al., 2006). In particular, adult bone density is heavily dependent on PA during youth (Malina, 2001). As a result, it is imperative that public health strategies support youth in achieving the national PA recommendations and avoiding the “adolescent decline” in PA to realize both immediate and future health benefits.

2.3 Theoretical Framework

When studying health behaviours, it is important to be guided by a theoretical framework that is appropriate for the research question(s). Since this dissertation was focused on health behaviour change and looking beyond the individual to their context, an ecological model was used as the overarching theoretical framework (Section 2.3.1). Accordingly, research literature regarding ecological models and both the individual and school context will be presented (Sections 2.3.1.1 and 2.3.1.2, respectively). At the school level, the CSH Framework will be introduced as the foundation to examining school-factors in the proposed research (Section 2.3.2), and each inter-related component of this framework discussed in detail (Sections 2.3.2.1 through 2.3.2.4). Finally, recognizing the challenges of ecological and school-based research, the concept of natural experiments will be explored, providing evidence on the appropriateness of using observational studies for this dissertation.

2.3.1 Ecological Model

The basic ecological model, as theorized by Bronfenbrenner (1977), is illustrated as concentric circles with the individual at the core and each circle moving outward representing increasingly distal factors that influence health behaviours (see Figure 1 on following page).

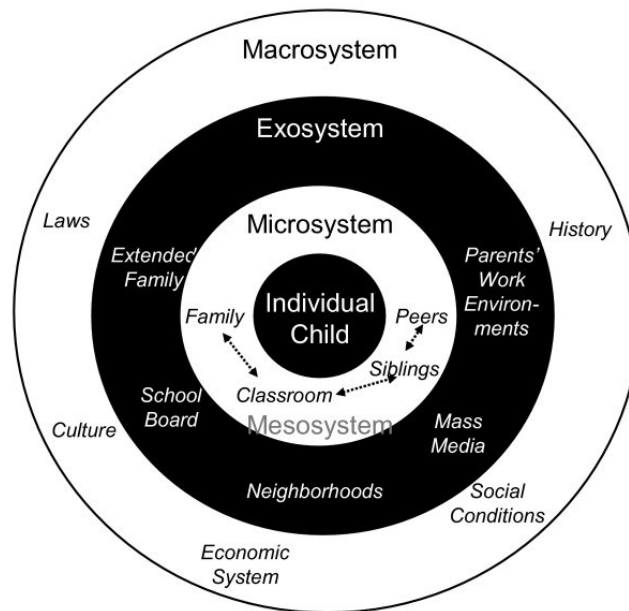


Figure 1. Bronfenbrenner's Ecological Model

(Bronfenbrenner, 1977)

Since the model proposed by Bronfenbrenner (1977), there have been hundreds of proposed ecological models of behaviour, including the Theory of Triadic Influence, the Ecological Model of Four Domains of Active Living, and the Behavioural Ecological Model (Sallis et al., 2008). Sallis, Owen, and Fisher (2008, p. 466) proposed four core principles of ecological models: 1) they describe multiple influences on specific health behaviours, including factors at the intrapersonal, interpersonal, organizational, community and public policy levels; 2) they include interactions between the different levels; 3) they are behaviour-specific, identifying the most relevant potential influences at each level for that behaviour; and 4) they infer that multilevel interventions should be most effective in changing behaviour. It is important to highlight that ecological models *do not* suggest that public health initiatives should solely target the individual's context or environment; instead, they suggest that coordinated efforts should target factors at both the individual and contextual levels to most effectively promote behaviour change.

Research indicates that habitual behaviours, such as PA, are more resistant to change compared to occasional actions, such as vaccination (Ewart, 1991). Recognizing this challenge, it has been suggested that PA promotion be approached using a coordinated effort at multiple levels (e.g., individual, family, school, neighbourhood, and government) to be most effective (Ball & McCargar, 2003). Accordingly, prominent public health strategy documents have advised using an ecological approach; that is, facilitating health behaviour change by providing environments and policies that support individuals in making healthy choices (Sallis et al., 2008). Some examples include *Centre for Chronic Disease Prevention Strategic Plan 2016-2019: Improving Health Outcomes, a Paradigm Shift* (Public Health Agency of Canada, 2015) and *Curbing Childhood Obesity: A federal, provincial, and territorial framework for action to promote healthy weights* (Public Health Agency of Canada, 2004). Therefore, ecological models are accepted within public health organizations as a pragmatic approach to promoting health behaviour change in the “real world.”

In a research context, multilevel analysis has been applied to simultaneously evaluate the effects of individual and contextual variables on health outcomes, including the evaluation of cross-level interactions, providing a comprehensive picture of the factors associated with health behaviour. The thesis followed the ecological model principles, evaluating variables at both the individual and contextual levels, as well as exploring cross-level interactions, to better understand the associations between youth PA behaviours and the school context.

2.3.1.1 Individual Level

Previous research has demonstrated that many individual-level variables, such as sex, age, ethnicity, weight status, and risk behaviours are all individual-level characteristics associated with PA (Hay et al., 2012; Leatherdale, 2015; Sallis et al., 2000). However, the focus of this dissertation was on the school context and, as such, only individual-level factors that were expected to be confounders

(i.e., associated with both the exposure and the outcome) were included in the analyses. Specifically, student gender, age/grade, and ethnicity were identified as potential confounders.

First, it has been repeatedly established that males are more likely to be active than females (Loucaides et al., 2007; Roberts et al., 2017; Sallis et al., 2000). At the same time, schools commonly allocate certain spaces based on student gender (e.g., change rooms) and may offer gender-specific PA opportunities (e.g., gendered athletic teams). Similarly, PA is noted to decline throughout adolescence, especially during secondary school (Sallis et al., 2000; Statistics Canada, 2020) and schools may offer different PA opportunities based on student grade level (e.g., junior versus senior teams). Finally, student ethnicity is associated with PA behaviours (Sallis et al., 2000) and some school offerings may be tailored toward specific ethnic or cultural groups (e.g., ethnic dance clubs). Therefore, student gender, age/grade, and ethnicity were included as individual-level factors within the analyses presented in this dissertation.

2.3.1.2 School Level

Schools are an integral part of the students' PA environment and up to 40% of total PA by youth occurs at school (Craig et al., 2001; Rainham et al., 2012). It has been suggested that all of the recommended 60 minutes of MVPA per day can be accumulated through physical education (PE), recess, intramural sports, and other school programs (Strong et al., 2005). Accordingly, many Canadian provinces have implemented policies requiring a minimum number of PE credits at the secondary level, but the policies vary between provinces and policy adherence is inconsistent (Canadian Fitness & Lifestyle Research Institute, 2016). The 2015 Opportunities for Physical Activity at School survey found that schools across Canada vary substantially in their programs, policies, and facilities related to PA and that these differences could be partially attributed to the school's region and size (Canadian Fitness & Lifestyle Research Institute, 2016). A survey by Dwyer et al. (2006) found differences between 474 secondary schools in Ontario, with 66% offering intramural programs

and 97% offering interschool sport programs; it also found that on-site facilities varied between Ontario secondary schools with 97% having an indoor gym, 80% a playing field, 27% a swimming pool, and 7% an ice rink; however, the prevalence of these features may have changed over the last 15 years. School characteristics, such as being rural or urban, number of students, and lower SES can also impact student PA (Hobin et al., 2013; Loucaides et al., 2007; Robertson-Wilson et al., 2008). In similar studies, school-level differences explained 3% of variability in MVPA among Ontario secondary school students (Hobin et al., 2012), 2-4% of variability in total PA among Ontario secondary students (Hobin et al., 2013), and 5% of PA among secondary students in Alberta (Fein et al., 2004). In a sample of Ontario students in grades 5-8, school-level differences (including neighbourhood and community partnerships) explained 4.8% of variance in the odds of being moderately active and 7.3% of the variance in the odds of being highly active (Leatherdale et al., 2010). The school-level variation observed in these studies supports the school context as a potential factor affecting youth PA levels.

2.3.2 Comprehensive School Health Framework in Canada

Despite the recognized importance of the school context and a history of PA interventions targeting this context, many interventions have been ineffective or have had modest effects (Dobbins et al., 2013). One reason for the poor performance of school-based interventions may be the lack of a multi-pronged approach that simultaneously targets multiple areas of influence. Research has demonstrated that interventions to increase youth PA are most effective when they are multi-faceted (Van Sluijs et al., 2008), which aligns with the tenets of the ecological model. Multi-faceted approaches to improving school health, sometimes referred to as CSH, coordinated school health, or health promoting schools (Veugelers & Schwartz, 2010), have shown promise in the areas of PA (World Health Organization, 2010). The 1985 *Ottawa Charter for Health Promotion* first described the framework for CSH; subsequently, the approach to health promotion in schools has evolved from

focusing on the individual to providing social and physical environments that support students in making healthier choices (Veugelers & Schwartz, 2010). The CSH framework has been adapted and applied in many countries worldwide. For example, a group-randomized controlled trial with female students in 24 secondary schools in the United States found that improvements to PA programming and environment based on a comprehensive framework significantly improved VPA among the female students (Pate et al., 2005).

The Joint Consortium for School Health (2016) has provided a CSH framework adapted for the promotion of PA and healthy eating in Canada. The framework defines four inter-connected components of CSH (see Figure 2): 1) social and physical environment; 2) partnerships and services; 3) teaching and learning; and 4) policy. Each of these components will be examined in relation to youth PA in the subsections below.



Figure 2. Four inter-related components of the CSH framework

(Joint Consortium for School Health, 2016)

2.3.2.1 Social and Physical Environment

The first component, social and physical environment, describes the relationship between students, staff, and the larger community, as well as the physical buildings, school grounds, and equipment. Examining the social environment, research has found that secondary school students attending schools with higher ratings of social support and encouragement to be active, were more likely to

participate in PA during lunch hours and after-school (Hohepa et al., 2007), and students in Grades 5-8 were more likely to be moderately active if they attended schools that used PA as a reward and not as a form of discipline (Leatherdale et al., 2010). In a study by Faulkner, Adlaf, Irving, Allison, and Dwyer (2009), school connectedness was measured by asking students in Grades 7-12 if they felt close to people at school, felt they were part of the school, and felt safe at school. They found that female students with lower levels of school connectedness were less likely to be physically active (Faulkner et al., 2009).

Examining the physical environment, a study by Nichol, Pickett, and Janssen (2009) evaluated data from the 2005/2006 Canadian Health Behaviour in School-Aged Children Survey, which included more than 7,600 Canadian students in Grades 6 through 10. This study found that the availability of PA facilities on school property, such as open fields and exercise rooms, was positively associated with increased PA during class and free time (Nichol et al., 2009); the relationship was stronger for secondary school students and followed a gradient as the number of recreational features increased (Nichol et al., 2009). In a sample of 610 secondary school students in Alberta, Fein et al. (2004) found no significant relationship between the perceived presence of equipment and opportunities to be active, using multilevel analysis and controlling for individual characteristics; however, the perceived importance of these resources and opportunities was significantly associated with PA (Fein et al., 2004). Since the perceived environment was rated by students, individuals who are less active may inaccurately perceive the available equipment and opportunities in their environment, confounding the measured relationship effect between the school environment and PA (Fein et al., 2004). Therefore, to better understand this relationship (i.e., PA and actual school resources available), it is important to have a school administrator or teacher familiar with the actual resources available providing data on the school environment. Further research could also explore improving student awareness of the available resources.

2.3.2.2 Partnerships and Services

The second component of CSH represents the collaboration between community organizations (e.g., public health, recreation centres, and community-based wellness groups) and the school to promote healthy behaviours. A study by Leatherdale et al. (2010) found that Grade 5- 8 students in Ontario were more likely to be highly active if they attend a school with community partnerships established. As noted by Craig et al. (2001), collaborations between schools and local PA facilities (e.g., pools, arenas) may be beneficial in increasing PA among youth and establishing lifelong patterns of using these facilities. In particular, these partnerships could have the greatest impact on high-risk youth who have lower socioeconomic status or are overweight, as demonstrated through a community after-school soccer program implanted at six large, urban schools (Madsen et al., 2013).

2.3.2.3 Teaching and Learning

The teaching and learning component represents school curriculum and programs related to physical activity. While many provinces have mandatory PE requirements, a systematic review by Sallis et al. (2000) found that having additional opportunities to exercise was consistently associated with higher levels of PA among youth. Studying the effects of a ban on extracurricular activities due to a teacher labour dispute in Montreal, researchers found that students' PA increased after extracurricular activities were reinstated, compared to students attending schools not impacted by the ban (Pabayo et al., 2006). A study in 10 Montreal secondary schools found that students attending schools with more intramural sports available had higher levels of total PA and VPA compared to schools with fewer intramural sports, regardless of whether the students participated in those activities (Fuller et al., 2011). In the same study, the availability of extracurricular sports was not significantly associated with student PA levels. Hobin, Leatherdale, Manske, and Robertson-Wilson (2010) found that the availability of interschool PA programming in elementary school was associated with lower levels of

PA; the authors suggest that schools with interschool programming may have a more competitive PA environment, decreasing participation overall.

Comparing organized and unorganized PA opportunities in schools, a study of students aged 12-17 found that participation in unorganized PA remained consistent throughout the school year, but participation in organized activities decreased significantly over the year (Bruner et al., 2009). Both total PA and VPA decreased following the same trend as organized PA, suggesting that maintaining opportunities for organized PA throughout the school year and encouraging participation could attenuate the decrease in PA and, in particular, VPA among youth in the second half of the school year. This relationship was consistent among all ages studied and both genders (Bruner et al., 2009). Studies have found that youth who participate in team sports (Kurc & Leatherdale, 2009; Sallis et al., 2000) and intramural sports (Kurc & Leatherdale, 2009; Leatherdale et al., 2010) have higher total PA levels, so it beneficial to have this type of PA available to youth.

2.3.2.4 Policy

The final component of CSH represents the administrative decisions, procedures, and policies related to physical activity. Some examples include funding for facilities and equipment, ongoing monitoring and evaluation, teacher training, and policies for student access to facilities outside of school hours (e.g., after school). There is very little research available evaluating these types of policies at the secondary school level (Lagarde & LeBlanc, 2010). At the elementary level, research has shown that having written policies related to PA was not significantly associated with PA among students (Leatherdale et al., 2010). However, higher levels of PA were associated with allowing student access to facilities and equipment outside of school hours (Leatherdale et al., 2010), providing funding for PA-related resources (Naylor et al., 2006; Sallis et al., 2001), and ensuring adequate teacher training (Leatherdale et al., 2010; Naylor et al., 2006). There is a gap in the literature regarding these policies and their impact on PA among secondary school students.

2.3.3 Natural Experiments and the “Real World” Context

Natural experiments are typically observational studies where the researcher cannot control the timing or allocation of the intervention (Leatherdale, 2018; Petticrew et al., 2005). For example, a researcher may examine the impact of new school policies to ban the sale of sugary beverages on site and the association with consumption of these beverages among students. Organically, some schools have adopted policies to eliminate these beverages altogether, while some schools have reduced their availability, and other schools have not limited their availability. Although the researcher has had no control over the intervention (ban on sugary beverages) or the degree of implementation (all, moderate, none), or the allocation (e.g., random allocation to intervention and control), there is substantial information that can be gained from studying these scenarios (Petticrew et al., 2005). Specifically, these types of studies provide strong evidence for effectiveness in a real-world setting, but potentially at the cost of low internal validity (Petticrew et al., 2005). However, platforms such as the COMPASS system (COMPASS), which contains multiple waves of data, can support quasi-experimental studies with strong internal validity (Leatherdale, 2018).

Although natural experiments can be used to evaluate effectiveness in real-world settings (Leatherdale, 2018; Petticrew et al., 2005), this approach is underutilized in public health research (Petticrew et al., 2005). Acknowledging this gap in research is particularly important for advancing school-based research since, as noted previously, many researcher-initiated interventions have been ineffective or have had modest effects (Dobbins et al., 2013). One reason for these poor results may be due to researchers not taking into consideration the resources available within the schools and how the intervention can be implemented and sustained in the real world. Thus, another approach can be to evaluate school-initiated programs, policies, and resources and understand how natural variances in these school features influence youth PA. This type of natural experiment may help identify school-level changes that can be practically implemented and maintained in similar schools. Schools are

continuing seeking to improve themselves, learning from other schools, implementing new directives from a higher level (e.g., school board, ministry), and adapting to a changing society; therefore, there is a natural variation in school practices, programs, and environments and schools are well-suited for natural experiments.

2.4 Summary and Gaps Identified

Only 31% of Canadian youth are meeting the national recommendations for MVPA (Statistics Canada, 2020), a modifiable risk factor for many chronic diseases and some cancers (Strong et al., 2005; Warburton et al., 2006). Schools are an important context for changing modifiable health behaviours in youth (Craig et al., 2001; Dobbins et al., 2013) and the CSH framework outlines four inter-related components that schools can strengthen to facilitate better student health: teaching and learning; social and physical environment; partnerships and services; and policy (Joint Consortium for School Health, 2016). There were no research studies identified that evaluated the association between school characteristics within all four components of CSH simultaneously and youth PA in a Canadian context. In addition, there were no studies identified that longitudinally evaluated the change in PA among secondary school students and its association with CSH-related factors.

2.5 Study Aims and Objectives

This dissertation aimed to fill the identified knowledge gaps through a series of three manuscripts as described below.

2.5.1 Manuscript 1 Aims and Objectives

The objectives of the first manuscript were:

- To determine the prevalence of school characteristics within the CSH framework in a large sample of Ontario and Alberta secondary schools.

- To evaluate the association between these school characteristics and student PA (total MVPA per week and achieving the national recommendations), stratified by gender and by grade.

By conducting an in-depth, cross-sectional investigation of a large sample of schools in Ontario and Alberta, the aim was to better understand the prevalence of school factors within the CSH framework in this sample. These findings were important to determine the feasibility of the subsequent manuscripts (i.e., heterogeneity of schools with respect to these factors) and also to inform school stakeholders and decision makers about which school factors within the CSH components have already been widely adopted in schools and which factors were less common. It was hypothesized that while some factors would be very common across schools (e.g., presence of a gymnasium), other factors would be less frequently present in the school sample. Observing this variability was necessary to support using a natural experiment approach in the subsequent manuscripts.

In addition, this manuscript aimed to explore the association between the school factors and student PA, stratified by gender and by grade. It has been well-established that male students are more likely to be active than female students (Loucaides et al., 2007; Roberts et al., 2017; Sallis et al., 2000) and that PA declines throughout secondary school (Sallis et al., 2000; Statistics Canada, 2020). It is also common for school programs and facilities to be allocated by gender (e.g., change rooms, gendered athletic teams) or by grade (e.g., junior versus senior divisions). Therefore, it was hypothesized that the associations between school-level factors within CSH and student PA would differ across genders and grades. Understanding these differences informed the continued stratification of analyses in the subsequent manuscripts and could also help guide schools in tailoring their initiatives to improve student PA.

2.5.2 Manuscript 2 Aims and Objectives

The objectives of the second manuscript were:

- To examine how youth MVPA changes over a three-year period in a large sample of secondary school students, stratified by gender.
- To evaluate the school characteristics associated with preventing the decline in MVPA over time, guided by the CSH framework.

By examining the trajectory of MVPA over time (i.e., the slope), the annual decrease in weekly MVPA minutes could be quantified for this sample of COMPASS students specifically. Next, by evaluating the associations between school-level factors within the CSH framework and student MVPA over time, the potential impact of school factors on attenuating this decline could be elucidated. As there is a dose-response relationship between MVPA and health outcomes (Janssen & Leblanc, 2010), achieving or maintaining higher levels of MVPA is desirable. It was hypothesized that there would be a significant decline in MVPA observed across the 3-year period and that this decline would be greater for female students, based on previous research (Sallis et al., 2000; Statistics Canada, 2020). Also, based on the findings of Manuscript 1, it was hypothesized that the school-level factors associated with attenuating this decline would be different for male and female students. As there has been very little longitudinal research in this area, and none identified that specifically examined many school-level factors within CSH simultaneously, this manuscript was exploratory in nature. These findings have implications for informing future research questions and guiding school-based changes to support students in maintaining MVPA over time.

2.5.3 Manuscript 3 Aims and Objectives

The objectives of the third manuscript were:

- To determine the proportion of students achieving all three PA recommendations at baseline who were still achieving them two years later.
- To determine the proportion of students not achieving all three PA recommendations at baseline who were achieving them two years later.

- To evaluate the school characteristics associated with achieving all three recommendations two years later for these two groups of students.

By examining the proportions of students achieving all three PA recommendations after two years, the extent to which active students can sustain their PA over time or inactive students can improve to achieve the PA recommendations can be quantified. The outcome of achieving the recommendations was purposefully selected due to its importance to public health stakeholders. Supporting children and youth in achieving the national PA recommendations is a priority of public health, specifically to help prevent chronic disease (Joint Public Health Ontario/Cancer Care Ontario Prevention Working Group, 2012). Based on the findings from Manuscript 1, it was hypothesized that there would be a substantial proportion of students who were no longer achieving all three PA recommendations after two years. Also, it was hypothesized that the school-level factors associated with achieving the PA recommendations would vary based on student gender. Similar to Manuscript 2, there has been very little research longitudinally examining multiple school-level factors within the CSH framework with student PA, therefore this study was exploratory in nature.

Chapter 3

Methods Overview: COMPASS Host Study

3.1 Overview

The three studies within this dissertation utilized data collected as part of the COMPASS host study. The COMPASS research platform is the largest, most comprehensive school-based primary prevention system in the world that collects data on both the student and their school simultaneously (COMPASS System, 2021; Leatherdale, Brown, et al., 2014). Collecting hierarchical, longitudinal data on both students and their schools each year, the study provides an in-depth look into numerous youth health-related behaviours (e.g., substance use, diet, bullying, sedentary behaviour) and the school environment (e.g., facilities, policies, practices) (Leatherdale, Brown, et al., 2014). COMPASS was developed purposefully to understand how changes at the school-level impact student health behaviours and as a platform for natural experiments (Leatherdale, Brown, et al., 2014). Student-level data is collected from students using a coding system, which allows the study to anonymously track the same students over time. School-level data is collected from a baseline survey completed by the administrators, followed by an annual survey on any changes to the school environment. At the time of student data collection, the study coordinator encouraged the school administrator to complete the school-level questionnaire. Schools receive a School Health Profile within four weeks of data collection, which provides a summary of health behaviours in their own school as well as comparisons with provincial averages from the previous year. This feedback report is a mechanism for the research team to provide value to the schools for their participation and acts as a motivator for school participation. Additional details about COMPASS can be found in a series of technical reports on the COMPASS website (<http://www.compass.uwaterloo.ca/>), including reports on the recruitment and sampling design (Thompson-Haile & Leatherdale, 2013), method of tracking students

anonymously over time (Bredin & Leatherdale, 2013), and the School Health Profile (Church & Leatherdale, 2013).

The COMPASS host study is further described in this chapter, including sampling (Section 3.2), ethics and consent (Section 3.3), data collection procedures (Section 3.4), data sources (Sections 3.4.1 through 3.4.3), and data linkage (Section 3.5). This chapter also provides a description of the dependent student PA variables (Section 3.6.1), student-level independent variables (Section 3.6.2), and school-level independent variables (Section 3.6.3) that were used in the three manuscripts (Chapters 4 through 6), followed by a general description of the data analysis (Section 3.7). More detailed information about the methods for each study are included within the respective chapters for each manuscript.

3.2 Sampling

The COMPASS sampling process included three phases. First, only school boards that allow “active-information, passive-consent” were invited to participate (further discussed in Section 3.3). Next, in school boards that provided permission to COMPASS, individual schools that had more than 100 students enrolled in Grades 9 through 12 were approached for participation. Finally, in schools that agreed to participate, students and their parents/guardians were informed about the study and provided multiple avenues for opting out (i.e., passive consent). Details on school and school board recruitment methods (e.g., invitation, communication, follow-up) are available in a technical report (see Thompson-Haile & Leatherdale, 2013).

This dissertation included students from 80 schools in Ontario and Alberta in Manuscript 1 (Chapter 4), and students from 78 schools in Ontario and Alberta in Manuscripts 2 and 3 (Chapters 5 and 6). Although these schools were a convenience sample and not selected probabilistically, many factors contribute to the robustness of these studies, including: a large number of schools, whole-

school samples (all students invited to complete the survey), high student-level participation rate (averaged 80% in first year), and longitudinal design. Also, the prevalence of multiple youth health behaviours published from the first wave of COMPASS data are similar to those found in nationally representative studies (Leatherdale, 2015). Students that did not participate in Year 1 (Y₁) of COMPASS (2012/2013) were due to absenteeism or classroom spares during the survey (18.8 %), parental refusal (0.9 %), and student refusal (0.1 %) (Leatherdale, 2015). Student participation rates remained consistent across the COMPASS data collection years included in this dissertation (see Chapters 4 through 6).

While the prevalence of student behaviours (e.g., MVPA) and school characteristics (e.g., policies) in this sample cannot be generalized to all Ontario and Alberta secondary schools, the relationship between the student behaviours and school characteristics to be examined in this dissertation can inform strategies for improving PA behaviours within schools that participated and similar schools.

3.3 Ethics and Consent

Active-information, passive-consent has been found to be most appropriate method of obtaining representative data when measuring self-reported youth behaviour (Courser et al., 2009; Pokorny et al., 2001; White et al., 2004). In particular, this approach encourages participation by students who are otherwise more likely to not follow through with obtaining active consent from parents, which may represent a specific population of students who are more likely to participate in risky behaviours (White et al., 2004). Using passive consent increases participation from this population of students, making the sample more representative of the school, reducing potential biases and including the population that may have the greatest need for school-based primary prevention. This is critical for

the school-based study design and for providing school feedback reports that represent the whole school population (Thompson-Haile et al., 2013).

A selection of school boards in Ontario and Alberta that allowed “active-information, passive-consent” were approached to participate in COMPASS and an application was submitted to the school board when required. If permission was granted by the school board, then individual schools within that board were approached for participation. Finally, students and parents at participating schools were provided information about the study (e.g. through automatic voice-relay calls); unless parents opted to not allow their child to participate, passive consent was implied. Students could also opt to not complete the survey on the day of data collection and could withdraw their survey at any time (Thompson-Haile et al., 2013).

The COMPASS host study was approved by the University of Waterloo Office of Research Ethics (Project: 17264), University of Alberta Research Ethics Office (Project: 00040729), and each of the participating school boards, as required

3.4 Data Collection Procedures

For each school, on the day of data collection, a trained data collector was present at the school to ensure study protocol fidelity, ease of participation for the school administration and teachers, respond to any questions, and ultimately facilitate successful data collection. The data collector identified the school contact most knowledgeable about the school programs and policies (e.g., administrator, student success staff) to complete the school-level survey (see Section 3.4.2). Teachers were provided with a package to collect student-level questionnaires from their students (see Section 3.4.1). After the student completed their survey (typically 35-40 minutes), they placed it in their individual, sealed envelope, which was then collected and placed into a larger classroom envelope.

