# Examining the effectiveness of school-based initiatives to increase student moderate- to vigorous- intensity physical activity participation in a sample of Ontario and Alberta secondary schools in the COMPASS study

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

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*Abstract*

**Background:** Regular participation in moderate-to vigorous- intensity physical activity (MVPA) is associated with multiple health benefits. However, adolescence is a period of time characterised by low physical activity participation. As a result, very few Canadian adolescents are active enough to receive optimal health benefits. One setting that has been identified as having the potential for physical activity promotion and intervention is the school. Schools reach a large proportion of adolescents and can offer both structured and unstructured opportunities to be active. However, school-based physical activity interventions for adolescents remain largely ineffective. Therefore, the purpose of this thesis was to examine how naturally-occurring changes to school physical activity policy, recreational programming, use of public health resources, and the physical environment, impact adolescent MVPA over a 1-year period.

**Methods:** Quasi-experimental longitudinal data was collected from grade 9-12 students (mean age = 15.1± 0.02 years) in year 2 (n=45,298) and year 3 (n=42,355) of the COMPASS study. Corresponding school-level data was collected from 89 administrators, and 89 schools enrolled in COMPASS from Ontario and Alberta, Canada. Only students, administrators, and schools that had complete data in both year 2 (2013-2014) and year 3 (2013-2014) were included in this thesis. This resulted in 18,777 students, and 86 administrators from 86 schools. Self-reported MVPA was measured at both time points via the COMPASS Student Questionnaire. Changes to physical activity policies, recreational programming, public health resources, and the physical environment were self-reported by school administrators via the COMPASS School Policies and Practices Questionnaire. Objective measurements of the quantity and condition of physical activity facilities were recorded using the COMPASS Environment Application, a hand-held device with image capturing capabilities. Multi-level modeling was used to examine change in

student MVPA between schools that made and did not make a physical activity related change. Models were adjusted for several student-level (age, sex, weekly spending money, typical PA, physical education enrolment) and school-level (school size, school location, and school area level socioeconomic status) confounders.

**Results:** Over the 1-year period, 70% (61/86) of schools made physical activity related changes. Of these, 66% (40/61) of schools seemed to make positive changes (e.g., added programs, equipment, and facilities); whereas, 34% (21/61) of schools seemed to make negative changes (e.g., removed programs, equipment, facilities). Compared to the control group of schools that made no physical activity changes, a significant change in student MVPA was only observed in 15% (9/61) of the schools that made changes, and a significant increase in student MVPA was only observed in 7% (4/61) of the schools that made changes. More specifically, opening the fitness centre at lunch (β=17.2**,** 95%CI: 2.6-31.7), starting an out-and-abouters club (β=17.8, 95%CI:7.4-28.1), adding a bike rack (β =14.9, 95%CI:0.7-29.1), and adding a weightlifting and run/walk club, archery, figure skating, increasing access to the sports field; and improving condition of the outdoor basketball court (β=15.5, 95%CI: 5.2-25.7) was associated with a significant increase in student MVPA, compared to the control group.

**Conclusions:** Changes that included adding or increasing access to fitness centres and fields during lunch, and adding multiple recreational opportunities seemed to be effective for increasing student MVPA over the 1-year period. Given the specificity of results, a one-size fits all approach may not be effective for increasing physical activity for adolescents. Instead, administrators may also need to consider the resources within and surrounding their school, and the interests of their students when thinking about making changes to increase students' MVPA.

***Preface***

Data used in this thesis is from year 2 and 3 of the cohort study for obesity, marijuana use, physical activity, alcohol use, smoking, and sedentary behaviour (COMPASS). COMPASS is an ongoing prospective cohort study in Alberta and Ontario, Canada that collects annual data from grade 9-12 students, administrators, and schools. All school boards, schools, and students enrolled in COMPASS were allowed to withdraw from the study at any point during the consent process and data collection period. All procedures within this research have received ethical approval from the University of Waterloo Office of Research Ethics, the University of Alberta Research Ethics Board, and the appropriate school board committees. Chapter 3 of this thesis is in submission to the International Journal of Behavioral Nutrition and Physical Activity under the working title "A quasi-experimental examination of how school-based physical activity changes impact secondary school student moderate- to vigorous- intensity physical activity over time in the COMPASS study." This manuscript is the work of Stephen Hunter in collaboration with his co-authors: Dr. Scott Leatherdale, Dr. Kate Story, and Dr. Valerie Carson. Specifically, Dr. Leatherdale conceived of the COMPASS study, secured the study funding, developed the study tools, and is leading the study implementation and coordination. Dr. Carson helped expand the COMPASS study to Alberta and is leading the study coordination in this province. Research staff of Dr. Leatherdale (Ontario) and Dr. Carson (Alberta) collected the data for the manuscript. Stephen Hunter was responsible for developing the research question, conducting background research, managing the datasets, leading the complex statistical analysis, interpreting the results, and writing the initial draft of the manuscript. Dr. Carson provided guidance on the statistical analysis. Drs. Leatherdale, Carson, and Storey revised the manuscript for important intellectual content.