Once all participating students submitted their envelopes, the classroom envelope was sealed and brought to the data collector.

Following data collection, all surveys were processed at the University of Waterloo. The student-level questionnaires are machine-readable paper booklets, increasing the speed and accuracy of data input. Within 8-10 weeks after collection, each school received a custom feedback report that provided descriptive feedback on the student health behaviours at their school, comparisons to relevant guidelines, and comparisons to provincial averages. The report also identified areas for improvement, provided relevant resources, and included contact information for a knowledge broker who could further help direct the school to appropriate resources. This approach of providing support to schools seeking ideas and solutions for improving student health engages the schools in the process and increases “buy-in,” increasing the likelihood of successful change (Church & Leatherdale, 2013).

3.4.1 COMPASS Student Questionnaire

The student questionnaire, called the COMPASS Questionnaire or C_q , was developed to represent the behaviours of greatest interest to researchers (e.g., obesity, sedentary behaviour) and stakeholders (e.g., bullying) (Bredin & Leatherdale, 2014). This survey includes 65 questions, which were selected to match other surveys for cross-study comparison (e.g., Health Behavior of School Children Survey), to correspond with national guidelines (e.g., questions based on national PA guidelines), for validity and reliability in a youth population, and with consideration for time limitations (i.e., needed to be administered within a class period) (Bredin & Leatherdale, 2014). Students completed the same C_q instrument each year. See Appendix B for a copy of the student-level (C_q) survey.

3.4.2 COMPASS School Policies and Practices Questionnaire

Schools completed a full COMPASS School Policies and Practices Questionnaire, or SPP, at baseline (first year recruited to COMPASS) and then a modified survey during the annual follow-up.

The full SPP was designed to collect information about the school environment relevant to the student behaviours collected in the C_q: school facilities, programs, policies, and resources (Leatherdale, Brown, et al., 2014). The data collector on site during the survey also collected physical copies of school policies or handbooks. In the years following baseline data collection, the survey was designed to identify any changes in school-level factors (e.g., policies). See Appendix C for a copy of the baseline SPP.

3.4.3 Census Data

Data from the 2011 Canada Census contributed information about the neighbourhood in which the school was located. Using the school's postal code, the school was defined as being situated in a rural area (population <1,000; density <400 per km²), small population centre (population 1,000 – 29,999; density ≥ 400 per km²), medium population centre (population 30,000 – 99,999; density ≥ 400 per km²), or large population centre (population ≥ 100,000; density ≥ 400 per km²) (Statistics Canada, 2011). School socio-economic status (SES) was based on the neighbourhood median income according to the census data for the school's postal code.

3.5 Data Linkage

As part of the annual C_q, students responded to a series of five questions that together became a unique, self-generated 5-digit code (Bredin & Leatherdale, 2013). These questions were purposefully selected such that they could maintain student anonymity, but previous research had indicated that the responses would be relatively stable over time allowing for longitudinal tracking based on this code (Bredin & Leatherdale, 2013). The five questions were:

- 1) The first letter of your middle name (if you have more than one middle name use your first middle name; if you don't have a middle name use "Z").
- 2) The name of the month in which you were born [converted into a numerical value].

- 3) The last letter of your full last name.
- 4) The second letter of your full first name.
- 5) The first initial of your mother's first name (think about the mother you see the most).

Students were also asked if they had participated in COMPASS the previous year to help facilitate linkage across years (Bredin & Leatherdale, 2013; Qian et al., 2015).

Successful linkage and inclusion in the longitudinal dataset required the student to be matched across at least two years of data, and the linkage rate using this approach was approximately 80% (Qian et al., 2015). Further details on the approach to longitudinal data linkage are available in the COMPASS technical reports (see Bredin & Leatherdale, 2013; Qian et al., 2015).

3.6 Measures

This section will describe the two PA dependent variables included in the dissertation manuscripts (Section 3.6.1), as well as the student-level independent variables (Section 3.6.2) and school-level independent variables (Section 3.6.3).

3.6.1 Student Dependent PA Variables (Outcomes)

There were two student-level PA outcomes examined throughout this dissertation: total minutes of weekly MVPA and achieving all three PA recommendations. These outcomes were derived from three PA questions in the C_q as described below (see Appendix B for the full C_q).

Question 11 (Q11) of the C_q asked students, “Mark how many minutes of HARD physical activities you did on each of the last 7 days. This includes physical activity during physical education class, lunch, recess, after school, evenings, and spare time.” It specifies

that, “HARD physical activities are jogging, team sports, fast dancing, jump-rope and any other physical activities that increase your heart rate and make you breathe hard and sweat.” The response options were presented in a table with hours (0 to 4) and minutes (0, 15, 30, and 45 minutes) for each of the seven days.

Similarly, Q12 of the C_q asked students “Mark how many minutes of MODERATE physical activities you did on each of the last 7 days. This includes physical activity during physical education class, lunch, recess, after school, evenings, and spare time.” It also specifies that, “MODERATE physical activities include lower intensity activities such as walking, biking to school and recreational swimming.” The response options were presented in a table with hours (0 to 4) and minutes (0, 15, 30, and 45 minutes) for each of the seven days.

The C_q also asked students in Q19, “On how many days in the last 7 days did you do exercises to strengthen or tone your muscles?” The examples of push-ups, sit-ups, and weight-lifting were provided to respondents and the response options were 0 days to 7 days.

The questions regarding VPA (Q11) and moderate PA (MPA; Q12) were found to have moderate test-retest reliability for self-reported MPA (intraclass correlation [ICC] = 0.71), VPA (ICC = 0.68), and MVPA (ICC = 0.75) (Leatherdale, Laxer, et al., 2014). When compared to objective accelerometer data, validity for Q11 and Q12 were found to be low (Pearson’s $r = 0.21$ and $r = 0.27$, respectively) since students tended to over-estimate VPA by 425.8 min/week and under-estimate MPA by 235.4 min/week (Leatherdale, Laxer, et al., 2014). Self-reported PA using these questions was most accurate when MPA and VPA were

combined as MVPA ($r = 0.31$) and the validity for MVPA was similar to other self-report questionnaires (Leatherdale, Laxer, et al., 2014).

There was no validity and reliability data available for the question regarding muscle and bone strengthening exercise (MBSE; Q19). While this is a limitation, the nature of this question is quite different than MPA and VPA; there is no minimum number of minutes required or intensity to assess, so it is expected that respondents would be able to estimate the number of days on which they did *any* MSBE activity in the last 7 days. Future research is needed to evaluate the reliability and validity of this MSBE measure.

Total Weekly Minutes of MVPA: This continuous outcome was derived by summing the total number of minutes provided by the student in response to Q11 and Q12.

Achieving all three PA recommendations: This binary outcome was derived based on the student achieving all three PA recommendations in the *Canadian 24-Hour Movement Guidelines for Children and Youth* (Tremblay et al., 2016):

- 1) average number of MVPA minutes per day being greater or equal to 60 (i.e., sum of Q11 and Q12, divided by 7);
- 2) number of days with *any* VPA being greater or equal to 3 (Q12); and
- 3) number of days with *any* MBSE being greater or equal to 3 (Q19).

Students who did not achieve all three recommendations were classified as not achieving the PA recommendations.

3.6.2 Student-level Independent Variables

The C_q asks students to provide basic demographic information including grade level (Q1), age (Q2), sex (Q3), and ethnicity (Q4). As age and grade are highly correlated, only grade

level was used in the analyses; grade level is a more practical measure for school-based research where policies are typically based on grade and not age, and similar studies have used grade level (Leatherdale, 2015; Hobin et al., 2012).

3.6.3 School-level Independent Variables

The same 33 school-level factors from the COMPASS research platform were included in all three manuscripts as independent variables; 30 of these school-level factors were collected from the SPP completed by the school administrator (see Section 3.4 for the data collection procedures and Appendix C for the SPP questionnaire), two school-level factors were derived from 2011 Canada Census, and one school-level factor was collected at the time of school recruitment. The school-level factors were organized according to the four components of the CSH framework (Joint Consortium for School Health, 2016), with the Social and Physical Environment component further divided into two categories. The school-level factors within the CSH framework and respective sources are listed below.

Social Environment:

- School enrolment size (collected at time of school recruitment)
- School SES (neighbourhood median income from 2011 Canada Census)
- School priority of PA (SPP - Q8).
- School promotion of PA events (SPP - Q24)

Physical Environment

- Location (Rural or small/medium/large population centre from 2011 Canada Census)
- Presence of:

- Gymnasium (SPP - Q14a)
- Indoor facilities (SPP - Q14a)
- Outdoor facilities (SPP - Q14a)
- Change rooms (SPP - Q16b)
- Curtains for changing (SPP - Q16c)
- Secure change room lockers (SPP - Q16a)
- Showers (SPP - Q16d)

Partnerships and Services

- Support from local public health for physical activity (SPP - Q6)
- Support from other organizations to promote health and/or health activities (SPP - Q7)
 - Non-Governmental Organizations
 - Parks or Recreation Department
 - Youth Organization
 - Health or Fitness Club
 - Consultant/Specialist

Teaching and Learning

- Intramural PA available (SPP - Q18)
- Non-competitive PA clubs (SPP - Q20)
- Interschool or varsity PA programs (SPP - Q21)

Policy

- Has a written policy for PA (SPP - Q1b)

- Uses data from student health assessments to plan (SPP - Q3)
- Policy permitting access during non-instructional time during school hours:
 - Indoor facilities (SPP - Q12)
 - Outdoor facilities (SPP – Q13)
 - Equipment (SPP - Q15)
- Policy permitting access outside of school hours:
 - Gymnasium (SPP - Q17a)
 - Indoor facilities (SPP - Q17b)
 - Outdoor facilities (SPP – Q17c)
 - Equipment (SPP – Q17d)
- School board provided resources to improve student health:
 - Budget (SPP - Q2a)
 - Staff time (SPP - Q2b)
 - Space (SPP - Q2c)

3.7 Statistical Analysis

The analyses conducted for each manuscript have been described in the respective chapters (Chapter 4 through 6). In general, descriptive statistics were conducted for all student- and school-level variables included in each study. Multilevel regression models were also employed for each study to evaluate the associations between school-level factors within the CSH framework and the student-level PA outcome of interest, given that the data were hierarchical in nature. The type of regression (e.g., linear or logistic) and number of levels

was dictated by the respective outcome variable (e.g., continuous versus binary) and study design (e.g., cross-sectional, repeated measures within students).

Chapter 4

Manuscript 1: A Comprehensive School Health approach to student physical activity: a multilevel analysis examining the association between school-level factors and student physical activity behaviours

This manuscript is presented as submitted to the Journal of School Health, including a section that highlights the implications for school health as per journal requirements. Referencing also appears according to journal requirements.

Pirrie, M., Carson, V., Dubin, J.A., & Leatherdale, S.T. (2021). A Comprehensive School Health approach to student physical activity: a multilevel analysis examining the association between school-level factors and student physical activity behaviours. Under review by the Journal of School Health (Manuscript ID: JOSH-09-21-RA-437).

Overview

Background

The Comprehensive School Health (CSH) framework has four components: social and physical environment; partnerships and services; teaching and learning; and policy. This study examines associations between CSH and student physical activity (PA).

Methods

Using 2015/2016 COMPASS study survey data of 37,397 students from 80 secondary schools in Ontario and Alberta, Canada, associations between school-level factors within CSH and student PA outcomes (weekly moderate-to-vigorous PA [MVPA] minutes and achieving the national PA recommendations of ≥ 60 min of MVPA daily, vigorous PA ≥ 3 days/week, strengthening activities ≥ 3 days/week) were analyzed using multilevel regression models stratified by gender and grade.

Results

Factors within all four CSH components were associated with student PA. Four student subgroups were more likely to achieve the recommendations if their school had youth organization partnerships (Range of AORs: 1.15-1.33, $p < 0.05$) and female students were less likely if their school had low prioritization of PA (AOR=0.77, 95%CI: [0.65-0.92]). Grade 9 students had higher MVPA when provided non-competitive PA opportunities ($\beta=100.4$, 95%CI: [30.0-170.9]). All student subgroups had better PA outcomes when schools provided access to equipment during non-instructional time.

Conclusion

There is opportunity to improve student PA through CSH-guided interventions, but different strategies may be more effective for each gender/grade.

Introduction

The *Canadian 24-Hour Movement Guidelines for Children and Youth*¹ and the *Physical Activity (PA) Guidelines for Americans*² recommend that youth achieve at least 60 minutes of moderate-to-vigorous physical activity (MVPA) per day, vigorous PA at least three days per week, and muscle- and bone-strengthening activity at least three days per week.¹ A dose-response relationship between MVPA and health benefits is widely recognized.³ However, considering that only 24.4% of Canadian youth achieve the MVPA recommendation,⁴ promoting youth PA should be a priority.

Schools play an integral role in shaping student PA^{5,6} and while many Canadian provinces have mandatory physical education and provide additional PA opportunities, schools vary substantially in their programs, policies, and facilities.⁷ A previous study found that 2-4% of variability in youth PA was attributable to the school they attend, above and beyond individual student characteristics.⁸ Therefore, examining school characteristics that contribute to student PA may be valuable to inform school-based PA promotion.

In Canada, some school systems have adopted the Comprehensive School Health (CSH) framework for developing whole school environments to advance student health.^{9,10} The CSH framework has four inter-connected components:^{9,10} 1) social and physical environment; 2) partnerships and services; 3) teaching and learning; and 4) policy. The first component, social and physical environment, describes the relationship between students, staff, and community, as well as the school's physical facilities and equipment. Research suggests that school location, enrollment number, and socioeconomic status (SES) can impact student PA.^{8,11} In addition, students attending schools with higher ratings of social

support¹² and greater availability of PA facilities¹³ had higher PA during class and non-instructional time. The second CSH component represents collaborations between community organizations and schools to promote healthy behaviours. Research has found that students are more likely to be highly active if their school has established partnerships with community organizations¹⁴ and local PA facilities (e.g., pools, arenas).⁵ The third component, teaching and learning, represents PA-related school curriculum and extracurricular programming. A systematic review found that providing more school-based opportunities for PA was consistently associated with higher levels of youth PA.¹⁵ Another study found that providing intramural sports was associated with higher PA, regardless of whether the students participated in those activities.¹⁶ The final CSH component represents administrative decisions, procedures, and policies related to PA. There is very little research evaluating these types of policies at the secondary school level.¹⁷ In elementary schools, research has found higher PA was associated with allowing student access to facilities and equipment outside of school hours,¹⁴ providing funding for PA-related resources^{18,19} and ensuring adequate teacher training;^{14,18} however, having written policies related to PA was not significantly associated with student PA.¹⁴

Although individual studies have examined some school characteristics within the CSH framework, no study has comprehensively evaluated all four CSH components simultaneously.⁹ The aim of this exploratory study was to determine the prevalence of school characteristics within the CSH framework in a large sample of Ontario and Alberta secondary schools and evaluate their association with student PA. Student gender, age/grade, and ethnicity are associated with PA¹⁵ and may also influence PA-related resources (e.g.,

gender-specific showers, ethnic dance clubs); therefore, this study controlled for these potentially confounding student-level factors. In addition, since gender and grade have been identified as moderators of the association between school characteristics and student PA,²⁰ the analysis was stratified by these factors.

Methods

Participants

Data used in this study were collected as part of the COMPASS study, a prospective cohort (2012-2021) following a large sample of Canadian Grade 9 to 12 students and the secondary schools they attend.²¹ Each year, COMPASS tools measure student-level outcomes (e.g., alcohol, cannabis, e-cigarettes, physical activity, mental health, etc.) and link them to school- and community-level measures of program, policy and built environment aligned with those student outcomes. COMPASS uses active-information, passive-consent, which is more appropriate for obtaining representative data of self-reported youth behaviour.²² COMPASS was approved by the University of Waterloo Office of Research Ethics (Project: 17264), University of Alberta Research Ethics Office (Project: 00040729), and each of the participating school boards, as required. Details on the COMPASS host study are available online (www.compass.uwaterloo.ca) and in print.²¹

Recruitment. The current study included data from a convenience sample of 80 secondary schools in Ontario (n=71) and Alberta (n=9) that participated in 2015/2016 (COMPASS Year 4). School boards permitting active-information, passive-consent were approached to participate. If permission was granted, then individual schools were approached for participation. Finally, students and parents/guardians at participating schools

were provided information about the study (e.g., automatic voice-relay calls); unless guardians opted to not allow the student to participate, passive consent was implied. Students could opt to not complete the survey on data collection day and could withdraw their survey at any time. Detailed recruitment methods have been published.²³

Student selection. The 80 participating schools in 2015/2016 had 49,950 students enrolled and 39,917 (80%) participated; missing students were primarily due to absenteeism or classroom spares on survey day since <1% of eligible students/guardians opted out. Of the participating students, 37,397 (94%) had complete data (gender, grade, ethnicity, and PA) and were included in the current study.

Instrumentation

School Characteristics. School postal code and 2011 Canada Census data were used to define school location and neighbourhood SES. A school administrator completed the COMPASS School Policies and Practices Questionnaire regarding school facilities, programs, policies, and resources.²¹ School-level characteristics that fit within the four CSH components and included in this study are those listed in Table 1, as well as the presence of indoor facilities, outdoor facilities, a gymnasium, change rooms, and interschool/varsity sports teams.

Student Characteristics. The COMPASS student questionnaire includes 65 health-related questions selected to match other surveys/guidelines, for validity and reliability in youth populations, and with consideration for time limitations.²¹ Student demographic characteristics included in this study were grade, gender, and ethnicity. The two PA

outcomes were total weekly minutes of MVPA (continuous) and achieving the national PA recommendations (binary).

Total weekly minutes of MVPA was calculated by summing the responses to, “Mark how many minutes of HARD physical activities you did on each of the last 7 days” and “Mark how many minutes of MODERATE physical activities you did on each of the last 7 days.” The validity of these measures are similar to other self-report questionnaires.²⁴

Achieving the PA recommendations was determined using the questions above, in addition to, “On how many days in the last 7 days did you do exercises to strengthen or tone your muscles?” with examples provided. There is no validity and reliability data available for this measure; while this is a limitation, there is no minimum number of minutes required or intensity to assess, so it is expected that respondents could estimate the number of days. Students who achieved an average of ≥ 60 minutes MVPA per day, vigorous PA ≥ 3 days per week, and bone-strengthening PA ≥ 3 days per week, were classified as achieving the recommendations.¹

Procedure

A COMPASS data collector visited each school to facilitate data collection, ensure protocol fidelity, and identify the school contact most knowledgeable about school programs/policies to complete the school-level survey. Students completed their survey during a class period and placed it in their individual sealed envelope.

Data Analysis

Descriptive analysis was conducted for school- and student-level characteristics. Comparisons across gender/grade subgroups were performed using chi-square for categorical

variables and ANOVA for continuous. Due to the hierarchical nature of the data, multilevel regression models (random intercept only) were conducted for both PA outcomes, stratified by gender and by grade. School characteristics with a prevalence of 95% or higher were excluded from the regressions due to lack of heterogeneity. For each subgroup, a null model was fit to determine variability in the PA outcome across schools. Next, school variables within the four components of CSH were added. Finally, student variables were added to provide the full model. All full models were assessed for multicollinearity (e.g., high variance inflation factors). All analyses were conducted using SAS 9.04. The GLIMMIX procedure with a binomial distribution and logit link was used for hierarchical logistic regressions, and the MIXED procedure for hierarchical linear regressions (i.e., linear mixed effects models).

Results

School and Student Descriptives

School features common across the 80 schools were: interschool/varsity sports teams (100%), outdoor facilities (98.8%), gymnasium (98.8%), other indoor facilities (97.5%), and change rooms (95.0%); these were not included in the regression models. Frequencies for the remaining school features are presented in Table 1. The school-level proportion of students achieving the PA recommendations ranged from 31.2% to 54.5% (mean=44.5%, SD=5.3%) and average student MVPA ranged from 704.6 to 1176.4 minutes/week (mean=892.2 minutes/week, SD=90.2) or 11.7 to 19.6 hours/week (mean=14.9 hours/week, SD=1.5).

Student demographics and PA outcomes are presented by grade in Table 2 and by gender in Table 3. The overall proportion of students (n=37,397) achieving the PA

recommendations was 45.2% and the average weekly MVPA was 886.8 (SD=640.0) minutes or 14.8 (SD=10.7) hours. There was a consistent and significant pattern of PA decreasing across grades, both in weekly MVPA minutes and achieving PA recommendations ($p<0.001$). Also, weekly MVPA minutes and proportion achieving the PA recommendations were significantly higher in male students ($p<0.001$).

Achieving PA Recommendations

The intraclass correlation (ICC) ranged from 0.009 to 0.020, suggesting that 0.9-2.0% of PA variance is attributable to characteristics of the school attended, above and beyond the students' own characteristics. The full hierarchical regression models are provided in Table 4.

Social environment. Male and Grade 9 students were more likely to achieve the PA recommendations if their school had 501-1000 students (AOR=1.17, 95%CI [1.05, 1.30]; AOR=1.32, 95%CI [1.13, 1.55]) or >1000 students (AOR=1.32, 95%CI [1.13, 1.55]; AOR=1.53, 95%CI [1.12, 2.10]), compared to ≤ 500 . Male and Grade 11 students were significantly more likely to achieve the PA recommendations when attending schools located in the highest SES neighbourhoods, compared to the lowest (AOR=1.34, 95%CI [1.04, 1.73]; AOR=1.52, 95%CI [1.03, 2.25]). Finally, female students were significantly less likely to achieve the PA recommendations if their school ranked PA mid or low priority, compared to high (AOR=0.83, 95%CI [0.74, 0.84]; AOR=0.77, 95%CI [0.65, 0.92]).

Physical environment. Grade 12 students attending schools in large urban locations were more likely to achieve the recommendations compared to rural/small urban locations (AOR=1.35, 95%CI [1.06, 1.72]). Also, female and Grade 10 students attending schools with

secure lockers in the change area were more likely to achieve the recommendations (AOR=1.21, 95%CI [1.04, 1.40]; AOR=1.29, 95%CI [1.04, 1.61]). Female students attending schools with girls' shower facilities and Grade 11 students attending schools with shower facilities for both boys and girls were less likely to achieve the recommendations, compared to schools without showers (AOR=0.73, 95%CI [0.63, 0.84]; AOR=0.71, 95%CI [0.54, 0.94]).

Partnerships and services. Males attending schools partnered with public health services were more likely to achieve the recommendations (AOR=1.13, 95%CI [1.03, 1.24]). Five student subgroups were consistently less likely to achieve the recommendations if their school was partnered with a non-governmental organization (Range of AORs:0.75-0.88, $p<0.05$). In contrast, four student subgroups were consistently more likely to achieve the recommendations if their school was partnered with a youth organization (Range of AORs:1.15-1.33, $p<0.05$).

Teaching and learning. Female and Grade 10 students were more likely to achieve the recommendations if their school offered non-competitive PA programs only (AOR=1.18, 95%CI [1.01, 1.38]; AOR=1.27, 95%CI [1.03, 1.58]), intramural programs only (AOR=1.20, 95%CI [1.03, 1.39]; AOR=1.46, 95%CI [1.18, 1.80]), or both types of opportunities (AOR=1.14, 95%CI [1.00, 1.30]; AOR=1.37, 95%CI [1.13, 1.65]), compared to schools without these opportunities. In addition, male students attending schools that offered both non-competitive and intramural options were more likely to achieve the recommendations (AOR=1.15, 95%CI [1.01, 1.30]).

Policy. During non-instructional hours, female, Grade 10, and Grade 11 students were less likely to achieve the PA recommendations if their school provided access to indoor facilities (Range of AORs: 0.77-0.87, $p < 0.05$), and female and Grade 9 students were less likely to achieve the recommendations if their school provided access to outdoor facilities (AOR=0.86, 95%CI [0.74, 1.00]; AOR=0.77, 95%CI [0.63, 0.94]). In contrast, always providing access to equipment during this time was consistently positively associated with achieving the recommendations for four student subgroups (Range of AORs:1.22-1.34, $p < 0.05$). During after-school hours, Grade 10 students were more likely to achieve the recommendations if their school provided access to the gymnasium (AOR=1.42, 95%CI [1.10, 1.81]) and Grade 11 students if their school provided access to other indoor facilities (AOR=1.30, 95%CI [1.09, 1.55]). For female, Grade 10, and Grade 12 students, they were less likely to achieve the recommendations if their school provided access to equipment after hours (Range of AORs=0.77-0.89, $p < 0.05$).

Finally, Grade 12 students were significantly more like to achieve the recommendations if their school received health-related staff time from the school board (AOR=1.21, 95%CI [1.03, 1.42]) and five student subgroups were consistently less likely to achieve the recommendations if their school was receiving the highest category of budget for health ($\geq \$1001$) compared to no funding (Range of AORs:0.78-0.88, $p < 0.05$).

Total weekly MVPA minutes

The null model ICCs ranged from 1.6% to 2.2%. See Table 5 for the final full regression models.

Social environment. Attending a school with 501-1000 enrollment was associated with significantly higher weekly minutes of MVPA, compared to attending a smaller school for female, male, Grade 9, and Grade 10 students (Range of β s: 50.4 to 77.6, $p < 0.05$). Neighbourhood SES of \$75,001-\$100,000 was associated with fewer MVPA minutes, compared to the lowest SES category, for female, male, Grade 11, and Grade 12 students (Range of β s: -101.6 to -68.1, $p < 0.05$).

Females had fewer MVPA minutes if their school ranked PA between 4th and 6th priority ($\beta = -43.8$, 95%CI -87.6, -0.03). For males, MVPA minutes were significantly higher for all categories of PA ranking, compared to a priority ranking of 1st to 3rd (Range of β s: 59.2 to 149.1, $p < 0.05$), and MVPA increased as the ranking decreased. Similarly, Grade 9, Grade 10, and Grade 12 students had increasing higher weekly MVPA minutes as school priority of PA decreased. Female, Grade 9, and Grade 11 students had fewer MVPA minutes if their school promoted PA events ($\beta = -61.4$, 95%CI [-115.7, -7.2]; $\beta = -89.8$, 95%CI [-160.6, -19.0]; $\beta = -100.6$, 95%CI [-178.7, -22.6]).