***Acknowledgements***

Special thanks to my supervisor, Dr. Valerie Carson, my supervisor committee members Drs. Scott Leatherdale and Kate Storey, and my arm's length committee member Dr. Kim Raine for their expert guidance and support in the development and completion of this thesis.

Finally, thanks to my family, lab mates, friends, and Ria for their support and encouragement throughout this degree.

Financial support was provided by the Faculty of Physical Education and Recreation at the University of Alberta, the Women & Children's Health Research Institute (WCHRI) through the generous support of The Stollery Children's Hospital Foundation, and my supervisor.

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***Glossary of Terms***

1. *Physical activity (PA)* is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen, Powell, & Christenson, 1985). MVPA is a combination of moderate-intensity physical activity (MPA) and vigorous-intensity physical activity (VPA). MPA is defined by the Canadian society for exercise physiology (CSEP) as PA that is performed at 4.0 to 6.9 times the intensity of rest (e.g., brisk walking, bicycle riding, house work and yard work, playing games that require catching and throwing). VPA is defined as PA that is performed typically 7.0 or more times the intensity of rest (e.g., active games involving running and chasing, jumping rope, martial arts, swimming) (Canadian Society for Exercise Physiology, 2015). In the COMPASS Study, MVPA is described to students as "hard" and "moderate" physical activities. Hard activities include jogging, team sports, fast dancing, jump-rope, and any other activities that increase your heart rate and make you breather hard and sweat. Moderate activities include lower intensity activities such as walking, biking to school, and recreational swimming.

2. *School-aged children and youth* are defined as children between 5-17 years old (Janssen & Leblanc, 2010). This thesis will be focusing on adolescents. Adolescence is defined as a period in human growth and development that occurs after childhood and before adulthood, from ages 10 to 19 years (World Health Organization, 2015). The term adolescent has been specifically selected as it resembles the time period in which students are attending secondary schools in Canada.

3. *Population based approach* is defined as a strategy to control the determinants of incidence, to lower the mean level of risk factors, to shift the whole distribution of exposure in a favourable direction (Rose, 2001).

4. *Multi-level modeling* is a statistical procedure that is used to examine the relationships between variables within and across multiple levels of a data hierarchy (Heck, Thomas, and Tabata, 2014). For example, as students are clustered in schools, this approach allows the influence of school level variables on MVPA to be examined while controlling for student level variables or vice versa (Hobin et al., 2012a).

5. *School physical environment* in this thesis is defined as physical features of the school (e.g. gymnasium, field) that are associated with PA ( Leatherdale, et al., 2014a)

6. *School recreational programming* is defined in this thesis as extra-curricular events or activities that allow or promote students to be physically active, such as intramural sports, physical activity clubs, and special events.

7. *School policy* is defined in this thesis as any written school-level rules or requirements regarding physical activity outside of physical education, and the provincially mandated daily physical activity.

8. *School resources* are defined in this thesis as any support or relationships established with community partners, public health agencies, and the COMPASS research team. Examples of school resources in this research can include local public health units, non-government organizations, community members, youth organizations, local parks and recreation units, and health and fitness clubs.

## Chapter 1: Introduction

Regular participation in moderate- to vigorous- intensity physical activity (MVPA) in accordance with the Canadian physical activity guidelines is associated with enhanced health benefits (Tremblay et al., 2011). However, in recent years only a small proportion of Canadian children and adolescents have engaged in the recommended amount of daily physical activity (PA) for optimal health (Colley et al., 2011). Of particular concern is the exceedingly low levels displayed by adolescents, as it has been shown that PA behaviour during adolescence can track into adulthood (Dumith, Gigante, Domingues, & Kohl, 2011). Globally, it has been estimated that 80% of adolescents fail to meet the recommended PA guidelines (Hallal, Andersen, Bull, Guthold, Haskell, & Ekelund, 2012). Accordingly, physical inactivity has been linked to morbid health conditions and premature death (Lee et al., 2012). Therefore, a population based approach to PA promotion seems warranted. Many experts have identified schools as an ideal setting for promoting healthy lifestyle behaviours such as PA (Lounsbery, McKenzie, Morrow, Holt, & Budnar, 2013; Winter, 2009). Possibly the largest strength tied to schools are their capability to reach a large proportion of children and adolescents during a period of time where they are still developing lifelong habits (Fox, Cooper, & McKenna, 2004). Furthermore, the typical school day provides ample opportunities for students to be physically active in both structured (e.g., physical education) and unstructured (e.g., during lunch, spare periods) settings. In Canada, physical education (PE) objectives and requirements are mandated at the provincial level; however, PE curricula varies by province and often becomes an optional subject for senior secondary students. Therefore, targeting PA promotion through PE may not be the most effective strategy for reaching all students. Though school-based initiatives exist, their sustainability and

effectiveness over time remains unknown (Durant et al., 2009). Additional research is needed to identify which school-based initiatives such as changes to PA policies, recreational programming, public health resources, and the physical environment are the most effective at increasing student MVPA participation over time.

### *Objectives*

The overall purpose of this thesis is to identify how changes to school PA related policy, recreational programming, public health resources, and the physical environment impact student MVPA over a one-year period.

### *Hypothesis*

There will be an increase in students' MVPA between those attending schools that have added PA policies, resources, programs, and improved the physical environment compared to those attending schools that have not.

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## Chapter 2: Literature Review

### *Health implications of physical activity*

Current national recommendations for PA suggest that children and youth aged 5-17 years should accumulate at least 60 minutes of MVPA per day, with muscle and bone strengthening activities occurring on three days of the week (Canadian Society of Exercise Physiology, 2015a; Canadian Society of Exercise Physiology, 2015b). These guidelines were developed in conjunction with the wealth of research that indicates a dose response relationship between MVPA and enhanced health benefits exists (Canadian Society of Exercise Physiology, 2011). The physical benefits of engaging in daily MVPA include improved bone strength, aerobic fitness, muscular strength and endurance (Janssen & Leblanc, 2010), as well as a reduction in the risk factors for metabolic syndrome (Adair, Gordon-Larsen, Du, Zhang, & Popkin, 2014). Psychological benefits associated with regular MVPA include improved self-concept (Janssen & Leblanc, 2010) and self-esteem (Ekeland, Heian, & Hagen, 2005) as well as a reduction in anxiety, depressive symptoms, psychological distress, (Janssen & Leblanc, 2010) and emotional disturbance (Ahn & Fedewa, 2011).

In contrast, a physically inactive lifestyle (i.e., not meeting the recommended amounts of MVPA) has been associated with increased risk for morbidity, decreased quality of life, and premature death (Janssen, 2012; Kohl et al., 2012; Lee et al., 2012). Consequently, physical inactivity has become one of the fourth leading behavioural risk factors for non-communicable disease alongside smoking, alcohol use, and poor diet (World Health Organization, 2009). Globally, physical inactivity has been identified as a major health concern (Hallal, Andersen, Bull, Guthold, Haskell, & Ekelund, 2012), as a result, health experts are advocating for PA

promotion to be considered as an investment in public health (Canadian Nurses Association, 2011; Kohl et al., 2012). Furthermore, recent estimates suggest that a reduction in global physical inactivity by 25% would reduce the incidences of major non-communicable diseases as well as the prevention of 1.3 million annual deaths (Lee et al., 2012).

### *Physical activity prevalence*

Despite the associated health benefits of regular participation in MVPA, the majority of Canadian children and adolescents are not physically active enough to enjoy enhanced health (Colley et al., 2011). A recent analysis of Canadian data reported that only 5% of adolescents aged 12-17 years are meeting the recommended guidelines (Canadian Health Measures Survey, 2012-2013). Furthermore, it appears that as children enter and progress through adolescence they become less active (Dumith et al., 2011). According to a recent comprehensive analysis of 105 countries, Canada ranked below average for the proportion of physically active adolescents (Barnes, 2014; Hallal, Andersen, Bull, Guthold, Haskell, & Ekelund, 2012) indicating that Canadian adolescents may be at particular risk. Given that previous research has suggested physically active and physically inactive behaviours tend to track into adulthood (Fernandes & Zanesco, 2010; R. Telama, 2009; Risto Telama et al., 2014), adolescence is a critical period for PA interventions to occur.

### *Ecological perspective*

A wealth of research has been conducted on the individual correlates that can be used to target and change PA behaviour (Sallis, Prochaska, & Taylor, 2000). However, given the complexity of most behaviours, an ecological perspective is commonly employed to examine the

broader influences to PA participation (Hinkley, Salmon, Okely, Hesketh, & Crawford, 2012; Kaushal & Rhodes, 2014; Nelson, Abbott, & Macdonald, 2010; Yan, Voorhees, Beck, & Min Qi, 2014). An ecological model posits that there are multiple levels that interact with each other and ultimately influence behaviour. For example, McLeroy and et al. (1988) developed an ecological model for health promotion that consists of five levels. Most proximal is the (1) *intrapersonal* level which is characterized by the knowledge, skills, and attitude towards the behaviour; (2) *interpersonal* level characterized by both formal and informal relationships such as family, friends, and work groups and their influences on the individual; (3) *organizational* level, which include social institutions with organizational characteristics (e.g., schools); therefore, possessing the capability to influence behavior through organization and structure (e.g., PA policies, programs, resources, environment); (4) *community* level, which relate to the relationships among organizations, institutions, and informal networks with defined boundaries (e.g., distribution of PA facilitators such as recreation centers); and most distal is (5) *public policy*, which is defined by local, state/provincial, and national laws and policies (e.g., physical education curriculum requirements) (McLeroy, et al., 1988). Although it is assumed that changes at distal levels in the model will result in a trickle-down effect, there is potential for reciprocal causation, meaning that influences can operate bi-directionally within the levels of the framework (Bandura, 1989). An example of a trickledown effect from distal to proximal would be having mandated physical education from kindergarten to grade 12, in which students' PA participation would be influenced through PE classes. In reverse, bi-directionality could be achieved if there were enough evidence gathered at proximal levels (i.e. successful school PA initiatives at the organizational level) that could be used to build a case for policy development.