Physical environment. Male and Grade 9 students had fewer MVPA minutes if they attended a school in a medium urban location ($\beta = -78.6$, 95%CI [-145.7, -11.5] and $\beta = -80.6$, 95%CI [-148.4, -12.8]), and female, Grade 9, and Grade 11 students had fewer MVPA minutes if they attended a school in a large urban location ($\beta = -64.3$, 95%CI [-118.8, 9.8]; $\beta = -87.2$, 95%CI [-162.0, -12.4]; $\beta = -83.9$, 95%CI [-165.8, -2.0]). Grade 10 students attending schools with curtains for both boys and girls had significantly more MVPA minutes ($\beta = 51.0$, 95%CI [5.9, 96.2]). Four student subgroups (males, Grade 9, Grade 10, and Grade 12) had

significantly fewer MVPA minutes if the school had secure lockers in change rooms (Range of β s: -96.3 to -67.9, $p < 0.05$).

Partnerships and services. Grade 10 students had fewer MVPA minutes if their school had an affiliation with a non-governmental organization for the purposes of PA ($\beta = -59.7$, 95%CI [-95.1, -24.4]). No other partnerships were associated with MVPA for any of the student subgroups.

Teaching and learning. Grade 9 students had more MVPA minutes if they attended a school that offers both intramural and competitive PA programs ($\beta = 69.3$, 95%CI [9.2, 129.5]) or non-competitive PA programs only ($\beta = 100.4$, 95%CI [30.0, 170.9]). Grade 12 students had fewer MVPA minutes if their school only offered intramurals ($\beta = -104.7$, 95%CI [-177.5, -31.8]).

Policy. Male and Grade 11 students attending schools with a written PA policy had fewer MVPA minutes ($\beta = -58.8$, 95%CI [-115.5, -2.0]; $\beta = -82.5$, 95%CI [-154.7, -10.3]). The Grade 9 and Grade 12 students attending schools that provided access to indoor facilities during non-instructional time had higher weekly MVPA ($\beta = 124.0$, 95%CI [69.0, 179.0] and $\beta = 73.0$, 95%CI [14.5, 131.5]), however, Grade 9 students had fewer MVPA minutes with access to outdoor facilities during this time ($\beta = -137.3$, 95%CI [-206.2, -68.5]). Four subgroups all had significantly higher MVPA minutes if their school always provided access to equipment during non-instructional time (Range of β s: 87.6 to 107.2, $p < 0.05$). In addition, females had higher MVPA minutes if their school sometimes provided access to equipment during this time ($\beta = 88.7$, 95%CI [30.8, 146.7]). Looking at policies for access to facilities and equipment after school hours, Grade 12 students had fewer MVPA minutes if they had

access to indoor facilities during this time ($\beta=-61.4$, 95%CI [-121.0, -1.9]). Finally, considering the resources provided by the school board, females had more weekly MVPA minutes if their school received staff time for health ($\beta=38.3$, 95%CI [11.9, 74.7]), fewer MVPA minutes if their school received space for health ($\beta=-52.5$, 95%CI [-100.5, -4.5]), and more MVPA minutes if the school received a budget of \$1-\$1000 for health, compared to no funding ($\beta=49.9$, 95%CI [2.07, 97.8]).

Discussion

We identified that some school characteristics within each component of CSH were significantly associated with students meeting PA recommendations and attaining higher MVPA. With the exception of a few characteristics shared by all or almost all schools (e.g., presence of a gymnasium), schools in the 2015/2016 COMPASS sample had varying facilities, programs, policies, and resources specific to PA. School differences accounted for 0.9% to 2.2% of the observed variance in youth PA, which is consistent with previous research;⁸ this may appear small but if the school context can shift student PA behaviour by even a small amount, it can have a substantial impact at the population level.²⁵

In this 2015/2016 COMPASS student sample, only 45.2% of students self-reported achieving all three PA recommendations, demonstrating that a substantial proportion are insufficiently active and there remains considerable room for improvement. The proportion of females achieving the recommendations was significantly lower than males, and females were attaining three and a half hours less MVPA per week than their male colleagues, a significant and meaningful disparity.²⁶ Similarly, as grade level increased there was a significant decrease in minutes of MVPA and proportion of students achieving the

recommendations, congruent with previous research.^{27,28} As such, it is important to not only explore paths to increasing PA among secondary school students as a whole population, but to also identify approaches that may be most effective for each gender and grade.

The current study identified that the school-level features within the CSH framework that were associated with PA varied by gender and grade, reinforcing that different strategies are needed for targeting each subgroup. For the social and physical environment component of CSH, while most student subgroups had a significant negative relationship between weekly MVPA minutes and their school's PA prioritization, female students had a consistently positive association. Further research is needed to understand whether the schools prioritizing PA are also the schools implementing the types of programs and policies that may promote PA among females in particular (e.g., intramural and non-competitive PA programs) or if there are other social dynamics at play. For example, one study found that perceived social support at school may be associated with PA.¹² Another notable finding was that male and Grade 9 students were significantly more likely to achieve the PA recommendations if they attended larger schools. This may be due to larger schools not only having the presence (versus absence) of facilities, equipment, or athletic programs, but a larger quantity and diversity.⁷ There were some unexpected results, such as secure lockers being associated desired PA outcomes for some student subgroups while being associated undesired outcomes for others; these need to be explored further to understand the relationships, presuming the underlying association is true.

For partnerships and services, the findings were fairly consistent across groups with youth organizations being associated with greater odds of achieving the PA

recommendations, but not total MVPA; this suggests that youth organizations may play an important role in supporting vigorous and strengthening activities. In contrast, non-governmental organization partnerships were consistently associated with lower odds of achieving the PA recommendations; this is counterintuitive and may indicate that schools with lower PA may first seek out these types of organizations for support. While previous research found that school partnerships with organizations may support student PA,^{5,14} the current study highlights that the type of organization is important and needs to be further studied prospectively.

For the teaching and learning CSH component, providing intramural and non-competitive PA opportunities had clear positive effects for female, Grade 9, and Grade 10 students. This aligns with previous studies, which found providing additional PA opportunities increases student PA,^{15,16} but the current study highlights these opportunities may be most important for female and younger students. Additionally, this supports previous findings that competition is a perceived barrier to PA for some female students.²⁹

Lastly, for the policy component of CSH, providing access to equipment during non-instructional time was the most consistent predictor desired PA behaviours across multiple student subgroups, however only 30% of schools reported having this policy. In addition, providing access to the gymnasium and other indoor facilities during non-instructional time may support Grade 10 and 11 students in achieving the PA recommendations. It was surprising to note that students attending schools with the highest budget for health from the school board also had the lowest odds of achieving the PA recommendations. This may be

indicative of the school recognizing the lower PA of its students and attempting to make changes, but further research is needed to understand this relationship over time.

Strengths and Limitations

A major strength of this study was the large sample of schools, which allowed for many CSH school characteristics to be analyzed simultaneously, addressing a gap in the literature. While previous studies have examined one or a few of these variables, examining them together in a single model demonstrates their relative association with student PA. The large student sample also allowed for subgroup analyses to be conducted by gender and grade. Another strength was the active-information, passive-consent process used by COMPASS, facilitating a high degree of student coverage within each school. A limitation was that the cross-sectional data lacks temporality, but longitudinal data available in COMPASS can be used to explore such temporal relationships moving forward. Another limitation was that school characteristics that could fall within CSH (e.g., teacher training) were unavailable; these could be added in future studies. Similarly, some school factors may interact with each other, or some factors may act as mediators for other factors. Future research is needed to examine these complex inter-relationships. Lastly, school location type and SES were based on the school's postal code and not the full catchment area for students who may be attending that school.

Conclusions

Overall, more than half of students were insufficiently active, but school-level factors within all four components of the CSH framework could play an integral role in supporting student PA. Most notably, school partnerships with youth organizations and school policies

allowing students to always access equipment during non-instructional time were consistently associated with higher MVPA and achieving the PA recommendations for multiple student subgroups. With the limited resources available to schools, these partnerships and policies within the CSH framework may be feasible areas to target for improvements. These findings suggest there is opportunity for schools to adopt changes within the CSH framework that have been successful in similar schools and support youth in achieving greater PA for optimal health and wellbeing.

Implications for School Health

We show that when examining many school characteristics within CSH in a single model, specific school characteristics were more strongly associated with PA behaviours in student subgroups. With limited school resources and a need to improve student PA, these findings can inform schools of which improvements could have the greatest impact with no or minimal investment (e.g., access to equipment during non-instructional time). These findings may be particularly informative in pandemic and post-pandemic contexts where schools may need to be even more selective in what programs or resources can be offered. There was purposefully no researcher-led intervention in this study with the intention that any school elements found to be beneficial for student PA has the potential to be replicated in similar schools. Communities of practice can help schools who have had success with enacting PA-promoting changes (e.g., partnering with local youth organizations) share their experiences with similar schools.

Human Subjects Approval Statement

Ethical approval was obtained from the University of Waterloo Office of Research Ethics (Project: 17264) and the University of Alberta Research Ethics Office (Project: 00040729). All school boards and schools approved study procedures. Active-information passive-consent was sought from parents, and assent was obtained from included participants on the day of data collection. Parents or students could decline to participate at any time.

Conflict of Interest Disclosure Statement

All authors of this article declare they have no conflicts of interest

Acknowledgements

This work was supported by a bridge grant from the Canadian Institutes of Health Research (CIHR) Institute of Nutrition, Metabolism and Diabetes (INMD) through the “Obesity—Interventions to Prevent or Treat” priority funding awards (OOP-110788; to S.T.L) and an operating grant from the Canadian Institutes of Health Research (CIHR) Institute of Population and Public Health (IPPH) (MOP-114875; to S.T.L). V.C. is supported by a CIHR New Investigator Salary Award and a Killam Accelerator Research Award.

Table 1. Characteristics of Schools Participating in Year 4 (2015–16) of the COMPASS Study in Ontario and Alberta, Canada

		N = 80 % (n)
Social Environment		
Enrolment	1 – 500	41.3 (33)
	501 – 1000	48.8 (39)
	> 1000	10.0 (8)
Socioeconomic status	25,000 – 50,000	10.0 (8)
	50,001 – 75,000	65.0 (52)
	75,001 – 100,000	21.3 (17)
	≥ 100,001	3.8 (3)
School priority of PA	1 st – 3 rd	22.5 (18)
	4 th – 6 th	45.0 (36)
	7 th – 10 th	22.5 (18)
	Missing	10.0 (8)
Promote PA events	Yes	88.8 (71)
	No	10.0 (8)
	Missing	1.3 (1)
Physical Environment		
Location	Rural	1.3 (1)
	Small Urban	43.8 (36)
	Medium Urban	16.3 (13)
	Large Urban	38.8 (31)
Curtains for changing	Both girls and boys	27.5 (22)
	Girls only	18.8 (15)
	Boys only	1.3 (1)
	None	43.8 (35)
	Other	8.8 (7)
Secure lockers in change room	Yes	80.0 (64)
	No	18.8 (15)
	Other	1.3 (1)
Showers	Both girls and boys	88.8 (71)
	Girls only	0.0 (0)
	Boys only	2.5 (2)
	None	5.0 (4)
	Other	3.8 (3)
Partnerships and Services		
Organizations providing support (check all that apply)	Local public health	47.5 (38)
	Non-governmental organization	60.0 (48)
	Parks and recreation	27.5 (22)
	Youth organizations	31.3 (25)
	Health and fitness club	50.0 (40)
	Consultant/specialist	35.0 (28)
Teaching and Learning		
	Both intramurals and non-competitive clubs	46.3 (37)

Non-curricular physical activity programs	Intramural only	18.8 (15)
	Non-competitive only	18.8 (15)
	None	16.3 (13)
Policy		
Written policy	Yes	56.3 (45)
	No	31.3 (25)
	Other	12.5 (10)
Use data from student health assessment to plan	Yes	40.0 (32)
	No	60.0 (48)
Access during non-instructional time:		
Indoor facilities	Yes	68.8 (55)
	No	31.3 (25)
Outdoor facilities	Yes	86.3 (69)
	No	11.3 (9)
	Other	2.5 (2)
Equipment	Always	30.0 (24)
	Sometimes	58.8 (47)
	Never	11.3 (9)
Access outside of school hours:		
Gymnasium	Yes	28.8 (63)
	No	21.3 (17)
	Other	0.0 (0)
Indoor facilities	Yes	77.5 (62)
	No	21.3 (17)
	Other	1.3 (1)
Outdoor facilities	Yes	86.0 (68)
	No	13.8 (11)
	Other	1.3 (1)
Equipment	Yes	68.8 (55)
	No	30.0 (24)
	Other	1.3 (1)
School board provided resource:		
Staff time	Yes	60.0 (48)
	No	33.8 (27)
	Other	6.3 (5)
Additional space	Yes	32.5 (26)
	No	58.8 (47)
	Other	8.8 (7)
Budget to improve health	≥ \$1001	36.3 (29)
	\$1- \$1000	15.0 (12)
	No funding	38.8 (31)
	Other	10.0 (8)

Notes: "Other" includes not applicable, no response, and uncodeable responses; due to rounding, percentages may not sum to 100

Table 2. Physical Activity of Students, By Grade, Participating in Year 4 (2015–16) of the COMPASS Study in Ontario and Alberta, Canada

	Grade 9 (n=9,761) % (n) / mean (SD)	Grade 10 (n=9,914) % (n) / mean (SD)	Grade 11 (n=9,485) % (n) / mean (SD)	Grade 12 (n=8,237) % (n) / mean (SD)	All Grades (n=37,397) % (n) / mean (SD)	Chi-square, df / F value[†], df
Gender						
Female	47.8 (4,670)	48.7 (4,829)	49.1 (4,654)	49.4 (4,070)	48.7 (18,223)	
Male	52.2 (5,091)	51.3 (5,085)	50.9 (4,831)	50.6 (4,831)	51.3 (19,174)	
Ethnicity						
White only	72.2 (7,046)	71.6 (7,095)	71.6 (6,791)	71.2 (5,862)	71.6 (26,794)	
Other	27.8 (2,715)	28.4 (2,819)	28.4 (2,694)	28.8 (2,375)	28.4 (10,603)	
Meets national physical activity guidelines						
Yes	50.9 (4,967)	45.3 (4,491)	44.0 (4,170)	39.8 (3,276)	45.2 (16,904)	$\chi^2 = 231.3^*$, df=3
No	49.1 (4,794)	54.7 (5,423)	56.0 (5,315)	60.2 (4,961)	54.8 (20,493)	
Total moderate-to-vigorous physical activity						
Minutes/week	957.3 (634.2)	887.9 (629.5)	864.0 (640.8)	828.2 (650.7)	886.8 (640.0)	F = 66.9*, df=3

Note: due to rounding, percentages may not sum to 100; [†] One-way Analysis of Variance (ANOVA) * p <

0.001

Table 3. Physical Activity of Students, By Gender, Participating in Year 4 (2015–16) of the COMPASS Study in Ontario and Alberta, Canada

	Female (n=18,223) n (%) / mean (SD)	Male (n=19,174) n (%) / mean (SD)	Total (n=37,397) n (%) / mean (SD)	Chi-square, df / F value†, df
Grade				
9	25.6 (4,670)	26.6 (5,091)	26.1 (9,761)	
10	26.5 (4,829)	26.5 (5,085)	26.5 (9,914)	
11	25.5 (4,654)	25.2 (4,831)	25.4 (9,485)	
12	22.3 (4,070)	21.7 (4,167)	22.0 (8,237)	
Ethnicity				
White only	73.0 (13,310)	70.3 (13,484)	71.7 (26,794)	
Other	27.0 (4,913)	29.7 (5,690)	28.4 (10,603)	
Meets national physical activity guidelines				
Yes	38.8 (7,061)	51.3 (9,843)	45.2 (16,904)	$\chi^2 = 597.6^*$, df=1
No	61.3 (11,162)	48.7 (9,331)	54.8 (20,493)	
Total Moderate-to-vigorous physical activity				
Minutes/week	777.8 (571.7)	990.3 (682.9)	886.8 (640.0)	F = 1058.3*, df=1

Note: due to rounding, percentages may not sum to 100; † One-way Analysis of Variance (ANOVA) * p <

0.001

Table 4. Adjusted Odds Ratios of Achieving National PA Guidelines According to Student and School Characteristics for each Gender and Grade Subgroup from Year 4 (2015–16) of the COMPASS Study in Ontario and Alberta, Canada

	Females n = 18,223 AOR [95% CI]	Males n = 19,174 AOR [95% CI]	Grade 9 n = 9,761 AOR [95% CI]	Grade 10 n = 9,914 AOR [95% CI]	Grade 11 n = 9,485 AOR [95% CI]	Grade 12 n = 8,237 AOR [95% CI]
ICC (null model)	0.016	0.009	0.013	0.020	0.012	0.016
Student-level						
Grade						
9	REF	REF	----	----	----	----
10	0.72 [0.66, 0.78]***	0.88 [0.82, 0.96]**	----	----	----	----
11	0.65 [0.60, 0.71]***	0.88 [0.81, 0.95]**	----	----	----	----
12	0.52 [0.47, 0.57]***	0.77 [0.70, 0.83]***	----	----	----	----
Gender						
Male [REF=Female]	----	----	1.35 [1.25, 1.47]***	1.67 [1.54, 1.81]***	1.82 [1.67, 1.98]***	2.00 [1.82, 2.19]***
Ethnicity						
Other [REF=White only]	0.84 [0.78, 0.90]***	1.03 [0.96, 1.09]	0.87 [0.79, 0.95]**	0.94 [0.85, 1.03]	0.98 [0.89, 1.08]	0.98 [0.88, 1.08]
School-level						
Social Environment						
Enrolment						
1 – 500	REF	REF	REF	REF	REF	REF
501 – 1000	1.06 [0.94, 1.18]	1.17 [1.05, 1.30]**	1.32 [1.13, 1.55]***	0.96 [0.81, 1.14]	1.08 [0.91, 1.27]	0.91 [0.76, 1.09]
> 1000	1.22 [0.98, 1.51]	1.32 [1.08, 1.61]**	1.53 [1.12, 2.10]**	1.01 [0.73, 1.40]	1.09 [0.80, 1.51]	0.97 [0.69, 1.38]
Socioeconomic status						
25,000 – 50,000	REF	REF	REF	REF	REF	REF
50,001 – 75,000	1.02 [0.89, 1.17]	1.01 [0.89, 1.15]	1.04 [0.85, 1.26]	0.94 [0.77, 1.16]	1.09 [0.89, 1.32]	0.96 [0.78, 1.19]
75,001 – 100,000	1.00 [0.84, 1.19]	0.88 [0.76, 1.03]	0.99 [0.77, 1.26]	0.91 [0.72, 1.16]	0.99 [0.78, 1.25]	0.83 [0.65, 1.07]
≥ 100,001	1.09 [0.84, 1.42]	1.34 [1.04, 1.73]*	1.44 [0.93, 2.22]	1.05 [0.69, 1.60]	1.52 [1.03, 2.25]*	0.89 [0.58, 1.38]
School Priority of PA						
1 st – 3 rd	REF	REF	REF	REF	REF	REF
4 th – 6 th	0.83 [0.74, 0.94]**	1.00 [0.89, 1.13]	0.94 [0.79, 1.11]	0.89 [0.74, 1.07]	0.88 [0.75, 1.05]	1.03 [0.85, 1.25]
7 th – 10 th	0.77 [0.65, 0.92]**	1.11 [0.95, 1.30]	1.13 [0.89, 1.42]	0.89 [0.70, 1.13]	0.93 [0.74, 1.18]	0.94 [0.72, 1.22]
Missing	0.65 [0.53, 0.79]***	1.05 [0.87, 1.28]	1.11 [0.85, 1.46]	0.56 [0.42, 0.76]***	0.79 [0.59, 1.06]	1.11 [0.80, 1.53]
Promotes PA events	1.09 [0.94, 1.27]	1.09 [0.96, 1.24]	1.00 [0.81, 1.23]	1.10 [0.90, 1.36]	1.02 [0.83, 1.26]	1.14 [0.90, 1.43]
Physical Environment						
Location						
Rural/Small Urban	REF	REF	REF	REF	REF	REF
Medium Urban	1.09 [0.95, 1.26]	0.98 [0.86, 1.12]	0.92 [0.76, 1.13]	1.11 [0.91, 1.36]	1.09 [0.89, 1.33]	1.16 [0.93, 1.45]
Large Urban	1.11 [0.95, 1.30]	1.03 [0.90, 1.18]	0.98 [0.78, 1.22]	1.08 [0.86, 1.36]	1.02 [0.81, 1.28]	1.35 [1.06, 1.72]*

Curtains						
Boys and girls	----	----	1.06 [0.89, 1.27]	1.04 [0.89, 1.22]	0.93 [0.80, 1.09]	1.13 [0.95, 1.34]
Boys only or girls only†	0.99 [0.90, 1.08]	1.03 [0.95, 1.13]	1.12 [0.95, 1.32]	1.06 [0.89, 1.25]	0.90 [0.76, 1.07]	1.08 [0.90, 1.31]
Other	----	----	1.09 [0.81, 1.46]	1.23 [0.93, 1.64]	1.03 [0.78, 1.37]	1.33 [0.98, 1.81]
None	REF	REF	REF	REF	REF	REF
Secure lockers available	1.21 [1.04, 1.40]*	1.04 [0.91, 1.20]	0.89 [0.72, 1.08]	1.29 [1.04, 1.61]*	1.10 [0.89, 1.36]	1.06 [0.84, 1.34]
Showers						
Boys and girls	----	----	0.87 [0.66, 1.14]	0.98 [0.75, 1.29]	0.71 [0.54, 0.94]*	0.77 [0.57, 1.02]
Boys only or girls only†	0.73 [0.63, 0.84]***	0.92 [0.80, 1.06]	0.94 [0.59, 1.50]	1.51 [0.93, 2.44]	1.11 [0.68, 1.81]	0.82 [0.49, 1.37]
Other	----	----	1.30 [0.75, 2.24]	1.16 [0.67, 1.99]	1.02 [0.60, 1.75]	0.88 [0.50, 1.55]
None	REF	REF	REF	REF	REF	REF
Partnerships and Services						
Public health	1.02 [0.92, 1.12]	1.13 [1.03, 1.24]**	1.01 [0.87, 1.17]	1.13 [0.96, 1.32]	1.13 [0.97, 1.32]	0.98 [0.83, 1.17]
Non-governmental organization	0.84 [0.77, 0.92]***	0.84 [0.77, 0.91]***	0.88 [0.78, 0.99]*	0.75 [0.67, 0.85]***	0.90 [0.79, 1.02]	0.81 [0.71, 0.93]**
Parks and recreation	0.95 [0.85, 1.06]	0.97 [0.88, 1.07]	0.98 [0.84, 1.14]	0.94 [0.80, 1.09]	0.98 [0.84, 1.14]	1.07 [0.90, 1.27]
Youth organizations	1.15 [1.03, 1.28]*	1.15 [1.03, 1.27]**	1.04 [0.89, 1.21]	1.16 [1.00, 1.36]	1.33 [1.13, 1.55]***	1.20 [1.01, 1.43]*
Health and fitness club	1.02 [0.91, 1.15]	0.96 [0.87, 1.07]	1.12 [0.95, 1.32]	0.97 [0.83, 1.15]	1.04 [0.88, 1.23]	1.12 [0.93, 1.34]
Consultant/specialist	0.94 [0.85, 1.05]	1.04 [0.94, 1.14]	1.01 [0.87, 1.17]	0.88 [0.76, 1.03]	0.95 [0.81, 1.10]	0.92 [0.78, 1.09]
Teaching and Learning						
Non-curricular PA programs						
Intramural and non-competitive	1.14 [1.00, 1.30]*	1.15 [1.01, 1.30]*	1.17 [0.98, 1.40]	1.37 [1.13, 1.65]**	1.04 [0.86, 1.24]	0.97 [0.79, 1.19]
Intramural only	1.20 [1.03, 1.39]*	1.05 [0.91, 1.20]	1.06 [0.85, 1.31]	1.46 [1.18, 1.80]***	1.05 [0.85, 1.31]	1.10 [0.79, 1.29]
Non-competitive only	1.18 [1.01, 1.38]*	1.01 [0.87, 1.17]	1.21 [0.98, 1.48]	1.27 [1.03, 1.58]*	1.06 [0.85, 1.31]	0.94 [0.74, 1.20]
No programs	REF	REF	REF	REF	REF	REF
Policy						
Has written policy	1.01 [0.89, 1.15]	0.96 [0.86, 1.07]	0.92 [0.77, 1.11]	0.96 [0.80, 1.17]	0.89 [0.73, 1.08]	0.89 [0.72, 1.09]
Uses data to plan	0.98 [0.88, 1.09]	0.99 [0.90, 1.09]	1.07 [0.92, 1.24]	0.95 [0.82, 1.10]	1.03 [0.89, 1.19]	0.96 [0.82, 1.13]
<i>Access during non-instructional time:</i>						
Indoor facility	0.87 [0.77, 0.98]*	0.89 [0.80, 1.00]	1.09 [0.93, 1.28]	0.77 [0.65, 0.92]**	0.79 [0.67, 0.95]**	0.90 [0.74, 1.09]
Outdoor facility	0.86 [0.74, 1.00]*	0.98 [0.85, 1.12]	0.77 [0.63, 0.94]*	1.10 [0.88, 1.37]	0.96 [0.77, 1.19]	0.88 [0.70, 1.11]
Equipment						
Always	1.25 [1.10, 1.43]***	1.29 [1.15, 1.46]***	1.22 [1.02, 1.47]*	1.21 [1.00, 1.48]	1.34 [1.11, 1.61]**	1.21 [0.99, 1.48]
Sometimes	1.24 [1.07, 1.45]**	1.10 [0.96, 1.26]	1.13 [0.91, 1.40]	1.11 [0.89, 1.38]	1.14 [0.92, 1.40]	1.11 [0.89, 1.40]
Never	REF	REF	REF	REF	REF	REF
<i>Access after school hours:</i>						
Gymnasium	1.18 [0.98, 1.43]	0.92 [0.79, 1.07]	0.94 [0.74, 1.19]	1.42 [1.10, 1.81]**	0.93 [0.73, 1.19]	0.91 [0.69, 1.20]
Indoor facility	1.11 [0.98, 1.26]	1.08 [0.96, 1.21]	1.12 [0.95, 1.33]	1.03 [0.86, 1.23]	1.30 [1.09, 1.55]**	1.03 [0.84, 1.25]
Outdoor facility	0.96 [0.86, 1.15]	0.94 [0.82, 1.07]	0.98 [0.80, 1.19]	0.82 [0.66, 1.01]	1.08 [0.88, 1.32]	1.23 [0.98, 1.55]
Equipment	0.77 [0.67, 0.89]***	1.04 [0.93, 1.18]	1.01 [0.84, 1.22]	0.80 [0.65, 0.99]*	0.83 [0.68, 1.02]	0.78 [0.62, 0.98]*
<i>Resources from school board:</i>						
Staff time	1.04 [0.94, 1.15]	1.00 [0.91, 1.10]	0.95 [0.83, 1.10]	0.98 [0.85, 1.13]	0.99 [0.85, 1.15]	1.21 [1.03, 1.42]*