The ecological model is appealing when trying to deliver a population-based approach for

PA and health promotion as it allows for multiple sectors to be involved. At distal levels of the model it has been suggested that a collaborative effort should be made among governments, policy makers, and the research community to make PA accessible, enjoyable, and safe for the broader population (Hallal et al., 2012; Kohl et al., 2012). One potential setting for this collaborative effort to occur is the school.

### *The school setting*

Schools provide an optimal setting for establishing healthy PA behaviour (Heart and Stroke Foundation of Canada, 2013). Unlike other settings, the school provides both structured (e.g., instructional PE, varsity sports) and unstructured (e.g., lunch break) opportunities for students to engage in PA. Furthermore, a large proportion of children and youth attend school for approximately 25 hours per week, for roughly three quarters of the year (Organization for Economic Cooperation and Development, 2015; Stewart-Brown, 2006); resulting in an avenue for population approaches targeting PA to take place.

From an ecological perspective, schools themselves are embedded within the organizational level of the framework. However, they also possess the ability to interact with both proximal and distal levels of the model as well. For instance, at distal levels they can streamline provincially mandated curriculum (policy), and have the ability to offer community recreational programming, such as youth sports drop-ins (community). While at more proximal levels, they can facilitate social interaction among peers and teachers (interpersonal), and have the ability to influence the behaviour of students through knowledge translation (intrapersonal). Therefore, school-based interventions have the ability to target either single, or multiple levels of the ecological framework when trying to increase PA among children and youth.

Although interventions can take place at many levels of the ecological framework to promote healthy behaviours, this thesis focussed on naturally-occurring changes that have occurred at the organizational level by schools in regards to PA policy, recreational programming, use of public health resources, and the physical environment.

### *School policies*

One recommended approach to promoting PA behaviour in children and youth is through policy (Gleddie, 2012; Nanney et al., 2014). Though this thesis focussed on the school-level policy it should be noted that changes to policy can be made at provincial-, district-, and school-levels. For instance, Ontario requires students to enroll in one PE class between grades 9 and 12, and Alberta mandates curricular PE up to grade 10 (ParticipACTION, 2015). In addition to PE curricula, other promotional PA policies exist in Ontario and Alberta. For instance, daily physical activity initiatives are adopted at the provincial level and require schools to provide additional time for PA outside of regularly scheduled physical education classes (ParticipACTION, 2015). Currently, six provinces and two territories have an existing daily physical activity initiative; however, only five provinces have reported any sort of tracking or recording of these (ParticipACTION, 2015). Without constant surveillance and assessment, the effectiveness of both curricula and PA policy initiatives is unknown and often relies on the presence, nature, and willingness of school administrators and teachers to carry them out (Carlson et al., 2013; Lounsbery et al., 2013; Patton & McDougall, 2009).

Previous research has indicated that PA policies inserted at distal levels of the ecological model have struggled to be implemented (Brener, Chriqui, O'Toole, Schwartz, & McManus, 2011; Holt, Bartee, & Heelan, 2013; McIsaac, Storey, Veugelers, & Kirk, 2014). A possible

explanation for the lack of success in implementing policies at distal levels could be a result of disconnect between provincial policymakers, school administrators, and teachers (Langille & Rodgers, 2010). In addition to fidelity issues, research has indicated that the development and composition of policies play an important role in their implementation. For instance, clarity and comprehensiveness have been acknowledged as being two important aspects of written policies that are essential to implementation (Schwartz et al., 2012). Furthermore, a recent comparative analysis between school- and district-developed polices, found that school-developed policies were stronger, more comprehensive, and reflected government initiatives more accurately than district-developed policies (Smith, Capogrossi, & Estabrooks, 2012). Perhaps one reason for success of school-developed policies is that school administration and staff have a better idea of the strengths of their personnel and were able to identify areas of student health that needed attention. Furthermore, Smith et al. (2012) suggested that school-developed policies excelled due to specificity, while the vagueness associated with district-developed policies could have been provided with the intention for future tailoring by teachers and administrators.

In addition to having school-developed policies, there is support from governing bodies and experts in health promotion for collaboration between multiple stakeholders – community members, teachers, parents, and students to develop effective and sustainable policies (Comprehensive School Health Framework, 2016; Piercy et al., 2015; World Health Organization, 2008; Williams & Mummery, 2015). Furthermore, with the inclusion of researchers it is possible to establish a circulatory feedback support system that allows for evaluation and feedback (Haggis, Sims-Gould, Winters, Gutteridge, & McKay, 2013). While there is some evidence to suggest that collaborating with community stakeholders to develop school policies is feasible (Hogan et al., 2014), one of the most comprehensive surveillance

systems coming from the United States has shown that over time there is a declination in student and parent involvement throughout this process (Johnston, O'Malley, Terry-McElrath, Colabianchi, & Robert Wood Johnson, 2012).

Previous research has indicated that the presence of a written policy alone was positively associated with PA. For example, there has been positive associations between secondary schools with a written PA policy and the prevalence of physically active students during non-instructional time (Haug, Torsheim, & Samdal, 2010); and PA during instructional time (Nichol, Pickett, & Janssen, 2009). In addition, a cross-sectional content analysis found that policies allowing after school access to fields and play areas was associated with an increase in the number of days that students were physically active (Haug, Torsheim, & Samdal, 2010). Meanwhile, longitudinal data has found that providing extended breaks of 30 minutes/day in addition to regular breaks, access to fitness facilities during all breaks, and supervised student led ball games; increased secondary student MVPA over the course of one academic year (Grasten, Yli-Piipari, Watt, Jaakkola, & Liukkonen, 2015).

Given that a large proportion of schools in Canada do not have a fully implemented school-level policy concerning PA (ParticipACTION, 2015), combined with the small amount of evidence regarding school policy development (Hogan et al., 2014), more research is needed to examining effective strategies for sustainable school-based policy implementation and how changes to school PA policy impact student MVPA.

### *School resources*

In 1995 the World Health Organization released a set of guidelines for health promoting schools, in which one of the recommendations was to promote the use of resources within the

community (WHO, 1996). Although these recommendations make intuitive sense, research examining the extent of which schools use community resources has yielded mixed results. For instance, schools that brought in university staff and students to teach classroom sessions on health saw increased females' intentions to be physically active (Perry et al., 1987), and PA participation among inactive students (Killen et al., 1989). In contrast, interventions that have integrated community recreational facilities, community support, and financial aid have yielded no effect on PA. This was demonstrated in the attempt by Phillipp, Piland, Seidenwurm, and Smith (1989) who examined the effectiveness of incorporating community resources such as ice rinks, aerobics classes, and hiking into a secondary school health education class and witnessed no differences between intervention and control groups. In addition, Moon et al. (1999) found that although receiving funding to become a health promoting school was beneficial for a range of healthy behaviours, there was no evidence that this financial support was effective at increasing PA.

Given the combined evidence, it seems that most school-community relationships are facilitated by research teams, and it remains unclear how schools themselves can maximize the resources around them to offer effective programs targeting PA. One potential relationship that has recently been suggested to help facilitate the use of community resources is between schools and their local public health units (Piercy et al., 2015; Joint Consortium for School Health, 2015). For instance, schools could reach out to public health units for assistance with PA related professional development for teachers (e.g., training, tools, instructional materials, and research findings) and strategies to offer an enhanced PE curriculum (Piercy et al., 2015). Furthermore, for schools wanting to make PA a priority, they could seek assistance from public health units who could in turn help them adopt health promoting programs (Piercy et al., 2015). As these are

just suggestions, it appears that more research is needed to examine how public health units can work with schools to develop PA programs and facilitate use of community resources.

### *School programs*

School programs to promote and increase PA can be delivered through a variety of settings. An intuitive method of delivery is through PE as it is the only scheduled instructional time period for PA during the day. There is substantial evidence suggesting that offering PE is positively associated with PA among many student populations (Cawley, Meyerhoefer, & Newhouse, 2007; Duncan, Strycker, & Chaumeton, 2015; Durant et al., 2009; Kirby, Levin, & Inchley, 2012; Pate, Ward, O'Neill, & Dowda, 2007). In addition, PE has provided a valuable setting for research interventions to take place. For instance, multiple interventions have shown success for increasing PA when delivered through the PE (Bronikowski & Bronikowska, 2011; Jamner, Spruijt-Metz, Bassin, & Cooper, 2004; Lubans & Sylva, 2006; Pate et al., 2005; Tsorbatzoudis, 2005).

While previous interventions targeting PE have differed in length, content, and delivery, they all shared an instructional component that targeted health benefits and strategies around scheduling and maintenance of regular PA. The most coveted of these interventions is the Lifestyle Education for Activity Program (LEAP) developed by Pate et al. (2005). LEAP was a 32-week intervention that made changes to PE instruction and the school psychosocial environment in order to improve PA among adolescent females (Pate et al., 2005). Furthermore, the LEAP research team conducted evaluations on implementation fidelity (Saunders, Ward, Felton, Dowda, & Pate, 2006; Ward et al., 2006) sustainability (Saunders et al., 2012), and follow-up measurements (Pate et al., 2007). Results demonstrated an increased prevalence of

VPA participation among females attending LEAP schools compared to females in control schools at post-intervention (Pate et al., 2005) and three year follow up (Pate et al., 2007). However, this follow up data was only significant in females attending high implementation schools (Pate et al., 2007). Although teachers initially thought LEAP would be sustainable (Ward et al., 2006), less than half of participating schools were high implementers, with low fidelity for the environmental components (Saunders et al., 2012). LEAP provides just one example of how even successful interventions delivered through PE have troubles with sustainability. Given that PE is not required throughout secondary school in most Canadian provinces (ParticipACTION, 2015) and fewer students continue to take PE once it becomes an optional subject (Dwyer et al., 2006), alternative avenues within the school should be considered.