Space Budget	0.90 [0.78, 1.03]	1.06 [0.93, 1.20]	0.98 [0.81, 1.18]	1.13 [0.93, 1.38]	0.94 [0.76, 1.15]	0.92 [0.74, 1.16]
No funding	REF	REF	REF	REF	REF	REF
\$1 – \$1000	0.94 [0.83, 1.07]	1.01 [0.90, 1.14]	1.03 [0.86, 1.22]	0.88 [0.73, 1.05]	1.04 [0.87, 1.25]	0.97 [0.79, 1.19]
≥ \$1001	0.87 [0.79, 0.96]**	0.88 [0.81, 0.96]**	0.86 [0.74, 1.00]*	0.78 [0.67, 0.91]*	0.84 [0.72, 0.97]*	0.88 [0.75, 1.03]
Other	0.89 [0.76, 1.05]	1.02 [0.88, 1.18]	0.88 [0.70, 1.09]	1.00 [0.80, 1.26]	1.04 [0.83, 1.30]	0.83 [0.65, 1.06]

Notes: Unless otherwise stated, the reference category is any response other than a definitive “Yes” (e.g., no, not applicable, no response, uncodeable); † For single gender subgroup analyses, this category represents having the school feature specific to that gender (e.g., showers for female students); AOR = Adjusted odds ratio; CI = Confidence interval; *p < 0.05; ** p < 0.01; *** p < 0.001

Table 5. Regression Coefficients for Total Weekly Minutes of MVPA According to Student and School Characteristics for each Gender and Grade Subgroup from Year 4 (2015–16) of the COMPASS Study in Ontario and Alberta, Canada

	Females n = 18,223 B [95% CI]	Males n = 19,174 B [95% CI]	Grade 9 n = 9,761 B [95% CI]	Grade 10 n = 9,914 B [95% CI]	Grade 11 n = 9,485 B [95% CI]	Grade 12 n = 8,237 B [95% CI]
ICC (null model)	0.0158	0.0209	0.0221	0.0163	0.0210	0.0167
Student-level						
Grade						
9	REF	REF	---	---	---	---
10	-85.7 [-108.6, -62.9]***	-49.7 [-76.1, 23.2]***	---	---	---	---
11	-121.8 [-144.9, -98.7]***	-56.4 [83.2, -29.6]***	---	---	---	---
12	-162.7 [-186.6, -138.8]***	-83.0 [-110.8, -55.1]***	---	---	---	---
Gender						
Male (REF=Female)	---	---	167.0 [142.0, 192.0]***	207.5 [183.0, 232.0]***	237.7 [212.3, 263.1]***	244.7 [217.0, 272.3]***
Ethnicity						
Other (REF=White only)	-22.7 [-42.2, -3.2]*	10.9 [-10.9, 32.8]	-30.1 [-59.2, -1.03]*	-20.9 [-48.9, 7.2]	-0.09 [-29.2, 29.0]	29.5 [-2.0, 61.0]
School-level						
Social Environment						
Enrolment						
1 – 500	REF	REF	REF	REF	REF	REF
501 – 1000	58.0 [17.7, 98.4]**	77.6 [24.3, 130.8]**	72.1 [18.0, 126.3]**	50.4 [1.2, 99.7]*	43.1 [-18.2, -104.5]	27.7 [-26.0, 81.4]
> 1000	77.9 [-0.5, 156.3]	35.6 [-67.0, 138.2]	62.2 [-45.5, 169.9]	28.5 [-65.6, 122.7]	-47.1 [-168.4, 74.2]	-38.3 [-143.7, 67.0]
Socioeconomic status						
25,000 – 50,000	REF	REF	REF	REF	REF	REF
50,001 – 75,000	-8.8 [-61.2, 43.6]	-7.1 [-78.9, 64.8]	-39.9 [-108.3, 28.4]	11.6 [-46.8, 70.1]	-50.3 [-128.3, 27.6]	24.1 [-40.9, 89.1]
75,001 – 100,000	-68.1 [-130.4, -5.8]*	-91.7 [-172.3, -11.1]*	-78.8 [-163.0, 5.5]	-57.1 [-124.9, 10.8]	-90.1 [-178.9, -1.2]*	-101.6 [-177.3, -26.0]**
≥ 100,001	37.5 [-61.5, 136.6]	-40.6 [-171.4, 90.2]	-8.4 [-154.9, 138.1]	-25.7 [-147.8, 96.4]	0.04 [-149.7, 149.7]	-24.1 [-40.9, 89.1]
School Priority of PA						
1 st – 3 rd	REF	REF	REF	REF	REF	REF
4 th – 6 th	-43.8 [-87.6, -0.03]*	59.2 [2.4, 116.1]*	45.7 [-12.3, 103.8]	59.1 [6.5, 111.8]*	-36.0 [-99.0, 27.1]	39.4 [-18.4, 97.2]
7 th – 10 th	-29.6 [-91.7, 32.5]	89.5 [9.0, 170.1]*	91.5 [12.2, 170.8]*	23.2 [-46.4, 92.8]	-0.2 [-88.8, 88.5]	88.5 [8.6, 168.3]*
Missing	5.2 [-67.2, 77.6]	149.1 [53.6, 244.7]**	149.0 [55.8, 242.1]**	94.1 [8.3, 180.0]**	41.7 [-66.4, 149.8]	156.2 [57.7, 254.7]**
Promotes PA events	-61.4 [-115.7, -7.2]*	-44.0 [-110.7, 22.7]	-89.8 [-160.6, -19.0]*	2.2 [-57.5, 62.0]	-100.6 [-178.7, -22.6]*	0.6 [-68.7, 70.0]
Physical Environment						
Location						
Rural/Small Urban	REF	REF	REF	REF	REF	REF
Medium Urban	-27.1 [-77.8, 23.7]	-78.6 [-145.7, -11.5]*	-80.6 [-148.4, -12.8]*	-25.2 [-83.3, 33.0]	-1.6 [-76.8, 73.5]	-54.9 [-121.8, 12.0]
Large Urban	-64.3 [-118.8, -9.8]*	-114.7 [-183.5, -45.9]	-87.2 [-162.0, -12.4]*	-52.1 [-117.5, 13.4]	-83.9 [-165.8, -2.0]*	8.6 [-64.2, 81.3]
Curtains						

Boys and girls	----	----	44.7 [-15.9, 105.4]	51.0 [5.9, 96.2]*	13.2 [-46.1, 72.6]	41.8 [-9.9, 93.4]
Boys only or girls only†	6.0 [-27.2, 39.2]	23.6 [-23.7, 71.0]	37.0 [-19.5, 93.5]	25.1 [-23.4, 73.6]	6.4 [-57.0, 69.8]	45.8 [-10.8, 102.4]
Other	----	----	104.6 [3.4, 205.7]*	10.5 [-71.8, 92.9]	65.9 [-42.0, 173.8]	-8.5 [-101.8, 84.8]
None	REF	REF	REF	REF	REF	REF
Secure lockers	-24.6 [-76.6, 27.4]	-94.2 [-161.2, -27.1]**	-92.8 [-161.5, -24.1]**	-67.9 [-130.8, -4.9]*	-63.9 [-142.7, 15.0]	-96.3 [-168.6, -24.1]**
Showers						
Boys and girls	----	----	23.8 [-69.7, 117.3]	47.5 [-30.8, 125.8]	-73.2 [-174.9, 28.5]	82.2 [-6.4, 170.8]
Boys only or girls only†	-14.9 [-68.2, 38.4]	-0.2 [-71.9, 71.5]	-17.8 [-178.6, 143.0]	-27.7 [-168.4, 112.9]	-69.7 [-253.8, 114.4]	-92.2 [-250.6, 66.1]
Other	----	----	-19.1 [-203.6, 165.4]	158.6 [1.6, 315.6]*	24.5 [-175.7, 224.8]	164.1 [-9.0, 337.1]
None	REF	REF	REF	REF	REF	REF
Partnerships and Services						
Public health	-22.4 [-58.7, 13.9]	14.8 [-34.0, 63.6]	-41.0 [-92.0, 10.0]	21.8 [-24.0, 67.7]	-10.2 [-68.4, 47.9]	-8.3 [-59.8, 43.2]
Non-governmental organization	-29.7 [-62.3, 2.9]	-1.9 [-42.1, 38.4]	6.6 [-34.0, 47.2]	-59.7 [-95.1, -24.4]**	-16.1 [-62.8, 30.7]	-40.1 [-81.3, 1.1]
Parks and recreation	-21.2 [-60.1, 17.7]	2.3 [-48.7, 53.3]	-12.8 [-65.4, 39.8]	-17.5 [-61.0, 26.0]	33.6 [-23.4, 90.7]	7.5 [-43.0, 58.0]
Youth organizations	14.4 [-25.4, 54.1]	-15.3 [-66.3, 35.7]	-35.9 [-88.0, 16.3]	35.1 [-9.4, 79.7]	37.9 [-21.1, 96.9]	-24.7 [-76.5, 27.1]
Health and fitness club	-17.8 [-57.9, 22.4]	-25.8 [-76.0, 24.4]	-7.8 [-62.8, 47.1]	-34.1 [-82.2, 14.1]	1.8 [-60.2, 63.8]	38.6 [-17.4, 94.6]
Consultant/specialist	12.4 [-26.7, 51.5]	26.2 [-24.9, 77.3]	42.1 [-9.2, 93.3]	-40.1 [-84.7, 4.5]	-11.9 [-69.3, 45.5]	20.8 [-29.9, 71.6]
Teaching and Learning						
Non-curricular PA programs						
Intramural and non-competitive	10.9 [-35.8, 57.5]	5.6 [-57.3, 68.5]	69.3 [9.2, 129.5]*	14.8 [-39.2, 68.9]	-65.5 [-134.2, 3.1]	-57.7 [-118.1, 2.8]
Intramural only	13.3 [-40.3, 66.9]	-4.6 [-73.6, 64.4]	30.0 [-42.9, 103.0]	5.8 [-55.8, 67.4]	-10.2 [-88.9, 68.6]	-104.7 [-177.5, -31.8]**
Non-competitive only	47.7 [-8.2, 103.7]	40.8 [-32.3, 114.0]	100.4 [30.0, 170.9]**	60.9 [-1.5, 123.2]	9.8 [-71.0, 90.5]	-16.3 [-87.9, 55.3]
No programs	REF	REF	REF	REF	REF	REF
Policy						
Has written policy	-21.0 [-66.9, 24.9]	-58.8 [-115.5, -2.0]*	-23.6 [-86.0, 38.9]	-47.6 [-103.0, 7.7]	-82.5 [-154.7, -10.3]*	-47.6 [-109.8, 14.6]
Uses data to plan	13.4 [-23.8, 50.6]	18.2 [-29.2, 65.6]	42.0 [-7.7, 91.7]	27.4 [-14.7, 69.5]	-5.6 [-59.5, 48.4]	35.7 [-12.9, 84.3]
<i>Access during non-instructional time:</i>						
Indoor facility	35.0 [-8.8, 78.8]	54.7 [-1.49, 110.9]	124.0 [69.0, 179.0]***	4.0 [-46.2, 81.0]	14.6 [-49.7, 78.9]	73.0 [14.5, 131.5]*
Outdoor facility	-51.8 [-106.7]	-37.5 [-109.6, 34.5]	-137.3 [-206.2, -68.5]***	17.5 [-46.2, 81.1]	63.4 [-17.9, 144.8]	-65.8 [-136.6, 4.9]
Equipment						
Always	107.2 [56.0, 158.5]***	59.9 [-7.5, 127.2]	22.1 [-42.4, 86.6]	95.4 [38.5, 152.4]**	96.6 [23.0, 170.3]*	87.6 [26.5, 148.8]**
Sometimes	88.7 [30.8, 146.7]**	5.1 [-69.6, 79.7]	15.0 [-59.0, 89.0]	55.0 [-8.8, 118.9]	41.1 [-42.1, 124.4]	25.9 [-43.1, 95.0]
Never	REF	REF	REF	REF	REF	REF
<i>Access after school hours:</i>						
Gymnasium	-24.7 [-95.0, 45.6]	-16.0 [-98.7, 66.7]	-22.0 [-103.9, 59.9]	-39.2 [-109.1, 30.7]	18.1 [-77.2, 113.3]	-66.1 [-150.0, 17.8]
Indoor facility	-20.5 [-68.3, 27.3]	-51.9 [-113.9, 10.1]	-22.8 [-81.9, 36.2]	-50.1 [-101.8, 1.5]	-32.2 [-99.3, 34.9]	-61.4 [-121.0, -1.9]*
Outdoor facility	-3.9 [-56.8, 49.1]	-30.7 [-100.0, 38.5]	-64.0 [-132.7, 4.7]	-32.8 [-94.5, 28.9]	48.6 [-30.8, 127.9]	10.2 [-59.1, 79.4]
Equipment	0.6 [-50.8, 52.0]	34.3 [-27.8, 96.4]	56.6 [-7.7, 120.9]	34.2 [-25.6, 93.9]	-43.7 [-121.2, 33.8]	21.2 [-48.8, 91.2]
<i>Resources from school board:</i>						
Staff time	38.3 [11.9, 74.7]*	-15.8 [-63.3, 31.8]	9.6 [-38.5, 57.8]	-1.5 [-43.7, 40.7]	3.7 [-50.1, 57.6]	23.8 [-25.1, 72.7]
Space	-52.5 [-100.5, -4.5]*	39.4 [-21.1, 100.0]	18.5 [-43.6, 80.7]	52.1 [-5.4, 109.7]	1.0 [-72.5, 74.4]	22.1 [-45.6, 89.7]

Budget	REF	REF	REF	REF	REF	REF
No funding						
\$1 – \$1000	49.9 [2.07, 97.8]*	-9.5 [-72.0, 53.0]	-8.0 [-68.2, 52.3]	33.3 [-18.2, 84.8]	50.8 [-18.1, 119.6]	-19.4 [-80.5, 41.8]
≥ \$1001	23.6 [-13.2, 60.4]	-9.9 [-55.6, 35.7]	-5.7 [-56.3, 44.9]	-40.2 [-82.4, 2.1]	-25.1 [-81.4, 31.2]	0.08 [-49.1, 49.3]
Other	47.2 [-13.0, 107.3]	-25.0 [-102.0, 52.0]	-30.1 [-106.2, 46.0]	3.4 [-63.4, 70.2]	43.9 [-41.7, 129.5]	11.1 [-61.9, 84.1]

Notes: Unless otherwise stated, the reference category is any response other than a definitive “Yes” (i.e., no, not applicable, no response, uncodeable); † For single gender subgroup analyses, this category represents having the school feature specific to that gender (e.g., showers for female students). *p < 0.05; ** p < 0.01; *** p < 0.001

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Chapter 5

Manuscript 2: School-level factors within Comprehensive School Health associated with the trajectory of moderate-to-vigorous physical activity over time: A longitudinal, multilevel analysis in a large sample of Grade 9 and 10 students in Canada

This manuscript is presented as submitted to the International Journal of Environmental Research and Public Health. Referencing also appears according to journal requirements.

Pirrie, M., Carson, V., Dubin, J.A., & Leatherdale, S.T. (2021). School-level factors within Comprehensive School Health associated with the trajectory of moderate-to-vigorous physical activity over time: A longitudinal, multilevel analysis in a large sample of Grade 9 and 10 students in Canada. Submitted to the International Journal of Environmental Research and Public Health (Manuscript ID: ijerph-1462207).

Overview

(1) The majority of Canadian youth are insufficiently active, and moderate-to-vigorous physical activity (MVPA) decreases substantially during secondary school. School factors within the Comprehensive School Health framework may help attenuate this decline. This study aimed to examine how youth MVPA changes over a three-year period and evaluate the school characteristics associated with preventing the decline in MVPA over time, guided by the CSH framework. (2) This study uses COMPASS survey data from 78 secondary schools in Ontario and Alberta that participated in Year 2 (2013/14), Year 3 (2014/15), and Year 4 (2015/2016), and 17,661 students attending these schools. Multilevel (linear mixed effects) models were used to determine the association between school-level factors and student MVPA (weekly minutes) over time, stratified by gender. (3) Both male and female students had a significant decline in MVPA across the 3 years, with a greater decrease observed among female students. Within the CSH framework, the school's social environment, partnerships, and policies were associated with student MVPA over time, however the specific school factors and directions of associations varied by gender. (4) School-based interventions (e.g., public health partnership) may help avoid the decline in MVPA observed in this critical period and support student health.

Introduction

Secondary school is a critical life stage when physical activity (PA) declines sharply [1–4]. There are numerous physical and mental health benefits for youth who participate in PA, such as reducing risk factors for hypertension and diabetes during their youth [5,6]. In addition, PA during adolescence is significantly correlated with adult PA behaviour and health [7,8]. Since active youth are more likely to be active adults, this leads to many health benefits, including reduced risk of some cancers, cardiovascular disease, stroke, and diabetes [6,7]. In particular, adult bone density is heavily dependent on PA during youth [7]. As a result, it is imperative to support youth in avoiding the ‘adolescent decline’ in PA during secondary school to realize both immediate and future health benefits.

The Canadian 24-Hour Movement Guidelines for Children and Youth [9] recommends that youth participate in at least 60 minutes of moderate-to-vigorous PA (MVPA) daily and that achieving additional MVPA is associated with even greater health benefits [9]. According to the combined cycle 2 (2009-2011) and cycle 3 (2012-2013) of the Canadian Community Health Measures Survey (CHMS), which objectively measured PA with accelerometers, only 31% of youth aged 12 to 17 years attained an average of 60 minutes of MVPA per day [10]. A significant decline in PA typically occurs around 15-16 years of age [3], and females are more likely to experience the PA decline earlier than males [4]. Adolescents spend a substantial amount of time at school each week and, although it is not their primary mandate, schools can play a critical role in supporting students in achieving optimal levels of MVPA during this pivotal period.

The Comprehensive School Health (CSH) framework [11] provides guidance on four inter-connected components on which schools can focus to improve health behaviours among its students: 1) social and physical environment; 2) partnerships and services; 3) teaching and learning; and 4) policy. Multiple cross-sectional studies have included school features found within the CSH framework in their analysis, finding that they can improve PA behaviour [11,12]. Specifically, student PA is higher in schools that have higher ratings of social support [13], have more facilities available [14], have established community partnerships [15], offer extracurricular and intramural PA opportunities [16,17], and provide access to facilities and outside of school hours [15]. However, there was no study that identified examining all components of the CSH framework simultaneously and its association with the trajectory of MVPA in a cohort of students followed longitudinally.

The aims of the current study are to examine how youth MVPA changes over a three-year period in a large sample of secondary school students, stratified by gender, and to evaluate the school characteristics associated with preventing the decline in MVPA over time, guided by the CSH framework. This novel study is exploratory and not seeking to confirm previous findings but instead will guide future comprehensive school health research specific to youth MVPA in a Canadian context.

Material and Methods

Design

This study uses linked longitudinal data available from the COMPASS study [18]. COMPASS is a prospective cohort study (2012-2021) following a large sample of Canadian grade 9

to 12 students and the schools they attend, where data are to be used to evaluate natural experiments related to school-level impact on student health behaviours [18,19].

School and Student Participants

The current study examines data collected from 78 schools in Ontario (n=69) and Alberta (n=9) that provided data in Year 2 (Y2: 2013/14), Year 3 (Y3: 2014/15), and Year 4 (Y4: 2015/2016). This time period corresponds with the largest initial intake of schools to COMPASS (Y1 and Y2) and when these schools completed the baseline COMPASS School Policies and Practices Questionnaire. Although COMPASS includes all students (Grades 9 to 12), this study only includes students in Grade 9 or 10 during Y2 so they could be tracked over three years prior to graduating from grade 12 and leaving the cohort. Due to the anonymous longitudinal linkage procedure (see ‘Data Collection’ for more details), only students who participated in COMPASS for at least two of the three years (did not need to be consecutive years) were included in the Y2 to Y4 linked COMPASS cohort (n=17,700). The current study sample was also restricted to students with complete data (sex, grade, ethnicity, and MVPA) for at least one of the study years (n=17,661 students); of those included in the study, 45.4% (n=8,011) had complete data for all three years, 51.7% (n=9,138) for any two years, and 2.9% (n=512) for only one year.

Recruitment

Detailed student and school recruitment methods have been published [18]. In summary, COMPASS approached school boards that allow active-information, passive-consent. With school board approval, individual schools were recruited and then students and parents were sent information with multiple mechanisms to opt-out. Students could decline to participate or withdraw at any time. All students attending these schools were invited to participate and less than 1% opted out annually. From these 78 schools, 79% of eligible students participated in Y2, 79% in Y3, and 80% in Y4.

Ethics approval was received by the University of Waterloo Office of Research Ethics (Project #30118), University of Alberta Research Ethics Office (Project #00040729), and by each school board and/or school as required.

Data Collection Procedures

A COMPASS staff member was onsite to facilitate data collection and identify the most appropriate individual to complete the school-level survey. Students completed the survey during a class period and placed it in a sealed envelope. An identification code was self-generated by the student based on a combination of facts specific to that student (e.g., second letter of first name). This allowed student data to be collected anonymously while also facilitating linkage across multiple COMPASS years. Successful linkage and inclusion in the longitudinal dataset required the student to be matched across at least two years of data, and the linkage rate is approximately 80% [20]. Further details on the approach to longitudinal data linkage are available [20,21].

Measures

School Variables

School-level data were collected the first year that the school took part in COMPASS. The COMPASS School Policies and Practices Questionnaire collects information on the school's facilities, policies, programs, and resources, and was completed by a school administrator or other person identified as most knowledgeable about these characteristics. The 2011 Canada Census and school postal code were matched to describe school location (e.g., urban) and neighbourhood socio-economic status (SES). School-level characteristics included in this study are listed in Table 6, in addition to the presence of indoor facilities, outdoor facilities, a gymnasium, change rooms, and interschool/varsity sports teams.

Student Variables

The COMPASS student questionnaire (Cq,) was completed annually. The Cq was designed to collect health behaviour data from students within their school setting, taking into consideration the feasibility of administration within a class period and student confidentiality [18]. Also, the questions were purposefully selected to align with national guidelines and match other surveys, allowing for cross-study comparison.

Two questions from Cq were summed to determine weekly MVPA: (1) “Mark how many minutes of HARD physical activities you did on each of the last 7 days,” and (2) “Mark how many minutes of MODERATE physical activities you did on each of the last 7 days,” A validation study found that students tended to under-report their moderate PA and over-report their vigorous activity, however the validity improved when combined as MVPA (Pearson correlation, $r = 0.31$) and was similar to other self-report questionnaires [22]. Test-retest reliability for the combined MVPA measure was moderate ($r = 0.68$). In addition, student gender, grade, and ethnicity were collected using the Cq.

Statistical Analysis

Descriptive analysis was conducted for school and student characteristics. Three-level linear mixed effects models (3-level growth models) with the outcome of weekly MVPA minutes were run for each gender separately. First, null models were run to identify the school-level intraclass correlations (ICCs) for female students and male students. Second, time was added as a Level-1 variable to create the unconditional growth model. Third, student ethnicity and grade cohort were added at the student-level (i.e., Level 2) as fixed effects, based on the first reported value by the student. Finally, school-level variables were added as fixed effects at Level 3, including cross-level interactions for each school-variable with time. All analyses were conducted using SAS 9.04 and the MIXED procedure was used to analyze the linear mixed models. As this study is exploratory, the

results section of this article is primarily focused on the factors within each CSH component that were found to be statistically significant, however all results have been included in the tables and should be scrutinized.

Results

School-level Characteristics

In the 78 schools, all or almost all had a gymnasium (98.7%), other indoor facilities (97.4%), change rooms (94.9%), outdoor facilities (98.7%), and intervarsity sports (100%), so these features were not included in any of the regression models. The frequencies for each of the remaining school characteristics included in the regression models are provided in Table 6.

Table 6. Baseline characteristics of schools participating in Year 2 (2013-14), Year 3 (2014-15), and Year 4 (2015–16) of the COMPASS Study in Ontario and Alberta, Canada

School Characteristics		N = 78 % (n)
Demographic		
Enrolment	1 – 500	41.0 (32)
	501 – 1000	50.0 (39)
	≥ 1001	9.0 (7)
SES	25,000 – 50,000	9.0 (7)
	50,001 – 75,000	65.4 (51)
	75,001 – 100,000	21.8 (17)
	≥ 100,001	3.9 (3)
Location	Rural	1.3 (1)
	Small Urban	43.6 (34)
	Medium Urban	16.7 (13)
	Large Urban	38.5 (30)
Social Environment		
School priority of PA	1 st – 3 rd	21.8 (17)
	4 th – 6 th	44.9 (35)
	7 th – 10 th	23.1 (18)
	Missing	10.3 (8)
Promote PA events	Yes	88.5 (69)
	No	10.3 (8)
	Missing	1.3 (1)

Physical Environment

Curtains for changing	Both girls and boys	26.9 (21)
	Girls only	19.2 (15)
	Boys only	1.3 (1)
	None	43.6 (34)
	Missing	9.0 (7)
Secure lockers in change room	Yes	79.5 (62)
	No	19.2 (15)
	Missing	1.3 (1)
Showers Available	Both girls and boys	88.5 (69)
	Girls only	0.0 (0)
	Boys only	2.6 (2)
	None	5.1 (4)
	Missing	3.9 (3)
Partnerships and Services		
Organizations providing support (check all that apply)	Local public health	52.6 (37)
	Non-governmental organization	60.3 (47)
	Parks and recreation	27.0 (21)
	Youth organizations	29.5 (23)
	Health and fitness club	50.0 (39)
	Consultant/specialist	34.6 (27)
Teaching and Learning		
Non-curricular physical activity programs	Both intramurals and non-competitive clubs	44.9 (35)
	Intramural only	19.2 (15)
	Non-competitive only	19.2 (15)
	None	16.7 (13)
Healthy School Policy		
Written policy	Yes	57.7 (45)
	No	30.8 (24)
	Missing	11.5 (9)
Use data from student health assessment to plan	Yes	38.5 (30)
	No	61.5 (48)
<i>Access during non-instructional time:</i>		
Indoor facilities	Yes	68.0 (53)
	No	32.1 (25)
Outdoor facilities	Yes	85.9 (67)
	No	11.5 (9)
	Missing	2.6 (2)
Equipment	Always	29.5 (23)
	Sometimes	59.0 (46)
	Never	11.5 (9)
<i>Access outside of school hours:</i>		
Gymnasium	Yes	78.2 (61)
	No	21.8 (17)

Indoor facilities	Yes	76.9 (60)
	No	21.8 (17)
	Missing	1.3 (1)
Outdoor facilities	Yes	84.6 (66)
	No	14.1 (11)
	Missing	1.3 (1)
Equipment	Yes	69.2 (54)
	No	29.5 (23)
	Missing	1.3 (1)
<i>School board provided resource:</i>		
Staff time	Yes	59.0 (46)
	No	34.6 (27)
	Missing	6.4 (5)
Additional space	Yes	32.1 (25)
	No	60.3 (47)
	Missing	7.7 (6)
Budget to improve health	≥ \$1001	34.6 (27)
	\$1- \$1000	15.4 (12)
	No funding	39.7 (31)
	Missing	10.3 (8)

Notes: PA = Physical Activity; SES = Socioeconomic Status; Due to rounding, the sum of the frequencies for a variable may not equal 100%.