Recreational programming can provide students who are not in enrolled in PE or participating in varsity sports, with a chance to engage in structured PA. One form of recreational programming that has shown a positive association with student PA is intramurals (Morton, Atkin, Corder, Suhrcke, & van Sluijs, 2016). Intramural programs can be an inclusive approach to PA promotion as they are usually not as competitive as varsity sports, and allow for a wide range of students to participate at their own will (Wechsler, Devereaux, Davis, & Collins, 2000). Furthermore, there is evidence to suggest that providing multiple intramural activities can result in increased frequency, intensity, and duration of student PA participation (Bocarro, Kanters, Edwards, Casper, & McKenzie, 2014; Fuller, Sabiston, Karp, Barnett, & O'Loughlin, 2011). For example, Fuller et al. (2011) conducted a longitudinal analysis of students aged 12 to 13 years and found that students attending schools that offered more intramural activities (measured only once at the average age of 16 years) engaged in more frequent PA sessions at age 20 than students attending schools that offered less intramurals, regardless of whether students

actually participated in intramurals or not. In addition, a comparative analysis found that the provision of intramural programs was more effective at increasing total PA than providing varsity sports programs (Fuller et al., 2011). Similar results have been found in cross-sectional analyses, in which participation in intramurals resulted in higher intensities of PA (Bocarro et al., 2014) and time spent being physically active (Hobin et al., 2012b).

Given that a high proportion of schools in Canada offer intramurals (Cameron, Craig, Coles, & Cragg, 2002) and there is evidence to suggest offering intramurals is positively associated with PA (Morton et al., 2016; Bocarro et al., 2014; Fuller et al., 2011, Hobin et al., 2012b) it appears to be a practical strategy for schools to implement. However, according to Canada's annual report card on PA, under half of the student population actually participates in intramurals (ParticipACTION, 2015). Therefore, providing intramurals as a single initiative to increase PA may not be a viable strategy for the entire student population, and should be considered as a supplemental option.

Offering a large assortment and quantity of schools sports has been associated with increased student PA (Fuller et al., 2011; Kirby et al., 2012). Previous research has found that students who participate in school sports tend to have increased participation in PA compared to students who do not participate (De Meester, Aelterman, Cardon, De Bourdeaudhuij, & Haerens, 2014; Hobin et al., 2012b; Kwon, Janz, Letuchy, Burns, & Levy, 2015). Furthermore, longitudinal studies have provided evidence that adults who participated in sports during their youth were more likely to be physically active later on in life (Allen, 2003; Dohle & Wansink, 2013).

Despite the positive school sport – PA relationship, the problem with offering school sports alone, much like intramurals, is that there is an apparent low student participation rate

(DeMeester et al., 2014; Dwyer et al., 2006). In addition, schools often face multiple barriers to providing school sports on a regular basis, which include financial constraints (Dwyer et al., 2006), political conflicts (Pabayo, O'Loughlin, Gauvin, Paradis, & Gray-Donald, 2006) and availability of facilities (Rainer, Griffiths, Cropley, & Jarvis, 2015). Therefore, to effectively increase PA among a broader spectrum of students it has been suggested that schools should offer both intramurals and competitive schools together (Edwards, Kanters, & Bocarro, 2014).

Given that the combined evidence for the most part has been conducted with only portions of the student population (e.g., through PE, intramural participants, varsity sport athletes), it appears that more research needs to be conducted examining how changes to these kinds of PA programs can influence MVPA among the entire student population.

***School physical environment***

In conjunction with the low PA experienced in adolescents, research has documented that the transition from primary to secondary school environments was associated with decreased levels of PA (Marks, Barnett, Strugnell, & Allender, 2015; Morton, Corder, et al., 2016). Therefore, it is important to examine aspects of the school environment that may influence student PA. Across Canada, the most common structures in the school physical environment relating to PA are gymnasiums, fields, and alternate PA rooms (Cameron, Wolfe, & Craig, 2007; Hobin et al., 2012b; Hobin et al., 2013; E. P. Hobin et al., 2012; Canadian Fitness and Lifestyle Research Institute, 2012). Further influencers of student PA include availability, quality, condition, and presence of PA facilities (Czerwinski, Finne, Kolip, & Bucksch, 2015; Martin, Bremner, Salmon, Rosenberg, & Giles-Corti, 2014; Nichol et al., 2009; Xu, Chepyator-Thomson, Liu, & Schmidlein, 2010) with increased number of facilities being most commonly

associated with higher reported rates of PA (Haug, Torsheim, & Samdal, 2008; Hood, Colabianchi, Terry-McElrath, O'Malley, & Johnston, 2014; Nichol et al., 2009; Rickwood, 2013).

Understanding the importance of providing numerous features in the school environment is important; however, for schools with limited financial and student resources, this may not be the most feasible option. Therefore, it is important to identify specific features of the physical environment (i.e., indoor versus outdoor facilities) that are more conducive for PA than others.

Stemming from a recent review of the literature, Brittin et al. (2015) published the first set of PA design guidelines for school architecture outlining ten domains that can assist both elementary and secondary schools in becoming more conducive to PA. According to their literature search, there was substantial evidence to support the provision of multiple and varied outdoor fitness facilities (Brittin et al., 2015). Specific findings from Haug, Torshiem, Sallis, & Samdal (2010) found that features located outdoors, such as hopscotch/skipping rope area, playground equipment, and soccer fields were associated with increased odds for adolescent males to be active during lunch breaks; while sledding hills seemed to be an appropriate PA facilitator for both adolescent males and females. In addition, research has indicated that features such as basketball hoops, soccer goals, and running tracks were also positively correlated with adolescent PA (Millstein et al., 2011).

Given that aspects of the physical environment are accessible to all students, identifying features of the school environment that provide the biggest impact on student PA has the potential to increase PA participation in a wide range of adolescents. Even still, this is a difficult task to accomplish given it has been found that student level characteristics such as gender (Hobin et al., 2012b) and socioeconomic status (Hood et al., 2014) influence how students

respond to environmental features. Furthermore, it has been shown that variation in school-level characteristics such as location (Cameron et al., 2007; Hobin et al., 2013; Hood et al., 2014; Martinez-Gomez et al., 2014; Silva, Sousa, Sá, Ribeiro, & Mota, 2015; Xu et al., 2010), size (Cameron et al., 2007; Hood et al., 2014), and estimated student socioeconomic status (Cameron et al., 2007; Hood et al., 2014) contribute to variation in the environmental features provided. In order to understand the value of the school physical environment, more research is needed examining how changes to the current environment (i.e., addition or removal, and condition of facilities) impact student MVPA.

***Limitations of current research***

While research exists measuring PA in response to the presence of policies (Durant et al., 2009; Grasten et al., 2015; Haug, Torsheim, & Samdal, 2010; Nichol et al., 2009); it has focused on the development (Haggis et al., 2013; Schwartz et al., 2012; Smith et al., 2012) and implementation (Brener et al., 2011; Hogan et al., 2014; Holt et al., 2013; Langille & Rodgers, 2010; McIsaac et al., 2015). As a result, little is known about how changes to current school policies impact student MVPA. Therefore, this thesis will utilize data to fill this gap in the literature. More specifically, it will obtain policy data from administrative surveys as an exposure, and changes in student MVPA over one year as the outcome. Furthermore, multiple strategies have been employed in order to integrate community resources (Killen et al., 1989; Moon et al., 1999; Perry et al., 1987; Phillipp, Piland, Seidenwurm, & Smith, 1989); however, these results are inconsistent, and it has been suggested that the relationship between local public health units and schools to increase student PA should be explored. This thesis examined how changes to school relationships with public health resources (i.e., utilize vs stop using) in regards

to PA impact student MVPA over a one-year period.

Although school-based PA programs have shown success at increasing student PA, the results have largely come from randomized control trials conducted in PE classes (Bronikowski & Bronikowska; Jamner et al., 2004; Lubans & Sylva, 2006; Pate et al., 2005; Tsorbatzoudis, 2005). Because PE is an optional subject in secondary schools, conducting research through this avenue is subject to a degree of selection bias. Another limitation of the research regarding school programs is study design. Similarly, the literature examining aspects of the whole school environment and PA has been conducted with randomized control trials and cross-sectional designs, with little evidence showing mixed results, coming from prospective designs (Morton et al., 2016). Therefore, it seems warranted that examining naturally-occurring changes in real world settings (e.g., school-led changes via quasi-experimental design) could reduce some of the potential issues of external validity that are often associated with controlled interventions (McGoey, Root, Bruner, & Law, 2015). Furthermore, while cross-sectional studies allow for larger, representative samples, it is impossible to determine causality as they only provide data for one point in time. Therefore, the longitudinal component of this thesis will assist in drawing causal inferences to support or negate previous associations.

Investigating the role of the schools' physical environment on student PA is often gathered data via self-report from students (Durant et al., 2009) and administrators (Cameron et al., 2007; Czerwinski et al., 2015; Haug et al., 2008; Hobin et al., 2012b; Hobin et al., 2013; Hobin et al., 2012a; Hood et al., 2014; Kirby et al., 2012; Marks et al., 2015; Nichol et al., 2009; Xu et al., 2010) rather than through objective measures (Martin et al., 2014; Rickwood, 2013). This method of data collection is subject to response bias as it may be more reflective of the perceived physical environment rather than the actual environment itself. Lastly, research has

used cross-sectional designs when examining the presence of features within the school environment, and thus has only been able to establish associations with student PA (Czerwinski et al., 2015; Duncan et al., 2015; Hobin et al., 2012b; Hobin et al., 2013; Hobin et al., 2012a; Martin et al., 2014; Nichol et al., 2009).

This thesis will try and fill these identified gaps in the literature. For instance, issues of small samples and selection bias are reduced through the use of active-information passive-consent. Active-information passive-consent in this this thesis involves distributing a letter to the participant's parents outlining the nature of the study, and providing parents with who to contact if they do not want their child to participate. As such, this consent protocol has yielded higher participation rates, as well as reduced selection bias, when compared to active consent (Pokorny, Jason, Schoeny, Townsend, & Currie, 2001; Courser, Shamblen, Lavrakas, Collins, & Ditterline, 2009). External validity and causal relationship will be addressed through the longitudinal quasi-experimental design, essentially allowing observations of naturally occurring changes in real world settings over time. Lastly, the use of objective measurements of the physical environment in this thesis will avoid some of the bias that is associated with self-report.