Student-level PA

Descriptive statistics for the student-level characteristics are provided in Table 7. The null 3-level linear mixed effects model for female students found that repeated measures within the same student accounted for 45.0% of variance and students within schools accounted for 1.9% of the variance in weekly MVPA. For male students, the null 3-level model found that repeated measures within the same student accounted for 46.0% of variance and students within schools accounted for 2.4% of the variance in weekly MVPA. This indicates that 1.9-2.4% of the variance in weekly MVPA minutes across the repeated measures from Y2 to Y4 was due to the school attended, above and beyond the individual student characteristics. When time was added to the model (see Table 7), it was found that weekly MVPA minutes significantly decreased across the three years for both female

students ($\beta=-39.89$ minutes/week, 95%CI: [-46.48, -33.31]) and male students ($\beta =-18.03$, 95%CI: [-26.25, -9.81]).

Table 7. Weekly minutes of moderate-to-vigorous physical activity, by gender, for students attending schools that participated in Year 2 (2013-14), Year 3 (2014-15), and Year 4 (2015–16) of the COMPASS Study in Ontario and Alberta, Canada.

	Year 2 2013-2014	Year 3 2014-2015	Year 4 2015-2016	3-Level Linear Mixed Effects Model (Unconditional Growth Model) B [95% CI]
	% (n) / mean (SD)	% (n) / mean (SD)	% (n) / mean (SD)	
Female Students	n=7,633	n=7,859	n=6,722	n=22,223
Cohort				
Grade 9 in Y ₂	50.2 (3,831)	52.0 (4,088)	53.7 (3,607)	-----
Grade 10 in Y ₂	49.8 (3,802)	48.0 (3,771)	46.3 (3,115)	
Ethnicity				
White only	76.7 (5,855)	76.5 (6,011)	76.9 (5,172)	-----
Other	23.3 (1,778)	23.5 (1,848)	23.1 (1,550)	
Moderate-to-vigorous physical activity				
Minutes/week	785.5 (533.8)	734.8 (528.0)	704.6 (524.0)	Time: -39.89 [-46.48, -33.31]***
Male Students	n=7,197	n=7,309	n=6,101	n=20,597
Cohort				
Grade 9 in Y ₂	53.3 (3,837)	54.9 (4,012)	56.5 (3,444)	-----
Grade 10 in Y ₂	46.7 (3,360)	45.1 (3,297)	43.6 (2,657)	
Ethnicity				
White only	75.8 (5,457)	75.0 (5,484)	74.5 (4,543)	-----
Other	24.2 (1,740)	25.0 (1,825)	25.5 (1,558)	
Moderate-to-vigorous physical activity				
Minutes/week	961.8 (618.5)	946.0 (653.5)	912.4 (647.9)	Time: -18.03 [-26.25, -9.81]***

Note: ***p < 0.001

Associations Between School-level Characteristics and Student PA

Fixed effects results from the final regression models are provided in Table 8. For both models, time was no longer a significant predictor ($p > 0.05$) after the cross-level interactions between school characteristics and time were added. Looking at the school's social environment, there were no school-level factors associated with student baseline MVPA in Y2 but there were several factors significantly associated with changes in MVPA over time (i.e., the slope of MVPA over the study years). Female students had significant increases in MVPA across years if their school was moderately sized (501-1000 students; $\beta = 30.04$ minutes/week, 95%CI: [5.76, 54.32]) whereas male students had significant decreases in MVPA over time if they attended a larger school (≥ 1001 students; $\beta = -74.12$, 95%CI: [-139.25, -8.98]). Female and male students showed a similar pattern of significant decreases in MVPA minutes across years as the SES of their school's neighbourhood increased, with the exception of female students attending schools in the highest SES neighbourhoods, where weekly MVPA across years was similar to that observed in the lowest SES category. Female students had a significant decrease in MVPA over time if their school ranked PA as 4th-6th priority compared to 1st-3rd ($\beta = -38.71$, 95%CI: [-65.14, -12.28]), whereas male students had significant increase in MVPA over time if their school ranked PA as 7th-10th priority compared to 1st-3rd ($\beta = 83.13$, 95%CI: [36.18, 130.08]). Finally, female students had significant decreases in MVPA over time if their school promotes PA events ($\beta = -33.28$, 95%CI: [-65.10, -1.45]).

For the school physical environment, female students had significantly lower MVPA minutes at baseline if their school provided showers ($\beta = -75.97$, 95%CI: [-143.93, -8.01]) but there was no significant association between shower facilities and change in MVPA over time, indicating that this relationship remained constant over time. Similarly, male students had significantly lower MVPA

minutes at baseline if their school was in a medium urban population centre ($\beta=-111.30$, 95%CI: [-196.91, -25.69]) and there was no change in this relationship over time.

Looking at partnerships and services, both female and male students attending schools partnered with a health and fitness club had significantly lower baseline MVPA levels ($\beta=-52.24$, 95%CI: [-102.41, -2.08] and $\beta=-88.80$, 95%CI: [-150.80, -26.79]), however there was a significant annual increase in MVPA for male students attending schools partnered with these clubs ($\beta=41.54$, 95%CI: [11.91, 71.18]). Additionally, a significant increase in MVPA over time was observed for female students attending schools partnered with a PA consultant ($\beta=32.44$, 95%CI: [8.93, 55.94]) and a decrease for schools partnered with public health units ($\beta=-44.96$, 95%CI: [-65.53, -24.38]).

For the teaching and learning component of CSH, none of the school-level factors included within the current study were found to be significantly associated with the baseline MVPA of students, nor with a change in MVPA over time.

Finally, there were many school-level factors within the policy component of CSH associated with student MVPA at baseline and over time. While using data to plan was not associated with baseline MVPA, it was significantly associated with an increase in MVPA over time for male students ($\beta=38.98$, 95%CI: [11.31, 66.64]). Females attending schools that permitted access to outdoor facilities during non-instructional time had a significantly higher baseline MVPA ($\beta=77.32$, 95%CI: [10.85, 143.79]) but then a significant decrease in MVPA for each year ($\beta=-74.83$, 95%CI: [-107.32, -42.34]). However, female students did have a significant increase in MVPA for each year if they attended a school that provided access to indoor facilities during non-instructional school time ($\beta=33.35$, 95%CI: [6.46, 60.23]). Both female and male students had substantially higher baseline MVPA if their school always provided access to equipment during non-instructional time ($\beta=103.24$, 95%CI: [41.61, 164.86] and $\beta=150.31$, 95%CI: [70.96, 229.67], respectively) or sometimes provided

access to equipment time ($\beta=80.00$, 95%CI: [7.65, 152.35] and $\beta=114.32$, 95%CI: [24.85, 203.78], respectively). While this relationship remained consistent over time for female students (i.e., no significant slope), male students had significant decreases in MVPA over time associated with their school providing equipment always ($\beta=-36.13$, 95%CI: [-70.98, -1.29]) or sometimes ($\beta=-48.61$, 95%CI: [-88.31, -8.92]). For female students, if their school received resources from the school board for student health, there was no significant association with baseline MVPA, however they did have significantly higher MVPA over time if their school received additional staff time or a budget over \$1,000 for health ($\beta=36.49$, 95%CI: [13.87, 59.11] and $\beta=41.11$, 95%CI: [18.82, 63.40], respectively) and significantly lower MVPA over time if their school received space for health ($\beta=-35.58$, 95%CI: [-68.90, -2.27]). In contrast, male students had a significant increase in MVPA over time if their school received space ($\beta=41.32$, 95%CI: [2.26, 80.37]). Lastly, male students had significantly higher baseline MVPA if their school received a moderate budget for health (\$1-\$1,000; $\beta=92.93$, 95%CI: [17.38, 168.48]) but also a significant decrease in MVPA over time associated with a moderate budget ($\beta=-36.42$, 95%CI: [-72.17, -0.68]).

Table 8. Fixed effects from longitudinal multilevel regression of student- and school-level variables associated with weekly minutes of MVPA in students attending schools that participated in Year 2 (2013-14), Year 3 (2014-15), and Year 4 (2015–16) of the COMPASS Study in Ontario and Alberta, Canada.

	Female Students n = 9,094 (n=22,212 repeated measures)	Male Students n= 8,567 (n=20,607 repeated measures)
NULL MODEL	ICC	ICC
Repeated measures within students	0.450	0.460
Students nested within schools	0.019	0.024
FULL MODEL	β [95% CI]	β [95% CI]
Level 1: Time		
Year (continuous)	60.36 [-46.35, 167.07]	21.58 [-104.11, 147.27]

Level 2: Student			
Grade in Y ₂	Grade 9	REF	REF
	Grade 10	-66.90 [-84.83, -48.96]***	-49.40 [-72.04, -26.75]***
Ethnicity	White only	REF	REF
	Other	-51.19 [-84.83, -48.96]***	-28.95 [-56.31, -1.59]*
Level 3: School			
Social Environment			
Enrolment	1-500	REF	REF
	501-1000	-5.62 [-54.61, 43.37]	45.65 [-18.72, 110.02]
	≥ 1001	-15.63 [-122.14, 90.88]	101.86 [-35.01, 238.73]
SES	25,000 – 50,000	REF	REF
	50,001 – 75,000	62.53 [-6.20, 131.26]	75.39 [-20.82, 165.61]
	75,001 – 100,000	5.06 [-76.14, 86.26]	37.27 [-66.89, 141.43]
	≥ 100,001	35.88 [-85.81, 157.56]	135.95 [-21.12, 293.01]
School Priority of PA	1 st – 3 rd	REF	REF
	4 th – 6 th	-0.57 [-54.17, 53.04]	1.20 [-67.09, 69.48]
	7 th – 10 th	-1.56 [-79.46, 76.35]	-55.97 [-155.69, 43.75]
	Missing	-2.18 [-96.56, 92.20]	-36.76 [-159.01, 85.48]
Promotes PA events	Yes	-1.47 [-66.50, 63.58]	-25.66 [-105.46, 54.14]
Physical Environment			
Location	Rural/Small Urban	REF	REF
	Medium Urban	42.53 [-18.62, 103.69]	-16.14 [-97.26, 64.98]
	Large Urban	1.70 [-67.30, 70.70]	-111.30 [-196.91, -25.69]*
Curtains Available	Yes	1.10 [-40.19, 42.39]	7.87 [-48.69, 64.43]
Secure Lockers Available	Yes	-5.27 [-75.66, 65.12]	-12.86 [-101.18, 75.46]
Showers Available	Yes	-75.97 [-143.93, -8.01]*	-52.06 [-141.89, 37.55]
Partnerships and Services			
Public health	Yes	41.10 [-2.49, 84.70]	-25.97 [-83.60, 31.65]
Non-governmental organization	Yes	5.46 [-34.58, 45.51]	-1.84 [-51.25, 47.58]
Parks and recreation	Yes	3.43 [-44.88, 51.73]	20.23 [-43.58, 84.04]
Youth organizations	Yes	43.89 [-6.56, 94.34]	23.32 [-42.18, 88.83]
Health and fitness club	Yes	-52.24 [-102.41, -2.08]*	-88.80 [-150.80, -26.79]**
Consultant/specialist	Yes	-38.07 [-86.17, 10.03]	57.66 [-4.28, 119.61]
Teaching and Learning			
Non-curricular PA programs	Intramural and non-competitive	-3.37 [-60.25, 53.51]	-8.99 [-85.68, 67.70]
	Intramural only	-12.32 [-78.23, 53.59]	16.34 [-68.18, 100.86]

	Non-competitive only	19.64 [-51.59, 90.87]	-27.91 [-119.29, 63.47]
	None	REF	REF
	Policy		
Has written policy	Yes	-2.22 [-59.65, 55.21]	-32.29 [-101.49, 36.91]
Uses data to plan	Yes	6.20 [-39.43, 51.82]	-38.44 [-96.14, 19.26]
<i>Access during non-instructional time:</i>			
Indoor facility	Yes	-27.46 [-80.96, 26.03]	-10.25 [-78.41, 57.91]
Outdoor facility	Yes	77.32 [10.85, 143.79]*	8.35 [-79.31, 96.01]
Equipment	Always	103.24 [41.61, 164.86]***	150.31 [70.96, 229.67]***
	Sometimes	80.00 [7.65, 152.35]*	114.32 [24.85, 203.78]*
	Never	REF	REF
<i>Access after school hours:</i>			
Gymnasium	Yes	46.80 [-41.53, 135.14]	-13.97 [-116.64, 88.70]
Indoor facility	Yes	12.67 [-47.54, 72.89]	-18.01 [-95.95, 59.93]
Outdoor facility	Yes	-31.27 [-94.07, 31.53]	-21.53 [-103.71, 60.64]
Equipment	Yes	-56.70 [-129.31, 15.91]	-2.26 [-87.11, 82.59]
<i>Resources from school board:</i>			
Staff time	Yes	-4.89 [-50.60, 40.83]	-2.37 [-61.30, 56.56]
Space	Yes	-26.82 [-93.38, 39.74]	-20.03 [-102.04, 61.98]
Budget	No funding	REF	REF
	\$1 - \$1000	30.49 [-27.81, 88.79]	92.93 [17.38, 168.48]*
	≥ \$1001	2.31 [-44.06, 48.69]	-37.19 [-93.48, 19.10]
	Other	12.47 [-62.48, 87.43]	-43.20 [-137.39, 51.00]
Cross-level interactions (School-level variables and time)			
Social Environment			
Enrolment * Time	1-500	REF	REF
	501-1000	30.04 [5.76, 54.32]*	-24.78 [-55.39, 5.82]
	≥ 1001	19.85 [-32.99, 72.69]	-74.12 [-139.25, -8.98]*
SES * Time	25,000 – 50,000	REF	REF
	50,001 – 75,000	-43.80 [-76.50, -11.09]**	-49.45 [-91.85, -7.05]*
	75,001 – 100,000	-67.87 [-107.58, -28.15]***	-68.40 [-117.01, -19.80]**
	≥ 100,001	-6.25 [-64.14, 51.64]	-74.29 [-147.34, -1.24]*
School Priority of PA * Time	1 st – 3 rd	REF	REF
	4 th – 6 th	-38.71 [-65.14, -12.28]**	19.27 [-13.49, 52.03]
	7 th – 10 th	-5.82 [-44.28, 32.64]	83.13 [36.18, 130.08]***
	Missing	-23.42 [-69.99, 23.14]	72.16 [14.60, 129.72]*
Promotes PA events * Time	Yes	-33.28 [-65.10, -1.45]*	-2.88 [-39.88, 34.11]
Physical Environment			

Location * Time	Rural/Small Urban	REF	REF
	Medium Urban	-25.25 [-54.87, 4.37]	-12.35 [-50.89, 26.20]
	Large Urban	-27.93 [-61.75, 5.88]	8.99 [-31.81, 49.78]
Curtains Available * Time	Yes	-1.45 [-21.38, 18.48]	2.98 [-22.65, 28.62]
Secure Lockers Available * Time	Yes	1.70 [-34.30, 37.70]	-30.51 [-73.94, 12.91]
Showers Available * Time	Yes	21.71 [-12.24, 55.66]	21.33 [-22.12, 64.78]
Partnerships and Services			
Public health * Time	Yes	-44.96 [-65.53, -24.38]***	3.55 [-22.99, 30.09]
Non-governmental organization * Time	Yes	-17.57 [-37.15, 2.01]	-0.95 [-24.25, 22.35]
Parks and recreation * Time	Yes	-1.94 [-25.33, 21.45]	6.48 [-23.48, 36.45]
Youth organizations * Time	Yes	-17.85 [-42.56, 6.87]	-21.68 [-53.30, 9.93]
Health and fitness club * Time	Yes	24.75 [-0.41, 49.92]	41.54 [11.91, 71.18]**
Consultant/specialist * Time	Yes	32.44 [8.93, 55.94]**	-6.95 [-35.80, 21.90]
Teaching and Learning			
Non-curricular PA programs * Time	Intramural and non-competitive	13.49 [-14.50, 41.49]	-18.06 [-54.75, 18.62]
	Intramural only	4.50 [-28.59, 37.59]	-24.56 [-65.48, 16.36]
	Non-competitive only	2.64 [-32.66, 37.95]	5.16 [-38.76, 49.09]
	None	REF	REF
Policy			
Has written policy * Time	Yes	-0.05 [-28.52, 28.43]	-7.21 [-39.86, 25.44]
Uses data to plan * Time	Yes	5.29 [-17.58, 28.43]	38.98 [11.31, 66.64]**
<i>Access during non-instructional time:</i>			
Indoor facility * Time	Yes	33.35 [6.46, 60.23]*	17.27 [-15.88, 50.42]
Outdoor facility * Time	Yes	-74.83 [-107.32, -42.34]***	-23.03 [-64.51, 18.45]
Equipment * Time	Always	3.43 [-25.13, 31.99]	-36.13 [-70.98, -1.29]*
	Sometimes	11.86 [-22.60, 46.33]	-48.61 [-88.31, -8.92]*
	Never	REF	REF
<i>Access after school hours:</i>			
Gymnasium * Time	Yes	-20.71 [-63.64, 22.22]	15.35 [-32.00, 62.69]
Indoor facility * Time	Yes	-11.35 [-39.84, 17.15]	-21.99 [-57.65, 13.67]
Outdoor facility * Time	Yes	3.23 [-26.47, 32.92]	28.68 [-8.70, 66.06]
Equipment * Time	Yes	1.64 [-33.72, 37.01]	3.35 [-35.19, 41.88]
<i>Resources from school board:</i>			
Staff time * Time	Yes	36.49 [13.87, 59.11]**	-3.02 [-31.07, 25.03]
Space * Time	Yes	-35.58 [-68.90, -2.27]*	41.32 [2.26, 80.37]*
Budget * Time	No funding	REF	REF
	\$1 - \$1000	19.10 [-9.01, 47.20]	-36.42 [-72.17, -0.68]*

≥ \$1001	41.11 [18.82, 63.40]***	11.02 [-14.93, 36.97]
Other	21.51 [-14.54, 57.55]	62.07 [17.92, 106.22]**

Notes: Unless otherwise stated, the reference category is any response other than a definitive “Yes” (i.e., no, not applicable, no response, uncodeable); ICC = Intraclass correlation; CI = Confidence Interval; SES = Socioeconomic Status; *p < 0.05; ** p < 0.01; ***p < 0.001

Discussion

Although the school-level ICCs for this outcome were low (1.9-2.4%), school-based interventions that cause small shifts in student MVPA can have a large impact at the population level [23]. In this study we found that many school-level factors were associated with the trajectory of weekly MVPA minutes over time. As expected, MVPA declined significantly across the three years and MVPA in female students declined at a significantly faster rate than in male students [1–4]; for each additional year, females participated in MVPA for 40 fewer minutes per week, whereas male students participated in 18 fewer minutes per week. However, the findings of this study suggest that school-based interventions may help attenuate the speed of this annual decline or even prevent the decline.

For the first component of CSH, the social and physical environment, there were no associations observed between student MVPA and the physical school characteristics included in the current study (i.e., rurality, showers, and change rooms), however many social school characteristics were significantly associated with the slope of student MVPA over time. For both female and male students, attending schools situated in wealthier neighbourhoods was related to greater declines in MVPA over time, even with adjustment for urban/rural location. A similar result was observed in a longitudinal study that objectively measured MVPA annually across four years for a sample of 533 students in Grades 9 and 10 from 31 secondary schools in Manitoba, Canada [24]. As it was beyond the scope of the current study to examine the interactions between school-level factors, future research with COMPASS data into the differences in PA-related characteristics between schools in

high versus low SES neighbourhoods are needed. In addition, investigation into the location of where the PA is taking place (i.e., at school or in other neighbourhood locations) may help to shed light on the observed attenuated decline in MVPA for students attending schools in low SES neighbourhoods.

Other social school characteristics associated with MVPA over time were the size of student body and the promotion of PA events. For male students, attending schools with a large enrolment (<1000 students) was associated with lower MVPA over time. While it is expected that larger schools would have more PA offerings [25,26], there may be other social differences in large schools that impact participation, such greater competition for resources (e.g., limited intramural spots) [26], more non-PA clubs in which to participate [26] (e.g., improv, robotics, debate, other special interests), or decreased social connectedness [27]. For female students, attending schools that promoting PA events was associated with a greater decline in PA over time. While seemingly counterintuitive, it is possible that the types of PA events being promoted or the method of promotion may not align with the needs of female students, and may even deter female students from participating.

For the second component of CSH, partnerships and services, there were different beneficial partnerships identified for male and female students. Female students had a substantial negative slope for MVPA over time if their school was partnered with a public health unit, which was not observed for male students. At the same time, females attending schools that were working with a PA consultant had significant positive slope in their MVPA. Together, these findings suggest that existing public health resources may not be adequately tailored for female students and that other PA consultants were better able to support schools in promoting PA among this at-risk group.

Male students had a significant positive slope for MVPA over time if their school was partnered with a health and fitness club. Interestingly, attending schools partnered with a health and fitness club was also associated with substantially lower MVPA at baseline for both male and female

students. It may be that for schools where incoming Grade 9 and 10 students frequently have very low PA, the schools have strategically partnered with a service that can offer access to PA equipment and programming. It may also be that schools with limited onsite facilities or equipment are more likely to seek partnerships with health and fitness clubs. Additional research using COMPASS data examining the interactions between the school characteristics (e.g., onsite facilities and external partnerships) is warranted to help understand the nature of this finding.

For the teaching and learning component of CSH, a school's offering of intramural or non-competitive PA options was not found to be associated with the slope of student MVPA over time for both male and female students. This was an unanticipated finding since providing additional opportunities for PA in schools has been found to increase MVPA among secondary school students [17], and, in particular, two previous research studies found that female students engage in more MVPA when there are non-competitive options available [28,29]. However, one of these studies was cross-sectional and examined the number of days per week with more than 60 minutes of MVPA [29], not total minutes of MVPA, and the other study was a focus group regarding the school factors that were perceived by students to impact their MVPA [28]. In addition, the current study included a substantial number of school characteristics in the models and these other school factors may have a greater impact on the MVPA of both male and female students over time.

For the policy component of CSH, there were many school factors associated with the slope of student MVPA. Male students attending schools that use data to plan had a significant positive slope in their MVPA over time, which suggests that schools have been successful in collecting the information needed for decision making and implementing changes based on that data. It is noteworthy that this finding was only for male students; further study is needed to determine whether schools need to collect additional information that is specific to the PA needs of female students, or if they are already collecting this information but are unable to enact the required changes. Looking at

specific policies, providing access to indoor facilities during non-instructional time was found in this study to be associated with a positive slope in MVPA for female students. Unexpectedly, there was a negative MVPA slope for females attending schools that provided access to outdoor facilities during this time. While beyond the scope of this study, future research using COMPASS data could examine whether schools that provided access to outdoor facilities were less likely to provide access to other facilities (e.g., indoor spaces and equipment). In a Canadian context, winter weather can impact student PA [30] and having access to indoor resources during non-instructional time periods may be very important in supporting student PA.

Lastly, staff and space resources provided by the school board for health purposes were associated with student MVPA over time. Receiving staff time for health and a budget for health (\geq \$1000) were both associated with a positive slope for MVPA over time among female students; however, it is unknown how the funding and staff time were allocated within the schools (e.g., staff time for professional development training versus staff implementing student programming). Similarly, additional space for health provided by the school board was associated with a positive slope in MVPA for male students and a negative slope for female students, but the use of this space is unknown. Further research into how the schools were using these resources could help determine the types of activities, equipment, additional staffing, or infrastructure improvements that were facilitated through this school board funding and whether allowing schools to choose how to utilize these funds provides flexibility in targeting their self-identified areas of need.

This study presents data from a very large sample of schools and students, multiple waves of data from the same students, and information collected from both the students and school simultaneously. The COMPASS prospective cohort provided the unique opportunity to evaluate the impact of many school characteristics, guided by the CSH framework, on student MVPA behaviour change over time. Although self-reported student PA data is a limitation, it is expected that any bias

would be in the same direction and magnitude each year. As such, the absolute MVPA measures may be inflated, but observed relationships and the change over time would not be affected by this self-report bias. There were some unexpected results identified and using a mixed approach of quantitative and qualitative in future research could shed light on these relationships. Another limitation is that only the baseline school characteristics were included due to substantial missing data and inconsistencies in schools reporting changes in follow-up surveys. Future research is needed to evaluate the impacts of school-level changes over time on the trajectory of student MVPA.

Conclusions

In conclusion, it is well-established that student MVPA decreases substantially over time, but the current study findings indicate that secondary schools can have a role in attenuating this decline. Within the CSH framework, the school's social environment, partnerships, and policies were all found to be associated with student MVPA over time, however the specific school factors and directions of associations varied between male and female students. As this study was exploratory, there are many opportunities for future researchers to better understand the underlying mechanisms of the observed relationships to inform future school programs, policies, and school board provided resources.

Author Contributions: Conceptualization, M.P. and S.T.L.; methodology, M.P, S.T.L., V.C., and J.D.; software, M.P. and J.D.; formal analysis, M.P.; writing—original draft preparation, M.P.; writing—review and editing, M.P, S.T.L., V.C., and J.D.; supervision, S.T.L.; funding acquisition, S.T.L. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by a bridge grant from the Canadian Institutes of Health Research (CIHR) Institute of Nutrition, Metabolism and Diabetes (INMD) through the “Obesity—Interventions to Prevent or Treat” priority funding awards (OOP-110788; to S.T.L) and an operating

grant from the Canadian Institutes of Health Research (CIHR) Institute of Population and Public Health (IPPH) (MOP-114875; to S.T.L). V.C. is supported by a CIHR New Investigator Salary Award and a Killam Accelerator Research Award.

Institutional Review Board Statement: The study was approved by the University of Waterloo Office of Research Ethics (Project: 17264) and the University of Alberta Research Ethics Office (Project: 00040729).

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study and from all participating school boards.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Chapter 6

Manuscript 3: Do school characteristics, using the Comprehensive School Health Framework, contribute to youth meeting national physical activity recommendations over time?

This manuscript is presented as submitted to the Health Promotion and Chronic Disease Prevention in Canada, including a section called “highlights” as per journal requirements. Referencing also appears according to journal requirements.

Pirrie, M., Carson, V., Dubin, J.A., & Leatherdale, S.T. (2021). Do school characteristics, using the Comprehensive School Health Framework, contribute to youth meeting national physical activity recommendations over time? Submitted to Health Promotion and Chronic Disease Prevention in Canada (Manuscript ID: 211021).

Overview

Introduction

Canadian youth are insufficiently active, and schools may play a role in promoting student physical activity (PA). Based on the Comprehensive School Health (CSH) framework, this study examines if school characteristics are associated with secondary school students meeting national PA recommendations over time.

Methods

This study uses COMPASS survey data from 78 schools in Ontario and Alberta and 9,870 Grade 9 and 10 students attending those schools. Students who provided two years of linked PA data (2013/14 and 2015/16) and gender were included. Multilevel analysis was conducted by gender, evaluating the relationship of school-level characteristics (guided by CSH) with students achieving all three PA recommendations after two years (≥ 60 min of MVPA daily, vigorous PA ≥ 3 days/week, strengthening activities ≥ 3 days/week).

Results

Of the 47.7% of students achieving the PA recommendations at baseline, more than half (56.9%) were no longer achieving them after two years. Of the 52.3% of students not achieving the PA recommendations at baseline, just a quarter (25.6%) achieved them after two years. Some school-level variables were associated with higher odds of achieving the PA recommendations (e.g., access to equipment, public health partnerships, staff time for health). Other school-level variables were associated with lower odds of achieving the PA recommendations, such as providing showers and curtains.

Conclusion

Modifications to school characteristics within CSH may play a role in supporting students in achieving or continuing to achieve the PA recommendations after two years. Further research is needed to better understand the underlying dynamics of the observed relationships

Highlights

- Approximately half of Grade 9 and 10 students were not meeting the national physical activity recommendations
- Although less common, there is evidence that inactive students can transition to being active two years later
- School characteristics within the Comprehensive School Health framework may support students in becoming active or staying active
- Schools can support student physical activity by partnering with public health, providing access to equipment during non-instructional time, and receiving staff time for student health from the school board
- Future research is needed to understand why providing showers and curtains for changing is associated with students not meeting the recommendations

Introduction

The *Canadian 24-hour Movement Guidelines for Children and Youth* recommends that youth accumulate an average of 60 minutes per day of moderate-to-vigorous physical activity (MVPA), participate in vigorous physical activity (PA) at least three days per week, and participate in muscle- and bone-strengthening activities at least three days per week.^{1,2} In 2017, objective data from the Canadian Health Measures Survey³ suggested that only 31% of Canadian youth were achieving the recommended average of 60 minutes per day of MVPA. The proportion of youth not achieving national PA recommendations is a major public health concern, as PA is a modifiable health behaviour that has many immediate health benefits and is associated with long-term prevention of chronic disease and some cancers.⁴⁻⁶

For secondary school students, an additional concern is that those meeting the PA recommendations in Grades 9 and 10 may not continue achieving them a few years later. Evidence consistently shows that PA declines throughout adolescence, especially in girls,^{3,7,8} with significant decreases around 15-16 years of age (Grades 10-11 for most students).^{8,9} Since PA during youth significantly predicts PA behaviours during adulthood,^{6,10} preventing a drop-off during this critical developmental period is important. Similarly, providing an environment that encourages students who are not already meeting the PA recommendations in Grades 9 and 10 to improve their PA behaviors may help put them on a healthier behavioural trajectory before entering early adulthood.

Ecological theory suggests that the individual's context (e.g., family, school, neighbourhood) can impact health behaviours.¹¹ As schools are an integral part of the students' PA environment,¹²⁻¹⁴ this is a context frequently targeted to improve youth PA behaviour.¹⁵ However, many investigator-initiated PA interventions in schools struggle to be sustained post-research due to a lack of capacity and resources.¹⁵ Taking a different approach, the evaluation of natural experiments through longitudinal data systems can be used to identify what programs, policies, and resources may be

successful in achieving higher PA in some schools to inform what may be feasible in other schools.¹⁶ The Comprehensive School Health (CSH) framework provides guidance on four inter-related components that schools can target to improve health behaviours, such as PA.^{17,18} The CSH components are: 1) social and physical environment; 2) teaching and learning; 3) partnerships and services; and, 4) policies.^{17,18} Many cross-sectional studies have examined the associations between school characteristics found within CSH and PA behaviours, finding students are more physically active if they attend schools with higher social support,^{19,20} established partnerships,²¹ extracurricular PA opportunities,²² PA facilities available,²³ student access to facilities and equipment outside of instructional time,²¹ and funding for PA-related resources.²⁴ However, there has been no longitudinal study examining how multiple school characteristics representing each component of the CSH framework are associated with students achieving the national PA recommendations over time.

This exploratory study aimed to fill an existing evidence gap by using longitudinal data to determine: (1) the proportion of students achieving all three PA recommendations at baseline who were still achieving them two years later; (2) the proportion of students not achieving all three PA recommendations at baseline who were achieving them two years later; and, (3) the school characteristics associated with achieving all three recommendations two years later for these two groups of students. Since gender has been identified as a moderator of the association between school characters and student PA,²⁵ these relationships were evaluated for each gender separately.

Methods

Design

COMPASS is a prospective cohort study (2012-2021) following a large sample of Canadian Grade 9 to 12 students and the schools they attend. COMPASS was designed as a platform to conduct natural experiments to evaluate the impact of school-level prevention program and policy changes on student health behaviours.²⁶

The current study examines data from 78 schools in Ontario (n=69) and Alberta (n=9) that provided data in both Year 2 (Y₂: 2013/2014) and Year 4 (Y₄: 2015/2016); this is the period in which COMPASS had the largest initial intake of schools to its cohort and the schools completed their baseline COMPASS School Policies and Practices Questionnaire. Although COMPASS is a rolling cohort that includes all grades of secondary students, the current study only included students in Grade 9 or 10 as of Y₂ since students in Grades 11 and 12 would have graduated and left the cohort by Y₄. The current study included 9,870 students who provided gender and PA data in both Y₂ and Y₄, and provided their grade for at least one of the years. Ethics approval was received by the University of Waterloo Office of Research Ethics (Project: 30188), the University of Alberta Research Ethics Board (Project: 00040729), and each school board and/or school as required.

Recruitment

Detailed school recruitment methods are available.²⁶ In summary, school boards that allow active-information, passive-consent protocols were approached to participate in COMPASS. With school board approval, individual schools were recruited and information was sent to students and guardians, with multiple mechanisms to opt-out. Students could also opt to not complete the survey on data collection day and could withdraw their survey at any time. 79% of eligible students from these 78 schools participated in Y₂ and 80% of eligible students participated in Y₄. Missing students were primarily due to absenteeism or classroom spares on the day of data collection; less than 1% of students opted out (themselves or their parent/guardian).

Data collection procedures

On each school's data collection day, a COMPASS staff member was onsite to ensure study fidelity and identify the most appropriate individual to complete the school-level survey. Students completed the survey during a class period and sealed it in an envelope to maintain confidentiality. Each student had a self-generated identification code derived from their birth month, name (e.g.,

second letter of first name), and mother's name, allowing student data to be de-identified while also being linked across multiple years. Detail on the longitudinal data linkage procedure is available in a technical report.²⁷

Measures

School Variables

School-level data used in this study was collected in Y₁ or Y₂ (whichever year the school first participated in COMPASS) using the COMPASS School Policies and Practices Questionnaire. The COMPASS staff member also collected school handbooks and written policies. School location (urban/rural) and neighbourhood socio-economic status were determined using the postal code and 2011 Canada Census. School-level characteristics included in this study are listed in Table 9, in addition to the presence of indoor facilities, outdoor facilities, gymnasium, change rooms, and interschool/varsity sports teams.

Student Variables

Student demographics from the annual COMPASS student questionnaire²⁸ (C_q) included in this study were gender, grade, and ethnicity.

The outcome variable was student achievement of all three PA recommendations, consistent with previous research.²⁹ Three questions from C_q were used to determine this status: (1) "Mark how many minutes of HARD physical activities you did on each of the last 7 days," (2) "Mark how many minutes of MODERATE physical activities you did on each of the last 7 days," and (3) "On how many days in the last 7 days did you do exercises to strengthen or tone your muscles?" with examples provided. The first two questions were used to determine whether the student achieved an average of ≥ 60 minutes/day of MVPA. A validation study found that while these two questions individually had low validity when compared to objectively measured PA (Pearson's $r=0.21$ and 0.27 , respectively), the validity was higher when combined ($r=0.31$) and was similar to other self-report questionnaires.³⁰

Test-retest reliability for these two questions was moderate ($r=0.69$ and 0.57 , respectively, and $r=0.68$ combined). There is no validity or reliability data available for the muscle and bone strengthening activity question, but since there is no intensity needed or minimum number of minutes, it is expected that students could estimate the number of days. Students who achieved an average of ≥ 60 minutes/day of MVPA, vigorous activity ≥ 3 days/week, and muscle and bone strengthening activity ≥ 3 days/week were designated as achieving all three PA recommendations; all others were classified as not achieving the recommendations.

Statistical Analysis

Descriptive analysis was conducted for school- and student-level characteristics. For each PA recommendation and the full set of three recommendations, comparisons across genders were performed using chi-square tests. Cross-tabulations were used to determine the proportion of students meeting the recommendations in Y_2 and who continued meeting them in Y_4 , as well as the proportion of students not meeting the recommendations in Y_2 who were able to meet them in Y_4 .

The regression analyses were stratified by gender, and then further stratified into two groups based on whether the student was achieving all three recommendations in Y_2 . Due to the hierarchical nature of the data, multilevel logistic regression models (random intercept only) were conducted for each student stratum, with the outcome of achieving all three PA recommendations in Y_4 . For each stratum, a null model was run to determine variability across schools in the outcome. To calculate the intraclass correlation (ICC), since the outcome was dichotomous, the student-level portion of the error variance was set at $\pi^2/3$, which is approximately 3.29.³¹ Next, school characteristics were added, excluding those with a prevalence of 95% or higher due to lack of heterogeneity. Student grade and ethnicity were added as potential confounders. Full models were assessed for multicollinearity (e.g., high variance inflation factors). All analyses were conducted using R Studio version 1.3.1 and R version 4.0.3. The `mixed_model` procedure of the `GLMMadaptive` package (version 0.7-15) was used

with binomial distribution, logit link, and 100 Expectation-Maximization iterations for each regression. As this was an exploratory study, the results and discussion are focused primarily on the statistically significant findings.

Results

The prevalence of PA-related school characteristics within the CSH framework are provided in Table 9. In addition, 98.7% (n=77) had a gymnasium, 97.4% (n=76) had other indoor facilities, 94.9% (n=74) had change rooms, 98.7% (n=77) had outdoor facilities, and 100% (n=78) had interschool/varsity sports.

Table 9. Characteristics of schools participating in both Year 2 (2013-14) and Year 4 (2015-16) of the COMPASS Study in Ontario and Alberta, Canada

		N = 78	
		n	%
Demographic			
Enrolment	1 – 500	32	41.0
	501 – 1000	39	50.0
	≥ 1001	7	9.0
SES	25,000 – 50,000	7	9.0
	50,001 – 75,000	51	65.4
	75,001 – 100,000	17	21.8
	≥ 100,001	3	3.9
Location	Rural	1	1.3
	Small Urban	34	43.6
	Medium Urban	13	16.7
	Large Urban	30	38.5
Social Environment			
School priority of PA	1 st – 3 rd	17	21.8
	4 th – 6 th	35	44.9
	7 th – 10 th	18	23.1
	Missing	8	10.3

Promote PA events	Yes	69	88.5
	No	8	10.3
	Missing	1	1.3
Physical Environment			
Curtains for changing	Both girls and boys	21	26.9
	Girls only	15	19.2
	Boys only	1	1.3
	None	34	43.6
	Missing	7	9.0
Secure lockers in change room	Yes	62	79.5
	No	15	19.2
	Missing	1	1.3
Showers	Both girls and boys	69	88.5
	Girls only	0	0.0
	Boys only	2	2.6
	None	4	5.1
	Missing	3	3.9
Partnerships and Services			
Organizations providing support (check all that apply)	Local public health	37	52.6
	Non-governmental organization	47	60.3
	Parks and recreation	21	27.0
	Youth organizations	23	29.5
	Health and fitness club	39	50.0
	Consultant/specialist	27	34.6
Teaching and Learning			
Non-curricular physical activity programs	Both intramurals and non-competitive clubs	35	44.9
	Intramural only	15	19.2
	Non-competitive only	15	19.2
	None	13	16.7
Healthy School Policy			
Written policy	Yes	45	57.7
	No	24	30.8
	Missing	9	11.5

Use data from student	Yes	30	38.5
health assessment to plan	No	48	61.5
Access during non-instructional time:			
Indoor facilities	Yes	53	68.0
	No	25	32.1
Outdoor facilities	Yes	67	85.9
	No	9	11.5
	Missing	2	2.6
Equipment	Always	23	29.5
	Sometimes	46	59.0
	Never	9	11.5
Access outside of school hours:			
Gymnasium	Yes	61	78.2
	No	17	21.8
Indoor facilities	Yes	60	76.9
	No	17	21.8
	Missing	1	1.3
Outdoor facilities	Yes	66	84.6
	No	11	14.1
	Missing	1	1.3
Equipment	Yes	54	69.2
	No	23	29.5
	Missing	1	1.3
School board provided resource:			
Staff time	Yes	46	59.0
	No	27	34.6
	Missing	5	6.4
Additional space	Yes	25	32.1
	No	47	60.3
	Missing	6	7.7
Budget to improve health	≥ \$1001	27	34.6
	\$1- \$1000	12	15.4
	No funding	31	39.7
	Missing	8	10.3

Notes: “Other” includes not applicable, no response, and uncodable responses. Due to rounding, the total frequencies for some variables do not sum to 100% exactly. SES = Socio-economic status.

Y₂ physical activity levels

Within these schools, 9,870 students in Grades 9 and 10 reported their PA in both Y₂ and Y₄. In Y₂, only 47.7% (n=4,706) of students reported achieving all three PA recommendations; 84.6% (n=8,351) reported achieving the VPA recommendation, 77.8% (n=7,683) the MVPA recommendation, and 55.0% (n=5,430) the muscle and bone strengthening activity recommendation. A significantly higher proportion of male students compared to female students reported achieving each of the separate PA recommendations as well as the full set of three recommendations (p<0.001); see Table 10.

Table 10. Physical activity behaviour of students, by gender, attending schools that participated in Year 2 (2013-14) and Year 4 (2015–16) of the COMPASS Study in Ontario and Alberta, Canada

	Total (n=9,870)		Female (n=5,200)		Male (n=4,670)		Chi-square, df
	n	%	n	%	n	%	
Grade in Y₂							
9	5,309	53.8	2,722	52.4	2,587	55.4	----
10	4,561	46.2	2,478	47.7	2,083	44.6	----
Ethnicity							
White only	7,579	76.8	4,046	77.8	3,533	75.7	----
Other	2,291	23.2	1,154	22.2	1,137	24.4	----
Physical activity in Y₂							
Meets MVPA recommendation	7,683	77.8	3,830	73.7	3,853	82.5	$\chi^2 = 111.8^*$, df=1
Meets VPA recommendation	8,351	84.6	4,281	82.3	4,070	87.2	$\chi^2 = 44.0^*$, df=1
Meets MBSA recommendation	5,430	55.0	2,736	52.6	2,694	57.7	$\chi^2 = 25.6^*$, df=1
Achieves all three recommendations	4,706	47.7	2,279	43.8	2,427	52.0	$\chi^2 = 65.4^*$, df=1

Notes: * p < 0.001; MVPA = moderate-to-vigorous physical activity, VPA = vigorous physical activity, MBSA = muscle and bone strengthening activity

Proportion achieving the PA recommendations over time

Table 11 presents the cross-tabulation of achieving all three recommendations in Y₄ against their baseline status in Y₂. Of the 4,706 students achieving all three recommendations in Y₂, 56.9% (n=2,679) continued achieving them in Y₄. A higher proportion of male students continued achieving the recommendations compared to female students (63.5% versus 49.9%). Of the 5,164 students not achieving all three recommendations in Y₂, 25.6% (n=1,321) were able to achieve them in Y₄. Again, a higher proportion of male students changed from not achieving the recommendations in Y₂ to achieving them in Y₄ compared to female students (30.7% versus 21.6%).

Table 11. Proportion of students achieving all three physical activity recommendations in Year 4 (2015-16) based on their status in Year 2 (2013-14) from the COMPASS Study in Ontario and Alberta, Canada.

Achieving all 3 PA recommendations at baseline (Y ₂)	Achieving all 3 PA recommendations at Y ₄			
	Yes (n=4,000)		No (n=5,870)	
	n	%	n	%
All students (n=9,870)				
Yes	2,679	56.9	2,027	43.1
No	1,321	25.6	3,843	74.4
Females (n=5,200)				
Yes	1,138	49.9	1,141	50.1
No	632	21.6	2,289	78.4
Males (n=4,670)				
Yes	1,541	63.5	886	36.5
No	689	30.7	1,554	69.3

Note: Due to rounding, the total frequencies for some variables do not sum to 100% exactly.

School characteristics associated achieving the PA recommendations in Y₄

The ICCs were very low across all four models (ICC=0.007-0.027) but was highest among females achieving the PA recommendations in Y₂ (see Table 12).

Table 12. Odds ratio of achieving PA guidelines in Year 4 (2015-16) based on status in Year 2 (2013-14) and according to student and school characteristics, from the COMPASS Study in Ontario and Alberta, Canada.

	Odds of students achieving all 3 PA recommendations in Y ₄ for those who were already achieving them at baseline (Y ₂)		Odds of students achieving all 3 PA recommendations in Y ₄ for those who were <u>not</u> achieving them baseline (Y ₂)	
	Females n=2,279	Males n=2,427	Females n=2,921	Males n=2,243
	AOR [95% CI]	AOR [95% CI]	AOR [95% CI]	AOR [95% CI]
Intraclass correlation (null model)	0.027	0.007	0.015	0.016
Student-level				
Grade in Y ₂				
Grade 10 (REF = Grade 9)	0.72 [0.61-0.85]***	0.92 [0.78-1.10]	0.80 [0.67-0.96]*	0.81 [0.67-0.97]*
Ethnicity				
Other (REF = White only)	1.17 [0.94-1.45]	1.35 [1.10-1.64]**	1.06 [0.85-1.32]	0.88 [0.71-1.10]
School-level				
Social Environment				
Enrolment				
1-500	REF	REF	REF	REF
501-1000	0.92 [0.67-1.28]	1.12 [0.82-1.55]	1.12 [0.79-1.57]	1.03 [0.72-1.46]
≥ 1001	0.69 [0.36-1.41]	1.40 [0.71-2.76]	1.30 [0.62-2.73]	0.97 [0.47-2.04]
Socioeconomic status				
25,000 – 50,000	REF	REF	REF	REF
50,001 – 75,000	1.21 [0.77-1.91]	0.81 [0.52-1.26]	0.96 [0.60-1.55]	1.36 [0.83-2.22]
75,001 – 100,000	0.95 [0.55-1.63]	0.70 [0.42-1.18]	0.96 [0.56-1.74]	0.99 [0.56-1.75]
≥ 100,001	1.87 [0.89-3.97]	1.06 [0.50-2.23]	1.25 [0.55-2.84]	2.06 [0.85-4.96]
School priority of PA				
1 st – 3 rd	REF	REF	REF	REF
4 th – 6 th	0.95 [0.67-1.35]	0.84 [0.59-1.18]	0.74 [0.52-1.05]	1.30 [0.89-1.89]
7 th – 10 th	0.88 [0.53-1.46]	1.04 [0.62-1.73]	0.56 [0.32-0.97]*	1.85 [1.09-3.14]*
Missing	1.25 [0.66-2.38]	0.63 [0.35-1.15]	0.72 [0.38-1.39]	1.73 [0.91-3.29]
Promotes PA events	0.97 [0.64-1.45]	1.01 [0.68-1.49]	0.62 [0.40-0.94]*	1.53 [1.00-2.33]*
Physical Environment				
Location				
Rural/Small Urban	REF	REF	REF	REF
Medium Urban	1.01 [0.68-1.50]	1.26 [0.84-1.89]	0.79 [0.52-1.18]	0.97 [0.62-1.52]
Large Urban	1.21 [0.78-1.88]	1.23 [0.80-1.88]	0.67 [0.41-1.07]	0.96 [0.59-1.54]
Curtains Available	0.99 [0.73-1.33]	0.67 [0.50-0.89]**	1.13 [0.83-1.54]	1.12 [0.83-1.50]
Secure Lockers Available	0.86 [0.54-1.36]	1.24 [0.80-1.94]	1.37 [0.84-2.24]	0.88 [0.53-1.44]
Showers Available	0.62 [0.38-0.99]*	1.09 [0.69-1.73]	0.63 [0.39-1.03]	0.62 [0.38-1.01]
Partnerships and Services				
Public health	1.13 [0.84-1.51]	1.37 [1.05-1.79]*	0.80 [0.59-1.10]	1.06 [0.77-1.45]
Non-governmental organization	0.80 [0.63-1.03]	0.96 [0.75-1.24]	0.92 [0.69-1.22]	0.82 [0.63-1.08]
Parks and recreation	0.96 [0.70-1.31]	0.88 [0.64-1.21]	1.33 [0.96-1.85]	0.85 [0.60-1.21]
Youth organizations	1.24 [0.89-1.72]	1.38 [0.97-1.94]	1.04 [0.73-1.48]	1.07 [0.75-1.53]
Health and fitness club	1.07 [0.77-1.47]	0.97 [0.70-1.33]	1.22 [0.86-1.73]	1.21 [0.86-1.70]
Consultant/specialist	0.93 [0.68-1.27]	1.18 [0.86-1.62]	0.99 [0.72-1.37]	1.14 [0.82-1.58]
Teaching and Learning				
Non-curricular PA programs				
Intramural and non-competitive	0.80 [0.55-1.17]	1.07 [0.73-1.58]	1.07 [0.72-1.58]	1.29 [0.85-1.97]
Intramural only	0.78 [0.51-1.18]	1.19 [0.77-1.84]	1.30 [0.82-2.06]	0.90 [0.56-1.47]
Non-competitive only	0.95 [0.60-1.51]	0.84 [0.53-1.33]	1.13 [0.70-1.83]	1.32 [0.80-2.19]
None	REF	REF	REF	REF
Healthy School Policy				

Has written policy	0.82 [0.56-1.19]	0.99 [0.71-1.38]	0.82 [0.55-1.21]	0.85 [0.59-1.23]
Uses data to plan	1.14 [0.85-1.53]	1.02 [0.76-1.38]	0.73 [0.53-1.02]	0.97 [0.71-1.33]
<i>Access during non-instructional time:</i>				
Indoor facility	1.11 [0.78-1.57]	0.83 [0.59-1.17]	0.64 [0.45-0.93]*	1.06 [0.72-1.57]
Outdoor facility	0.75 [0.49-1.15]	0.77 [0.49-1.19]	0.78 [0.51-1.20]	0.84 [0.53-1.36]
Equipment				
Always	1.20 [0.83-1.73]	1.56 [1.09-2.22]*	1.40 [0.94-2.09]	1.01 [0.68-1.51]
Sometimes	1.04 [0.65-1.66]	1.51 [1.00-2.27]*	1.51 [0.94-2.42]	0.93 [0.60-1.45]
Never	REF	REF	REF	REF
<i>Access after school hours:</i>				
Gymnasium	0.72 [0.41-1.26]	0.90 [0.55-1.47]	0.79 [0.44-1.45]	0.50 [0.29-0.86]*
Indoor facility	1.26 [0.88-1.81]	1.01 [0.71-1.45]	1.26 [0.84-1.89]	1.38 [0.90-2.10]
Outdoor facility	1.26 [0.87-1.83]	1.04 [0.71-1.54]	1.30 [0.87-1.95]	1.01 [0.66-1.54]
Equipment	0.75 [0.49-1.15]	1.16 [0.78-1.71]	0.68 [0.42-1.09]	0.95 [0.61-1.48]
<i>Resources from school board:</i>				
Staff time	0.82 [0.60-1.11]	0.88 [0.66-1.18]	1.42 [1.02-1.98]*	1.00 [0.71-1.41]
Space	0.98 [0.64-1.51]	1.11 [0.75-1.65]	0.62 [0.39-0.97]*	1.11 [0.70-1.76]
Budget				
No funding	REF	REF	REF	REF
\$1 - \$1000	1.15 [0.80-1.64]	1.29 [0.87-1.92]	1.29 [0.89-1.89]	0.84 [0.56-1.27]
≥ \$1001	1.00 [0.75-1.33]	0.92 [0.71-1.21]	1.25 [0.92-1.70]	0.81 [0.60-1.10]
Other	0.76 [0.47-1.22]	1.01 [0.64-1.61]	1.17 [0.72-1.91]	0.86 [0.52-1.42]

Notes: Unless otherwise stated, the reference category is any response other than a definitive “Yes” (e.g., no, not applicable, no response, uncodeable); PA = Physical Activity; *p < 0.05; ** p < 0.01; *** p < 0.001

Social environment. Female students not achieving the PA recommendations in Y₂ had significantly lower odds of achieving them in Y₄ if their school gave PA a priority ranking of 7th-10th in Y₂ compared to a priority of 1st-3rd (AOR=0.56, 95%CI:[0.32-0.97]). This group also had lower odds of achieving the recommendations if their school promoted PA events (AOR=0.62, 95% CI:[0.40-0.94]). In contrast, male students not achieving the guidelines in Y₂ had higher odds of achieving them in Y₄ if their school ranked PA in the lowest priority group (AOR=1.85, 95%CI:[1.09-3.14]) and promoted PA events (AOR=1.53, 95%CI:[1.00-2.33]). For students already achieving the recommendations in Y₂, no significant associations were found between the social environment factors in this study and achieving the recommendations in Y₄.

Physical environment. Male students achieving the recommendations in Y₂ had lower odds of achieving them in Y₄ if their school provided curtains in the change room (AOR=0.67; 95%CI:[0.50-0.89]). Female students who were achieving the recommendations had lower odds of achieving them in Y₄ if their school provided showers (AOR=0.62, 95%CI:[0.38-0.99]). While not

significant, it is notable that both female and male students who were not achieving the recommendations in Y₂ were also trending towards lower odds of achieving them in Y₄ if their school provided showers (AOR=0.63, 95%CI:[0.39-1.03] and AOR=0.62, 95%CI:[0.38-1.01]).

Partnerships and services. Male students achieving the recommendations in Y₂ had greater odds of continuing to meet them in Y₄ if their school was partnered with public health (AOR=1.37, 95%CI:[1.05-1.79]).

Teaching and learning. There were no significant associations observed between schools offering non-competitive or intramural PA opportunities and student odds of achieving the PA recommendations in Y₄ for any of the student strata.

Policy. Looking first at policies for student access during non-instructional time within school hours, female students not achieving the recommendations in Y₂ had significantly lower odds achieving them in Y₄ if their school provided access to indoor facilities (AOR=0.64, 95%CI:[0.45-0.93]), whereas male students achieving the recommendations in Y₂ had higher odds of continuing to meet them if their school provided access to equipment sometimes or always (AOR=1.51, 95%CI:[1.00-2.27] and AOR=1.56, 95%CI:[1.09-2.22], respectively). For after-school hours, male students not achieving the recommendations in Y₂ had lower odds of achieving them in Y₄ if their school provided access to the gymnasium (AOR=0.50, 95%CI:[0.24-0.84]). Finally, considering resources provided by the school board to improve student health, female students not achieving the recommendations in Y₂ had higher odds of achieving them in Y₄ if their school received staff time to support student health but lower odds if their school was provided additional space (AOR=1.42, 95%CI:[1.02-1.98] and AOR=0.62, 95%CI:[0.39-0.97]).

Discussion

Despite finding that the majority of students in this sample were not achieving all three PA recommendations, some school characteristics within the CSH framework were positively associated

with students achieving these recommendations after two years. For students not achieving the recommendations in Y₂, one quarter achieved them two years later; this is a meaningful achievement given the evidence that PA typically declines with age.^{3,7,8} Among students achieving the recommendations in Y₂, nearly half were no longer attaining this standard after two years, demonstrating a need to not only focus on increasing PA among insufficiently active students, but also to support active students to continue being active. There was a negligible clustering effect for male students already achieving the recommendations in Y₂, meaning that male students in this stratum sampled from the same school were just as similar to each other as they were to male students from other schools. However, there were school characteristics associated with PA behaviours over time for all four student groups studied.

For the first component of CSH, social and physical environment, the social environment was associated with achieving the PA recommendations only for students not already achieving them at baseline in our sample. Specifically, a school's low prioritization of PA relative to other health-related issues was positively associated with male students achieving the guidelines two years later but negatively associated for female students. This contrasting finding may suggest that school administrators are prioritizing PA based on observed male engagement with PA programming and not female engagement. Another potential explanation is that the health-related issues being prioritized over PA (e.g., tobacco use, cannabis use, bullying) may indirectly increase PA among males more than females.³²⁻³⁴ Another contrasting finding was also observed for the school's promotion of PA events, whereby males attending schools that promoted PA events had higher odds of achieving the recommendations after two years, but female students had lower odds. The consistency in these contrasting male/female results further supports that male PA levels may be driving school prioritization and the types of PA events being promoted, but additional research is needed to better understand the dynamics behind these observed results.

For the physical environment, this study unexpectedly found that providing curtains and showers was negatively associated with achieving the guidelines for some student groups. In fact, the provision of showers was the only school-level factor significantly associated with achieving the guidelines for female students already achieving the recommendations in Y₂, and it was a negative relationship. There is insufficient information within this study to know the degree of privacy offered in the shower area, but social pressures and psychological discomfort in using the showers may contribute to students shying away from PA as they progress through puberty.³⁵⁻³⁷ Although not statistically significant, similar associations (i.e., nearly the same effect size and confidence intervals) were observed for female students not achieving the recommendations at baseline and for both male subgroups. In addition, male students achieving the recommendations at baseline had lower odds of continuing to achieve them if their school provided privacy curtains in the change room. An in-depth examination is needed into the specific features of the showers and curtains being provided (e.g., degree of privacy) and the social dynamics around their use. For example, there may be bullying or stigma attached to boys who choose to use the curtains or who avoid the showers. Previous studies have shown that boys who withdraw from physical education classes when they are no longer mandatory often make this decision based on experiencing bullying and abuse by peers, not due to a disinterest in PA.³⁴

For the second component of CSH, partnerships and services, the results of this study suggest that a public health partnership can be beneficial in supporting active male students in maintaining their PA over time; however, it also suggests that public health materials or other supports being provided may need to be expanded to target other student groups (i.e., female students and male students not already achieving the guidelines). This relationship between partnerships and PA had been reported in a study of middle schools,²¹ but has not been explored in a secondary school sample. This is an important finding as linking schools with local public health units is both an affordable and

feasible intervention that could be promoted as part of CSH for schools seeking to improve student PA.

For the teaching and learning component of CSH, there were no associations found between providing intramural or non-competitive PA options and students achieving the PA recommendations after two years. This was unexpected since previous research found that female students were more likely to participate in PA when provided these options.^{37,38} It may be that these PA offerings only facilitate achieving one or two of the PA recommendations and not all three. While beyond the scope of the work presented here, additional investigation with COMPASS data should explore this hypothesis.

For the policy component of CSH, male students already meeting the recommendations had approximately 50% higher odds of continuing to meet them if their school permitted access to equipment during non-instructional time. However, this relationship was not observed during the after-school period, indicating that the period in which students are permitted access is important for having the desired effect. Receiving staff time for health from the school board was significantly associated with female students transitioning from not achieving the PA recommendations to achieving them two years later. Since it is well-established that female students are significantly less active than males and tend to stop being active at a younger age,^{8,9} interventions associated with increasing PA among this at-risk group is highly desirable. Further research into how this additional staff time is being used in practice could inform similar approaches for other schools.

Strengths and Limitations

Two major strengths of this study were the large cohort of students with linked PA data over time and having data collected simultaneously from the schools they were attending. This unique resource available through COMPASS allowed for a longitudinal analysis of the associations between student PA and many school characteristics within the CSH framework. A limitation was the self-

reported PA data, since it is known that students tend to underestimate their moderate PA and overestimate their vigorous PA.³⁰ However, this is expected to be partially mitigated by the longitudinal nature of the study, since individuals may have a similar degree of self-report bias at both time points and were being compared against their own baseline. Another limitation is that only the baseline school characteristics were included, since there were inadequate data on school-level changes over time for all factors included in the models. Future studies are needed that can incorporate these school-level changes into the longitudinal model.

Conclusion

In conclusion, schools can play a role in supporting students in both achieving the PA recommendations and maintaining them over time, countering the well-documented decline in PA behaviour during this life stage. The significant school-based factors identified in this study were generally affordable, feasible changes (e.g., public health partnership, access to equipment during school hours) that are already being implemented by other schools. The CSH framework can guide schools in providing a health promoting environment for students, but the elements that will be most effective depend on the student subgroup being targeted and the context of the schools themselves.

Conflicts of interest

The authors have no conflicts of interest to declare.

Author contributions

MP and SL conceptualised the work; SL and VC led the data acquisition; MP conducted the analysis and all coauthors contributed to the interpretation of the data; MP drafted the paper; all authors contributed to revisions and approved the final manuscript

Acknowledgements

This work was supported by a bridge grant from the Canadian Institutes of Health Research (CIHR) Institute of Nutrition, Metabolism and Diabetes (INMD) through the “Obesity—Interventions to Prevent or Treat” priority funding awards (OOP-110788; to S.T.L) and an operating grant from the Canadian Institutes of Health Research (CIHR) Institute of Population and Public Health (IPPH) (MOP-114875; to S.T.L). V.C. is supported by a CIHR New Investigator Salary Award and a Killam Accelerator Research Award.

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Chapter 7

General Discussion

7.1 Overview

Chapters 4, 5, and 6 presented three manuscripts exploring the relationships between school-level characteristics, guided by the CSH framework, and student-level PA. The combined objectives of these manuscripts were to: (1) describe the prevalence of school-level factors within the CSH framework and their association with student PA (weekly MVPA and meeting the three PA recommendations) in a large sample of Ontario and Alberta secondary schools; (2) examine how youth MVPA changes over a three-year period, stratified by gender; (3) evaluate the school characteristics associated with preventing the decline in MVPA over time, guided by the CSH framework; (4) determine the proportion of students achieving all three PA recommendations at baseline who were still achieving them two years later; (5) determine the proportion of students not achieving all three PA recommendations at baseline who were achieving them two years later; and, (6) evaluate the school characteristics associated with achieving all three recommendations two years later for these two groups of students, stratified by gender. In this chapter is a summary of the key findings (Section 7.2), implications for school health and public health (Section 7.3), overall strengths (Section 7.4), overall limitations (Section 7.5), future research directions (Section 7.6), and conclusions (Section 7.7).

7.2 Summary of Key Findings

The three studies presented within this dissertation addressed a gap in the research literature as they not only identified the school-level characteristics within a CSH framework that are associated with PA at a single point in time (Chapter 4), but also the association of these school-level characteristics on the MVPA trajectory (Chapter 5) and odds of achieving the guidelines two years later (Chapter 6).

Across the three manuscripts, all four components of CSH were found to be associated with student PA outcomes in some capacity, but many of the associations differed based on the PA outcome, study design (cross-sectional/longitudinal), and student subgroup (gender/grade). The iterative, methodical approach in which the three studies were undertaken has provided a comprehensive view of the complex relationships between each school component within the CSH framework and student PA, as well as uncovered many new research questions that could be examined in future studies.

The first manuscript (Chapter 4) provided the foundation for the two subsequent manuscripts. It established that the frequency of each school-level factor varied across the schools in this sample, as hypothesized, with a few exceptions (e.g., presence of a gymnasium). This observed heterogeneity in school contexts allowed for natural experiment methodology (Leatherdale, 2018; Petticrew et al., 2005) to be used to better understand the influence of the school context on PA behaviours among youth in Ontario and Alberta. As this paper was cross-sectional and was not dependent on longitudinal linkage, it had a larger student sample compared to Chapters 5 and 6, and it was also able to examine the subgroups of students in Grades 11 and 12. The results of this study supported the hypothesis that school-level factors within CSH were associated with student PA (weekly MVPA minutes and PA achieving the recommendations), and that the significant school-level factors were not the same for all gender/grade subgroups or for both PA outcomes.

The second study (Chapter 5) focused on the trajectory or slope of weekly MVPA minutes from Y_2 to Y_4 , not solely the end point. The aim was to identify the school-level factors that could attenuate the downward slope that is typically observed in MVPA during secondary school. As noted previously, there is a significant decline in student PA at 15-16 years of age (Sallis et al., 2000; Strong et al., 2005) and there is a dose-response relationship between PA and health benefits (Janssen & Leblanc, 2010). Therefore, examining potential school-level factors that could help attenuate, if not avoid, this downward slope was important. Using the same school-level characteristics identified in

Chapter 4, 3-level linear mixed effects models (3-level growth models) were used to evaluate the relationship between school-level factors within the CSH and student MVPA for each gender. The findings supported the hypothesis that school factors within the CSH framework could attenuate the decline in student MVPA over time, and that the significant school-level factors were different for each gender subgroup.

The final manuscript (Chapter 6) was focused not on the pathway but on the odds of ultimately achieving all three PA recommendations two years later, based on gender and whether the student was already achieving the recommendations at baseline. This outcome aligns with the public health goal of supporting youth in improving their PA to achieve the recommendations and prevent chronic disease (Joint Public Health Ontario/Cancer Care Ontario Prevention Working Group, 2012). This manuscript identified that while there is substantial opportunity to support students in continuing to meet the recommendations over time (43.1% students who were achieving the recommendations initially were no longer doing so two years later), it was also encouraging to find that 25.6% of students not achieving the recommendations at baseline were able to meet them two years later. As with Chapter 5, using a multilevel modelling approach, there were school-level factors within the CSH that were found to be associated with the odds of students achieving all three recommendations after two years, and these school-level factors varied based on gender and baseline PA status.

7.2.1 Student-level PA

Student-level PA observed in each of the studies followed the expected trends. In Chapter 6, the rate of students achieving the MVPA recommendation at baseline was substantially higher than the prevalence reported by the Canadian Health Measures Study (77.8% versus 24.4%, respectively) (Roberts et al., 2017), however this was expected. The Canadian Health Measures Study objectively measured PA using accelerometers (Roberts et al., 2017) while the studies within this dissertation used self-reported PA measures, and a previous validation study found that students tend to

overestimate their PA when collected using self-report survey compared to accelerometer (Leatherdale et al., 2014). Also, in Chapters 4 through 6, the student-level PA outcomes (weekly minutes of MVPA and achieving the PA recommendations) were observed to be significantly lower among female students compared to male students and PA for both genders decreased significantly over time, which aligned with the existing literature (Dumith et al., 2011; Roberts et al., 2017; Sallis, 2000; Statistics Canada, 2020).

7.2.2 School Social and Physical Environment

While there were many social and physical environment factors associated with the student PA outcomes for various subgroups that can be found in Chapters 4 to 6, there were two notable findings to highlight.

First, female students attending schools that ranked PA as a lower priority had significantly lower MVPA (Chapter 4), lower odds of achieving the PA recommendations (Chapter 4), negative slope for MVPA across three years (Chapter 5), and, in those who were not achieving the recommendations at baseline, significantly lower odds of improving to achieve them after two years (Chapter 6). In contrast, male students attending schools with lower priority ranking of PA had significantly higher MVPA (Chapter 5), a positive slope for MVPA across three years (Chapter 6), and, in those not achieving the recommendations at baseline, a significantly higher odds of improving to achieve them after two years (Chapter 6). A similar pattern was observed for the school promotion of PA activities. These very consistent findings may suggest that schools are ranking the importance of PA based on the activity levels of male students. Alternatively, it may suggest that schools that rank PA as high priority are concurrently implementing strategies that promote PA among female students. Previous research has found that perceived social support for PA at school may be associated with youth PA (Hohepa et al., 2007), and schools that are placing a higher prioritization on

PA may be creating this type of supportive environment, however this would need to be studied through future research.

Second, for the physical environment, providing showers and privacy curtains was unexpectedly found to be negatively associated with student PA for some subgroups. In particular, for female students who were already achieving the guidelines, the only school-level factor found to be significantly associated with continuing to achieve the guidelines after two years was the availability of showers and it was a negative association (Chapter 6). It was also noted that, while not significant, the three other categories of students also had decreased odds of achieving the guidelines if showers were provided (similar effect size and confidence interval). Similarly, for male students who were achieving the PA recommendations, they had significantly lower odds of continuing to achieve them if their school provided privacy curtains (Chapter 6). Additionally, there were no student subgroups for which there was a positive association between the school provision of showers or curtains and student PA for any of the three manuscripts. These findings suggest that providing showers and/or curtains may have a negative impact on PA over time, particularly among active students. As noted in Chapter 6, the life stage being studied corresponds with when many students are experiencing puberty, and there may be stigma, bullying, or other psycho-social factors affiliated with PA and the use of showers or privacy curtains (Frydendal & Thing, 2020; Jachyra, 2016; Kirby et al., 2012; Sandercock et al., 2016). Also, the degree of privacy in the shower area (e.g., open concept or stalls) was not considered in these studies. Therefore, these results do not necessarily suggest that the showers or curtains should be removed, but instead more research is needed to understand the functional space and the underlying social or psychological dynamics (e.g., could changing the perception around the use of privacy curtains reduce stigma).

7.2.3 Partnerships and Services

Across the three manuscripts, there was substantial variability in the associations between school partnerships with different organizations and student PA. These significant findings within manuscripts but not between manuscripts suggests that each partnership may contribute to supporting PA for a particular gender, grade, or PA outcome, and having multiple partnerships may be the most appropriate approach. For example, there was a consistent finding that female, Grade 11, and 12 students attending schools partnered with a youth organization had higher odds of achieving the PA recommendations (Chapter 4). However, there were no significant associations between youth organization partnership and odds of achieving the guidelines after two years, regardless of baseline PA status (Chapter 6). Therefore, it may be that senior female students benefit the most from school partnerships with youth organizations. For another example, male students who were achieving the PA recommendations at baseline were significantly more likely to continue achieving them after two years if their school was partnered with public health (Chapter 6). In contrast, female students had a significant negative slope for MVPA over time if attending a school partnered with public health (Chapter 5). These findings suggest that current public health materials or resources may be better suited to supporting active males in continuing to stay active, and may be less effective for female students and inactive male students. Previous research has generally found that school partnerships with organizations can be beneficial for student PA (Craig et al., 2001; Leatherdale et al., 2010), but the results of the three manuscripts within this dissertation highlight the complexity of these relationships, including some partnerships that had negative associations with student PA outcomes. There is a need to delve deeper into this topic to understand which partnerships work best for each subgroup and PA outcome (including VPA and MBSE as separate outcomes), and what features of the partnership are having the positive or negative impact on student PA.

7.2.4 Teaching and Learning

For the teaching and learning component of CSH, there were consistently positive associations observed between the provision of intramural and non-competitive PA opportunities and students achieving the PA recommendations in the cross-sectional analysis (Chapter 4), however, there were no significant associations observed in any of the longitudinal analyses (Chapters 5 and 6). This was unexpected given the existing research literature suggesting that providing additional types of PA opportunities can increase student PA (Fuller et al., 2011; Sallis, 2000), and that non-competitive options may be of particular interest to female students (Dwyer et al., 2006; Kirby et al., 2012). It is possible that intramural and non-competitive PA opportunities have a greater impact on VPA or MBSE over time, which were not independently evaluated in this dissertation (neither cross-sectionally nor longitudinally). It is also possible that with the large number of school-level factors included in the models that other school characteristics had a relatively greater effect on the PA outcomes than providing intramural or non-competitive PA options.

7.2.5 Policy

For the policy component of CSH, there were many school-level factors evaluated under this heading, however there were two areas that stood out across the three manuscripts.

First, the provision of equipment during non-instructional time was significantly associated with higher MVPA and odds of achieving the recommendations for most student gender and grade subgroups in the cross-sectional analysis in Chapter 4. In addition, male students who were already achieving all three PA recommendations at baseline had significantly higher odds of continuing to achieve them if they were permitted to access equipment during non-instructional time (Chapter 6). Despite this finding, only one-third of schools had a policy that permitted student access to equipment during non-instructional time, highlighting an opportunity for policy change that can help students maintain PA over time. Second, resources being provided by the school board were found to have a

meaningful impact on student PA over time. Although the odds of achieving the PA guidelines was observed to be lower with the highest budget in the cross-sectional analysis (Chapter 4), female students had a significant positive slope in MVPA over time when attending schools with the highest category of budget for student health from the school board (Chapter 5). Together, these results indicate that schools where PA levels are lower may be receiving a higher budget to support student PA and longitudinally this resource may be having a positive effect on MVPA specifically. Female students also appeared to benefit from staff time for student health being provided by the school board (Chapters 5 and 6), while male students benefited from space for student health being provided by the school board (Chapter 5). Therefore, each of the school board resources evaluated (budget, staff, space) were associated with positive PA outcomes over time and the school board can play a role in promoting student PA. Understanding how the resources were being used by the school was beyond the scope of this dissertation, but would be informative for similar schools and school boards in order to replicate the findings.

7.2.6 School-level ICCs

In each of the multilevel regression models analysed in Chapters 4 through 6, there was a small degree of clustering observed in the PA outcome variables, indicating that there was at least some correlation between students within the same school compared to students from other schools with respect to the outcome measure. Although these ICCs were very small (1-3%), they were within the expected range based on previous research (Fein et al., 2004; Hobin et al., 2010, 2013). According to Rose's (1992) strategy of preventive medicine, from a population health perspective, even small improvements to student PA when applied across the student population can have a large impact on the overall health and wellbeing of Canadian youth.

It is also possible that the school-level ICCs were underestimated in these studies. For example, student MVPA was self-reported using questions that had moderate validity (Pearson's $r =$

0.31) (Leatherdale et al., 2014). As measurement tool validity decreases and measurement error increases, there is a tendency for individual-level variability to increase but not cluster-level variability (Wilms et al., 2020). In the first study (Chapter 4), it was reported that the mean MVPA across students was 886.8 minutes/week with a standard deviation of 640.0minutes/week, but when aggregated by school, mean MVPA was 892.2 minutes/week with a standard deviation of 90.2 minutes/week. Therefore, there was a meaningful difference observed in student MVPA across schools, a range of approximately 3 hours/week of MVPA between schools that were one standard deviation above and below the mean. However, since the student-level variability was so large in comparison to the school-level variability (640.0 minutes/week versus 90.2 minutes/week), the resulting school-level ICC was very low. Future research examining the ICC of student PA across schools using an objective measure of PA might help to determine whether the ICCs in Chapters 4 through 6 were in fact underestimated due to using a self-reported PA measure and, if so, may provide a closer approximation of what the true ICCs might be for student PA outcomes within schools.

7.3 Implications for Practice

Overall, many associations between school-level characteristics and student-level PA were identified within this dissertation and have the potential for real-world impact on student PA and health. In general, there were some school-level characteristics that positively affected the PA behaviour of all students, while other characteristics were most effective for a particular subgroup of students. With limited resources available to schools, the results of this dissertation can assist schools in tailoring improvements to their specific need and identifying which changes may have the greatest impact for little or no cost. The current study was purposefully designed to not have a researcher-led intervention such that any of the effects observed were due to variations organically occurring within schools and with the potential to be replicated by similar schools. Communities of practice can play a

role in facilitating this knowledge exchange by having schools who have already implemented changes assist other schools through sharing both the pitfalls and successes they have experienced.

The following are four notable examples of school-level changes identified within this dissertation that could impact the PA behaviours of students. First, providing access to equipment (e.g., basketballs) during non-instructional times within the school day was consistently associated with higher MVPA and students achieving the PA guidelines, yet only implemented by 30% of schools in this sample. Second, community partnerships with youth organizations appeared to promote achieving the PA guidelines in many student subgroups, especially among senior female students. For male students, partnerships with public health and local health and fitness clubs were associated with improved PA outcomes. Third, the provision of alternatives to interschool sports, such as intramurals and non-competitive clubs, may support PA among Grade 9 and female students. Fourth, prioritizing PA may create a school environment that can foster PA among female students. Altogether, these changes may help students in achieving the PA recommendations and having improved health and wellbeing.

7.4 Overall Strengths

There are several strengths in the studies conducted for this dissertation. The school- and student-level data in the COMPASS research platform were collected simultaneously from a large number of Ontario and Alberta schools and with a high coverage rate of students within these schools due to the active-information, passive-consent process. As such, due to the large sample size available through COMPASS, it was possible to concurrently evaluate 33 unique school-level characteristics, representing the four components of CSH. By including all of these school-level factors in the same model, it was possible to evaluate their relative importance, which is a significant addition to the research literature.

In addition, due to the large sample size it was possible in Chapter 4 to examine six different subgroups of students, gaining a better understanding of how the school-level characteristics differentially impacted each grade level and students of each gender. This was a major contribution to the literature, as the school-level factors associated with student PA were quite different for male and female students. There were even some cases where contrasting results were noted that may have been otherwise masked if this subgroup analysis could not be conducted. For example, school ranking of PA was positively associated with PA among female students and negatively associated with PA among male students. If all students had been analyzed as a single group, this relationship would likely have been lost. Aside from other studies using data collected through the COMPASS platform, having sufficient data to conduct these types of analyses and subgroups analyses is rare.

Another strength was the multiple waves of linked annual data from the same schools and students available through the COMPASS platform. Chapters 5 and 6 utilized linked data from Y_2 , Y_3 , and Y_4 for longitudinal analyses, which provided the unique opportunity to evaluate the impact of many school characteristics, guided by the CSH framework, on student MVPA behaviour change over time and odds of achieving the PA recommendations over time in a prospective cohort of students. Understanding not only the relationship between school factors and PA at a single point in time, but also the school-level factors that may alter the trajectory of student MVPA over time and their odds of achieving the PA recommendations after two years is a substantial addition to the literature.

7.5 Overall Limitations

There were also some limitations for the studies within this dissertation. One of the first challenges was missing data at the school-level. In an effort to reduce the number of schools or students excluded from the studies, missing data was categorized as “Other/Missing” where needed. Also, since the school-level changes from year-to-year were not well-documented, the school’s baseline

intake data was used to represent the school-level characteristics for all analyses. This was not expected to have a substantial effect on the results since it is hypothesized that it may take a year or two before any change in school-level factors may have substantial impact, but further research would be needed to evaluate this speculation. Also, the student-level data was self-reported, which is susceptible to social desirability bias and recall error. Accordingly, the absolute MVPA and vigorous PA measures may be inflated (Leatherdale et al., 2014) but it was expected that the direction and magnitude of bias would be consistent across students and years, thus the comparisons between groups and changes over time would not be affected by this self-report bias.

7.6 Future Research Directions

While it was a strength to be able to evaluate a large number of school-level factors simultaneously and their relative effect on student PA, this broad approach does not allow the researcher to investigate the observed associations in-depth and understand the ‘why’ and ‘how’ of these findings, especially those findings that are in conflict with each other. Many potential research questions have been posed throughout the dissertation, therefore the focus here will be on the overarching topics for future research directions.

First, this dissertation was restricted to school-level factors collected through the SPP, which was completed by a school administrator. There may be differences between this objective measure of the school environment and student perceptions (e.g., school policy for student access to facilities) (Scott et al., 2007), which could impact the findings and the appropriate interpretation. Future research that incorporates student perceptions could identify where these gaps may lie and the subsequent implications for both school administrators (e.g., areas for improved communication) and researchers.

Second, it was beyond the scope of this dissertation to examine interactions between the school factors within the CSH framework. For example, the association between intramural sports

and student PA may be different for schools located in high SES neighbourhoods compared to low SES neighbourhoods. Also, schools that rated PA as a high priority may be substantially different from those that ranked PA as a low priority with respect to many other characteristics within the CSH framework. Future research to explore these interactions may identify moderating effects of certain school-level factors on the relationships between other school-level factors and student PA.

Third, the studies in this dissertation only focused on two PA outcomes: weekly minutes of MVPA and achieving all three PA recommendations. Some of the conflicting results between the cross-sectional analysis (Chapter 4) and the longitudinal analyses (Chapters 5 and 6) may be due to not analysing VPA and MBSE as independent PA outcomes as well in order to see the full picture. There is also a dearth of research focused on MBSE for the general population of students (i.e., not student athletes), despite MBSE being part of the national PA recommendations (Tremblay et al., 2016). Future studies examining VPA and MBSE as PA outcomes would be valuable contributions to the research literature.

Finally, there were many research questions identified that would have benefited from having a complementary qualitative component (mixed methods) to fully understand the results. For example, the negative association between privacy curtains and male students achieving the PA recommendations after two years might be better understood using a qualitative approach. Another example would use qualitative methods to determine how schools receiving resources from the school board were using those resources in practice. These findings would improve the interpretability of some of the findings within this dissertation.

7.7 Conclusions

Schools can play an integral role in promoting student PA, supporting them in achieving the PA guidelines, and putting students on the path to healthy adulthood (Craig et al., 2001; Rainham et al., 2012; Sallis, 2000). PA in youth has been linked to many physical and psychological benefits

(Warburton et al., 2006), but PA declines significantly throughout secondary school (Sallis, 2000). The CSH framework suggests four inter-related components through which schools can effect health-related change (Joint Consortium for School Health, 2016; Veugelers & Schwartz, 2010) and potentially mitigate this decline in PA. Using the CSH framework, the three manuscripts within this dissertation identified multiple school-level characteristics that were associated both positively and negatively with student-level PA. The school-level characteristics associated with PA behaviours were found to differ by grade level and gender, therefore the specific elements within the CSH framework that will achieve the desired effect will depend on the student subgroup being targeted. There were many areas for future research identified throughout the discussions, especially where the results were not as expected and there were no existing studies for comparison. A mixed methods approach may help to shed light on some of these unexpected results and delve deeper into the mechanisms behind the observed relationships; for example, the provision of showers being negatively associated with PA outcomes. However, there were also many positive findings with the potential for real-world impact that schools could feasibly implement; such as policies for access to equipment, opportunities for non-competitive PA clubs and intramural sports, and partnerships with public health and local organizations. By implementing the changes that fit best with the school's own needs and capacity, as well as schools learning from each other through communities of practice, there is a greater likelihood of successfully improving student PA behaviour.

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Appendix A

Physical Activity Recommendations

GUIDELINES

For optimal health benefits, children and youth (aged 5–17 years) should achieve high levels of physical activity, low levels of sedentary behaviour, and sufficient sleep each day.

A healthy 24 hours includes:



SWEAT

MODERATE TO VIGOROUS PHYSICAL ACTIVITY

An accumulation of at least 60 minutes per day of moderate to vigorous physical activity involving a variety of aerobic activities. Vigorous physical activities, and muscle and bone strengthening activities should each be incorporated at least 3 days per week;

STEP

LIGHT PHYSICAL ACTIVITY

Several hours of a variety of structured and unstructured light physical activities;

SLEEP

SLEEP

Uninterrupted 9 to 11 hours of sleep per night for those aged 5–13 years and 8 to 10 hours per night for those aged 14–17 years, with consistent bed and wake-up times;

SIT

SEDENTARY BEHAVIOUR

No more than 2 hours per day of recreational screen time; Limited sitting for extended periods.

Preserving sufficient sleep, trading indoor time for outdoor time, and replacing sedentary behaviours and light physical activity with additional moderate to vigorous physical activity can provide greater health benefits.

About You

1. What grade are you in?

- Grade 9
- Grade 10
- Grade 11
- Grade 12

2. How old are you today?

- 13 years or younger
- 14 years
- 15 years
- 16 years
- 17 years
- 18 years or older

3. Are you female or male?

- Female
- Male

4. How would you describe yourself? (Mark all that apply)

- White
- Black
- Asian
- Aboriginal (First Nations, Métis, Inuit)
- Latin American/Hispanic
- Other _____

5. About how much money do you usually get each week to spend on yourself or to save?

(Remember to include all money from allowances and jobs like baby-sitting, delivering papers, etc.)

- Zero
- \$1 to \$5
- \$6 to \$10
- \$11 to \$20
- \$21 to \$40
- \$41 to \$100
- More than \$100
- I do not know how much money I get each week

6. How do you usually travel to and from school? (If you use two or more modes of travel, choose the one that you spend most time doing)

- | <u>To school</u> | <u>From school</u> |
|---|---|
| <input type="radio"/> By car (as a passenger) | <input type="radio"/> By car (as a passenger) |
| <input type="radio"/> By car (as a driver) | <input type="radio"/> By car (as a driver) |
| <input type="radio"/> By school bus | <input type="radio"/> By school bus |
| <input type="radio"/> By public bus, subway, or streetcar | <input type="radio"/> By public bus, subway, or streetcar |
| <input type="radio"/> By walking | <input type="radio"/> By walking |
| <input type="radio"/> By bicycling | <input type="radio"/> By bicycling |
| <input type="radio"/> Other _____ | <input type="radio"/> Other _____ |

7. Did you attend this school last year?

- Yes, I attended the same school last year
- No, I was at another school last year

Physical Activity

HARD physical activities include jogging, team sports, fast dancing, jump-rope, and any other physical activities that increase your heart rate and make you breathe hard and sweat.

MODERATE physical activities include lower intensity activities such as walking, biking to school, and recreational swimming.

11. Mark how many minutes of **HARD** physical activity you did on each of the last 7 days. This includes physical activity during physical education class, lunch, after school, evenings, and spare time.

	Hours					Minutes			
Monday	0	1	2	3	4	0	15	30	45
Tuesday	0	1	2	3	4	0	15	30	45
Wednesday	0	1	2	3	4	0	15	30	45
Thursday	0	1	2	3	4	0	15	30	45
Friday	0	1	2	3	4	0	15	30	45
Saturday	0	1	2	3	4	0	15	30	45
Sunday	0	1	2	3	4	0	15	30	45

For example: If you did 45 minutes of hard physical activity on Monday, you will need to fill in the 0 hour circle and the 45 minute circle, as shown below:

	Hours					Minutes			
Monday	●	1	2	3	4	0	15	30	●

12. Mark how many minutes of **MODERATE** physical activity you did on each of the last 7 days. This includes physical activity during physical education class, lunch, after school, evenings, and spare time. **Do not** include time spent doing hard physical activities.

	Hours					Minutes			
Monday	0	1	2	3	4	0	15	30	45
Tuesday	0	1	2	3	4	0	15	30	45
Wednesday	0	1	2	3	4	0	15	30	45
Thursday	0	1	2	3	4	0	15	30	45
Friday	0	1	2	3	4	0	15	30	45
Saturday	0	1	2	3	4	0	15	30	45
Sunday	0	1	2	3	4	0	15	30	45

For example: If you did 1 hour and 30 minutes of moderate physical activity on Monday, you will need to fill in the 1 hour circle and the 30 minute circle, as shown below:

	Hours					Minutes			
Monday	0	●	2	3	4	0	15	●	45

13. Were the last 7 days a typical week in terms of the amount of physical activity that you usually do?

- Yes
 No, I was *more* active in the last 7 days
 No, I was *less* active in the last 7 days

14. Your closest friends are the friends you like to spend the most time with. How many of your closest friends are physically active?

- None
 1 friend
 2 friends
 3 friends
 4 friends
 5 or more friends

15. Are you taking a physical education class at school this year?

- Yes, I am taking one **this term**
 Yes, I will be taking one or have taken one this school year, **but not this term.**
 No, I am not taking a physical education class at school this year

Healthy Eating

24. If you do not eat breakfast every day, why do you skip breakfast? (Mark all that apply)

- I eat breakfast every day
- I don't have time for breakfast
- The bus comes too early
- I sleep in
- I'm not hungry in the morning
- I feel sick when I eat breakfast
- I'm trying to lose weight
- There is nothing to eat at home
- Other _____

25. In a *usual* school week (Monday to Friday), on how many days do you do the following?

	None	1 day	2 days	3 days	4 days	5 days
a) Eat breakfast	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b) Eat breakfast provided to you as part of a school program	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c) Eat lunch at school - lunch packed and brought <u>from home</u>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d) Eat lunch at school - lunch <u>purchased in the cafeteria</u>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e) Eat lunch purchased at a fast food place or restaurant	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f) Eat snacks purchased from a vending machine in your school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g) Eat snacks purchased from a vending machine, corner store, snack bar, or canteen off school property	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h) Drink sugar-sweetened beverages (soda pop, Kool-Aid, Gatorade, etc.) <u>Do not include diet/sugar-free drinks</u>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i) Drink high-energy drinks (Red Bull, Monster, Rock Star, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
j) Drink coffee or tea with sugar (include cappuccino, frappuccino, iced-tea, iced-coffees, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
k) Drink coffee or tea without sugar	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

26. On a *usual* weekend (Saturday and Sunday), on how many days do you do the following?

	None	1 day	2 days
a) Eat breakfast	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b) Eat lunch	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c) Eat foods purchased at a fast food place or restaurant	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d) Eat snacks purchased from a vending machine, corner store, snack bar, or canteen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e) Drink sugar-sweetened beverages (soda pop, Kool-Aid, Gatorade, etc.) <u>Do not include diet/sugar-free drinks</u>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f) Drink high energy drinks (Red Bull, Monster, Rock Star, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g) Drink coffee or tea with sugar (include cappuccino, frappuccino, iced-tea, iced-coffees, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h) Drink coffee or tea without sugar	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

27. **YESTERDAY, from the time you woke up until the time you went to bed, how many servings of meats and alternatives did you have?** One 'Food Guide' serving of meat and alternatives includes cooked fish, chicken, beef, pork, or game meat, eggs, nuts or seeds, peanut butter or nut butters, legumes (beans), and tofu.

- None
- 1 serving
- 2 servings
- 3 servings
- 4 servings
- 5 or more servings

Canada's Food Guide Serving Sizes of Meats and Alternatives



28. **YESTERDAY, from the time you woke up until the time you went to bed, how many servings of vegetables and fruits did you have?** One 'Food Guide' serving of vegetables and fruit includes pieces of fresh vegetable or fruit, salad or raw leafy greens, cooked leafy green vegetables, dried or canned or frozen fruit, and 100% fruit or vegetable juice.

- None
- 1 serving
- 2 servings
- 3 servings
- 4 servings
- 5 servings
- 6 servings
- 7 servings
- 8 servings
- 9 or more servings

Canada's Food Guide Serving Sizes of Vegetables and Fruits



29. **YESTERDAY, from the time you woke up until the time you went to bed, how many servings of milk and alternatives did you have?** One 'Food Guide' serving of milk or milk alternatives includes milk, fortified soy beverage, reconstituted powdered milk, canned (evaporated) milk, yogurt or kefir (another type of cultured milk product), and cheese.

- None
- 1 serving
- 2 servings
- 3 servings
- 4 servings
- 5 servings
- 6 or more servings

Canada's Food Guide Serving Sizes of Milk and Alternatives



30. **YESTERDAY, from the time you woke up until the time you went to bed, how many servings of grain products did you have?** One 'Food Guide' serving of grain products includes bread, bagels, flatbread such as tortilla, pita, cooked rice or pasta, and cold cereal.

- None
- 1 serving
- 2 servings
- 3 servings
- 4 servings
- 5 servings
- 6 servings
- 7 servings
- 8 servings
- 9 or more servings

Canada's Food Guide Serving Sizes of Grain Products



Food photos source: Canada's Food Guide, Health Canada, 2011. Reproduced with the permission of the Minister of Health, 2011.

39. Have you ever smoked every day for at least 7 days in a row?

- Yes
- No

40. On how many of the last 30 days did you smoke one or more cigarettes?

- None
- 1 day
- 2 to 3 days
- 4 to 5 days
- 6 to 10 days
- 11 to 20 days
- 21 to 29 days
- 30 days (*every day*)

41. Thinking back over the last 30 days, on the days that you smoked, how many cigarettes did you usually smoke each day?

- None
- A few puffs to one whole cigarette
- 2 to 3 cigarettes
- 4 to 5 cigarettes
- 6 to 10 cigarettes
- 11 to 20 cigarettes
- 21 to 29 cigarettes
- 30 or more cigarettes

42. Your closest friends are the friends you like to spend the most time with. How many of your closest friends smoke cigarettes?

- None
- 1 friend
- 2 friends
- 3 friends
- 4 friends
- 5 or more friends

43. Have you ever tried to quit smoking cigarettes?

- I have never smoked
- I have only smoked a few times
- I have never tried to quit
- I have tried to quit once
- I have tried to quit 2 or 3 times
- I have tried to quit 4 or 5 times
- I have tried to quit 6 or more times

44. In the last 30 days, did you use any of the following? (*Mark all that apply*)

- Pipe tobacco
- Cigarillos or little cigars (*plain or flavoured*)
- Cigars (not including cigarillos or little cigars, *plain or flavoured*)
- Roll-your-own cigarettes (tobacco only)
- Loose tobacco mixed with marijuana
- E-cigarettes (electronic cigarettes that look like cigarettes/cigars, but produce vapour instead of smoke)
- Smokeless tobacco (chewing tobacco, pinch, snuff, or snus)
- Nicotine patches, nicotine gum, nicotine lozenges, or nicotine inhalers
- Hookah (water-pipe) to smoke tobacco
- Hookah (water-pipe) to smoke herbal sheesha/shisha
- Blunt wraps (a sheet or tube made of tobacco used to roll cigarette tobacco)
- I have not used any of these things in the last 30 days

Your School and You

52. How strongly do you agree or disagree with each of the following statements?

	Strongly Agree	Agree	Disagree	Strongly Disagree
a) I feel close to people at my school.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b) I feel I am part of my school.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c) I am happy to be at my school.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d) I feel the teachers at my school treat me fairly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e) I feel safe in my school.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f) Getting good grades is important to me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

53. In the last 30 days, in what ways were you bullied by other students? (Mark all that apply)

- I have not been bullied in the last 30 days
- Physical attacks (e.g., getting beaten up, pushed, or kicked)
- Verbal attacks (e.g., getting teased, threatened, or having rumours spread about you)
- Cyber-attacks (e.g., being sent mean text messages or having rumours spread about you on the internet)
- Had someone steal from you or damage your things

54. In the last 30 days, how often have you been bullied by other students?

- I have not been bullied by other students in the last 30 days
- Less than once a week
- About once a week
- 2 or 3 times a week
- Daily or almost daily

55. In the last 30 days, in what ways did you bully other students? (Mark all that apply)

- I did not bully other students in the last 30 days
- Physical attacks (e.g., beat up, pushed, or kicked them)
- Verbal attacks (e.g., teased, threatened, or spread rumours about them)
- Cyber-attacks (e.g., sent mean text messages or spread rumours about them on the internet)
- Stole from them or damaged their things

56. In the last 30 days, how often have you taken part in bullying other students?

- I did not bully other students in the last 30 days
- Less than once a week
- About once a week
- 2 or 3 times a week
- Daily or almost daily

57. How supportive is your school of the following?

	Very supportive	Supportive	Unsupportive	Very unsupportive
a) Making sure there are opportunities for students to be physically active	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b) Making sure students have access to healthy foods and drinks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c) Making sure no one is bullied at school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d) Giving students the support they need to resist or quit tobacco	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e) Giving students the support they need to resist or quit drugs and/or alcohol	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

58. What academic level was your current or most recent Math course?

- Applied
- Academic
- Other _____

59. In your current or most recent Math course, what is your approximate overall mark?
(Think about last year if you have not taken math this year)

- 90% - 100%
- 80% - 89%
- 70% - 79%
- 60% - 69%
- 55% - 59%
- 50% - 54%
- Less than 50%

60. In your current or most recent English course, what is your approximate overall mark?
(Think about last year if you have not taken English this year)

- 90% - 100%
- 80% - 89%
- 70% - 79%
- 60% - 69%
- 55% - 59%
- 50% - 54%
- Less than 50%

61. What is the highest level of education you would like to get? (Choose only one)

- Some high school or less
- High school diploma or graduation equivalency
- College/trade/vocational certificate
- University Bachelor's degree
- University Master's / PhD / law school / medical school / teachers' college degree
- I don't know

62. What is the highest level of education you think you will get? (Choose only one)

- Some high school or less
- High school diploma or graduation equivalency
- College/trade/vocational certificate
- University Bachelor's degree
- University Master's / PhD / law school / medical school / teachers' college degree
- I don't know

63. In the last 4 weeks, how many days of school did you miss because of your health?

- 0 days
- 1 or 2 days
- 3 to 5 days
- 6 to 10 days
- 11 or more days

64. In the last 4 weeks, how many classes did you skip when you were not supposed to?

- 0 classes
- 1 or 2 classes
- 3 to 5 classes
- 6 to 10 classes
- 11 to 20 classes
- More than 20 classes

65. How often do you go to class without your homework complete?

- Never
- Seldom
- Often
- Usually



[serial]

Appendix C

School Practices and Policies Questionnaire (SPP)



General School Health Questions

1. Does your school have written policies on the following?

	Yes, a copy will be provided to COMPASS staff	No
a. Healthy Eating	<input type="radio"/>	<input type="radio"/>
b. Physical Activity	<input type="radio"/>	<input type="radio"/>
c. Tobacco Use	<input type="radio"/>	<input type="radio"/>
d. Alcohol & Drug Use	<input type="radio"/>	<input type="radio"/>
e. Bullying	<input type="radio"/>	<input type="radio"/>

2. What resources are available annually from your school board to support efforts to improve the health of students at your school?

- a. Budget
 - Annual budget greater than \$1000
 - Annual budget \$500-\$999
 - Annual budget \$100-\$499
 - Annual budget less than \$100
 - We receive no funding from the board for this
- b. Staff time (e.g., for professional development, monitoring of policy compliance, etc.)
 - Yes
 - No
- c. Space
 - Yes
 - No

3. Has your school used data from a student health assessment at least once in the past two years to help in planning actions that will improve your school's environment and/or to help determine the impact of changes that you have made on student attitudes and behaviours?

(Examples of student assessments are: SHAPES student survey, Youth Smoking Survey, Ontario Student Drug Use and Health Survey [OSDUHS].)

- Yes
- No

4. Has your school made any health policy or health program changes in the past year (e.g., introducing a ban on beverages containing sugar in school vending machines)?
- Yes
 - No
5. During the past 12 months, what role did your local Public Health Unit play when working with your school on health promotion and/or activities for students? *(Check all that apply)*
- No contact with local Public Health Unit regarding health promotion and/or activities
 - Provided information/resources/programs (e.g., posters, toolkits)
 - Solved problems jointly
 - Developed/implemented program activities jointly
6. In which fields does your school receive support from your school's local Public Health Unit? *(Check all that apply)*
- We do not receive any resources from Public Health
 - Healthy eating
 - Physical activity
 - Tobacco use
 - Alcohol and drug use
 - Sedentary behaviour
 - Obesity
 - Bullying
7. During the past 12 months, has your school worked with any of the following to promote health and/or health activities? *(Check all that apply)*
- Health organization (e.g., Canadian Cancer Society, Heart and Stroke Foundation, Canadian Diabetes Association)
 - Parks or Recreation department
 - Youth organization (e.g., YMCA/YWCA, Boys/Girls Clubs, Boy Scouts/Girl Guides)
 - Health or fitness club
 - Board/division/district itinerant teacher (e.g., consultant, specialist)
8. Please rank these school/health-related issues in terms of importance to your school (1=highest priority, 2=second highest priority, etc.):
- | | | |
|----|----------------------------|-------|
| a. | Tobacco Use | _____ |
| b. | Alcohol and other Drug Use | _____ |
| c. | Healthy Eating | _____ |
| d. | Physical Activity | _____ |
| e. | Bullying/Violence | _____ |
| f. | Mental Health | _____ |
| g. | Sexual Health | _____ |
| h. | Sun safety/tanning beds | _____ |
| i. | Obesity | _____ |

j. Sedentary behaviours / screen-time _____

9. Are there any other school/health-related issues that are important to your school that are not listed in Question 8 above?

- Yes → Please list: _____
- No

10. Are your school's written health policies (e.g., smoking rules, healthy eating requirements, drug policies) communicated to students?

- Yes → Please indicate how they are communicated:

- No

Physical Activity Questions

11. Is the physical inactivity of students a problem at your school?

- Yes
- No
- I don't know

12. Do the majority of students at your school have regular access to INDOOR physical activity areas during non-instructional school time? (e.g., during lunch, spare periods)

- Yes on school grounds only
- Yes, off school grounds only
- Yes, both on and off school grounds
- No
- I don't know

13. Do the majority of students at your school have regular access to OUTDOOR physical activity areas during non-instructional time? (e.g., during lunch, spare periods)

- Yes on school grounds only
- Yes, off school grounds only
- Yes, both on and off school grounds
- No
- I don't know

14. Does your school have:

		Yes	No
a.	Gymnasium(s)	<input type="radio"/>	<input type="radio"/>
b.	Indoor facilities (e.g., dance studio, yoga room, fitness room)	<input type="radio"/>	<input type="radio"/>
c.	Outdoor facilities (e.g., playing fields, paved activity areas, baseball diamond)	<input type="radio"/>	<input type="radio"/>

15. Do students have access to physical activity equipment such as soccer and basketballs during non-instructional times throughout the school day? (e.g., during lunch, or spare periods)

- Always
- Sometimes
- Never

16. Do the majority of students at your school have regular access to any of the following?

		Yes	No
a.	Secure change room lockers available for use during physical activity	<input type="radio"/>	<input type="radio"/>
b.	Change rooms available for use before and after physical activity	<input type="radio"/>	<input type="radio"/>
c.	If yes, are privacy curtains/stalls (not including shower or bathroom stalls) available for ...	i. Girls?	<input type="radio"/>
		ii. Boys?	<input type="radio"/>
d.	Clean showers available for use before and after physical activity	i. Girls?	<input type="radio"/>
		ii. Boys?	<input type="radio"/>

17. Outside of school hours, does your school permit regular student access to the following?

(Outside of school hours means before school, after school, evenings, and weekends. Student access may occur via school-led, community-led, or informal use.)

		Yes	No	N/A
a.	Gymnasium(s)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b.	Indoor facilities (e.g., dance studio, yoga room, fitness room)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c.	Outdoor facilities (e.g., playing fields, paved activity areas, baseball diamond)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d.	Equipment (e.g., soccer balls, basketballs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

18. Does your school offer intramural programs/club activities that involve physical activity?

(Intramural programs/club activities are school-sponsored physical/recreational activities that occur outside of instructional time, are available to all students, are focused on maximizing participation, and are limited to individuals/groups/teams of the school population.)

- Yes
- No

19. During the past 12 months, how many intramural programs that involve physical activity were available to students over the course of the school year?

- Fall _____
- Winter _____
- Spring _____

20. Does your school offer non-competitive sports clubs (e.g. rock climbing, dance, outdoor club) that involve physical activity?

- Yes

c. Vending Machine(s)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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27. Does your school have a breakfast program for students?

- Yes
- No (Skip to question 31)

28. How often is the breakfast program offered?

- 1 day per week
- 2 days per week
- 3 days per week
- 4 days per week
- 5 days per week

29. Is the breakfast program free?

- Yes
- No → How much does it cost? _____

30. Is the breakfast program available to all students?

- Yes
- No → What is the restriction? _____

31. Does your school offer any of the following? (Check all that apply)

	Yes	No
a. Cooking classes	<input type="radio"/>	<input type="radio"/>
b. Gardening (e.g., growing produce)	<input type="radio"/>	<input type="radio"/>
c. Field trips to farms/farmers' markets	<input type="radio"/>	<input type="radio"/>
d. Media literacy on special topics related to healthy eating (e.g., body image, eating disorders)	<input type="radio"/>	<input type="radio"/>
e. Field trips to the local grocery store	<input type="radio"/>	<input type="radio"/>

32. Does your school have programs in place to help students understand nutrition?

- Yes → Please list: _____
- No

33. During the past 12 months, have school staff received:

	For nutrition	For promoting positive body image
a. In-service training (e.g., by Public/Regional Health)	<input type="radio"/>	<input type="radio"/>
b. Conferences	<input type="radio"/>	<input type="radio"/>
c. Workshops on professional development days	<input type="radio"/>	<input type="radio"/>
d. Presentations by Community Organizations	<input type="radio"/>	<input type="radio"/>

e.	Teacher initiated self-training on the Internet at home	<input type="radio"/>	<input type="radio"/>
f.	Teacher initiated self-training on the Internet at school	<input type="radio"/>	<input type="radio"/>
g.	Faculty of Education courses	<input type="radio"/>	<input type="radio"/>
h.	Other (please specify): _____ _____ _____	<input type="radio"/>	<input type="radio"/>

34. Does school staff have clear guidelines to refer students with suspected eating disorders to the appropriate health professional or community agency?

- Yes
- No
- I don't know

Bullying Questions

35. Is bullying a problem at your school?

- Yes
- No
- I don't know

36. Does your school have any programs that address bullying?

- Yes → Please list:

- No

Substance Use Questions

37. Are any of the following substance use behaviours a problem among students at your school?

	Yes	No	I don't know
a. Tobacco use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Alcohol use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Drug use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

38. Does your school **prohibit** students smoking tobacco (e.g. cigarettes, cigars, cigarillos) in each of the following locations? (*Check all that apply*)

	Yes	No
a. Within a specified distance of school grounds	<input type="radio"/>	<input type="radio"/>
b. Private vehicles parked on school grounds	<input type="radio"/>	<input type="radio"/>
c. Sponsored events <u>off</u> of school grounds	<input type="radio"/>	<input type="radio"/>

39. Does your school prohibit student use of smokeless tobacco (e.g. chewing tobacco, pinch, snuff, or snus) in each of the following locations?

		Yes	No
a.	In class	<input type="radio"/>	<input type="radio"/>
b.	Anywhere on school property during school hours	<input type="radio"/>	<input type="radio"/>
c.	During school activities off school property (e.g. field trips, school sport events)	<input type="radio"/>	<input type="radio"/>

40. Does your school have a designated spot on school grounds where students are allowed to smoke?

- Yes
- No
- No, but there is an area off of school grounds within view of the school

41. What are the consequences for a first offense for students who are caught violating your school's written policies or practices on the following? (*Check all that apply*)

	Tobacco	Alcohol	Drugs
a. Issue warning (written or verbal)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Inform parents or guardians	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Refer to a school administrator	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Refer to a school counsellor	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. <i>Encourage</i> , but not require, to participate in an assistance, education, or cessation program	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. <i>Require</i> to participate in an assistance, education or cessation program	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Confiscate substance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h. Assign additional class work (written/presentation)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i. Assign to help around school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
j. Fine	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
k. Place in detention	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
l. Give in-school suspension	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
m. Suspend from school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
n. Alert police		<input type="radio"/>	<input type="radio"/>

42. Do sanctions get stronger with subsequent violations (i.e., progressive discipline approach)?

	Tobacco	Alcohol	Drugs
a. Always	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Sometimes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Never	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

43. How consistently are your school's written policies (e.g., smoking/drinking/using drugs on school property) ADHERED to by students?

	Tobacco	Alcohol	Drugs
a. Always	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Most of the time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

c. Sometimes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Rarely	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Never	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

44. Does your school provide any tobacco prevention programs?

Yes→ Please list:

No

45. Does your school provide any tobacco cessation programs?

Yes→ Please list:

No

46. Does your school provide any alcohol use prevention programs?

Yes→ Please list:

No

47. Does your school provide any marijuana/drug use prevention programs?

Yes→ Please list:

No

48. Are students at your school allowed to carry or wear apparel or paraphernalia with company names or logos on them for any of the following?

	Yes	No	I don't know
Tobacco	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Alcohol	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Marijuana/ other drugs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

49. Which of the following methods have been used to provide teachers with prevention and/or cessation education during the last school year? (Check all that apply)

	Tobacco	Alcohol	Drugs
a. In-service training (e.g., by Public/Regional Health)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Conferences	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Workshops on professional development days	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Presentations by organizations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Teacher initiated self-training on the Internet at home	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Teacher initiated self-training on the Internet at school	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Faculty of Education courses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>