Previous research has looked at associations between school policies, resources, recreational programs, and the physical environment and student PA. However, the generalizability of results from one population to the next is limited due to cross-cultural differences, between school variability, and heterogeneous outcome variables (Kahn et al., 2002; Lai et al., 2014; Naylor & McKay, 2009; E. M. van Sluijs, McMinn, & Griffin, 2007). Furthermore, research has yet to explore the effect of how change to each of these variables (policy, recreational programming, public health resources, and physical environment) at the school level impacts student MVPA through a longitudinal design. Therefore, this thesis will

strengthen the current literature through its use of data from the cohort for obesity, marijuana use, physical activity, alcohol use, smoking, and sedentary behavior (COMPASS).

COMPASS is a prospective cohort study designed to collect longitudinal data on multiple student health behaviours, through a quasi-experimental design in a large sample of Canadian secondary schools (Leatherdale et al., 2014). This thesis examined how changes to school PA related policy, recreational programming, public health resources, and the physical environment will impact student MVPA over a one-year period. As a result, it has provided insight into some strategies that are effective for increasing student MVPA among the typically inactive Canadian adolescent population (Colley et al., 2011).

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# Chapter 3:

# A quasi-experimental examination of how school-based physical activity changes impact secondary school student moderate- to vigorous- intensity physical activity over time in the COMPASS study

This manuscript has been submitted to the International Journal of Behavioral Nutrition and Physical Activity and is presented according to the journal formatting requirements.

**Abstract**

**Background:** Adolescence is characterised by low moderate- to vigorous- intensity physical activity (MVPA) levels. Targeting the school setting can increase MVPA among a large proportion of adolescents. However, school-based physical activity interventions for adolescents remain largely ineffective. Therefore, the purpose of this study was to examine how naturally-occurring changes to school physical activity policy, recreational programming, public health resources, and the physical environment, impact adolescent MVPA over a 1-year period.

**Methods:** Quasi-experimental longitudinal data from 18,777 grade 9-12 students (mean age = 15.1±0.02 years), and 86 principals from 86 schools, participating in year 2 (2013-2014) and year 3 (2014-2015) of the COMPASS study (Ontario and Alberta, Canada) was used. Total MVPA over the previous week was self-reported at both time points using the COMPASS Student Questionnaire and average daily MVPA was calculated. Changes to physical activity policies, recreational programming, public health resources, and the physical environment were self-reported by school principals. Changes to the number and condition of physical activity facilities were objectively measured during school audits using the COMPASS School Environment Application. Multi-level modeling was used to examine change in student MVPA between schools that made changes and schools that did not. Models were adjusted for several student and school level confounders.

**Results:** Over the 1-year period, 61 of 86 schools made physical activity related changes. Of these, 9 significantly changed student MVPA. However, only 4 of 9 schools' changes increased student MVPA, including opening the fitness centre at lunch (β=17.2**,** 95%CI: 2.6-31.7), starting an outdoor club (β=17.8, 95%CI:7.4-28.1), adding a bike rack (β =14.9, 95%CI:0.7-29.1), and

adding weightlifting and run/walk clubs, archery, figure skating, increased access to the sports field, and improved condition of the outdoor basketball court (β=15.5, 95%CI: 5.2-25.7).

**Conclusions**: Changes such as adding or increasing access to facilities, and adding multiple recreational programs, seemed to be effective for increasing student MVPA over the 1-year period. However, given the specificity of results, a one-size fits all approach may not be effective for increasing MVPA. Instead, school principals need to consider the resources within and surrounding their school, and the interests of the students.

**Keywords:** adolescent, youth, environment, longitudinal, programs, policy, intervention

## Introduction

Regular moderate- to vigorous-intensity physical activity (MVPA) is associated with several physical, mental health, and cognitive benefits in school-aged children and youth [1, 2, 3]. According to recent global estimates, approximately 80 % of adolescents failed to meet the recommended amount of MVPA for optimal health benefits [4]. Further, evidence has suggested that there is an actual decline in the amount of time spent in MVPA during adolescence [5, 6]. Given the adverse health consequences associated with physical inactivity [4,7], identifying effective strategies to increase MVPA and promote a healthy active lifestyle among adolescents is warranted.

Ample research has identified individual correlates that can be targeted to increase MVPA among adolescents [8]. However, some models suggest that factors outside of the individual also have potential to influence MVPA. For instance, ecological models often recognize that the development of health-enhancing behaviours, such as MVPA, involves interactions between the individual (e.g., self-efficacy, enjoyment, attitudes) [9] and the multiple contexts (e.g., home, school, community) in which they are situated [10, 11]. Since most adolescents spend approximately 25 h each week in school throughout the school year [12, 13], the school environment represents one important context for shaping MVPA [3, 14, 15, 16].

Examination of the school environment's influence on student MVPA has been a growing body of research within the last five years [17]. According to a recent systematic review examining aspects of the whole-school environment, it was found that activity setting, perceived teacher support, and intramurals were consistently positively associated with student MVPA [17]. However, the majority of included studies were cross-sectional in nature, and the evidence

from the limited longitudinal and experimental studies was mixed [17]. Similar mixed results were found in a separate review, stemming from heterogeneity in terms of frequency, duration, and intensity of school-based PA interventions [18]. While the authors of the review identified several PA intervention successes for increasing MVPA in younger children, it was concluded that PA interventions targeting adolescents were ineffective [18].

Given the combined evidence, one way to strengthen the current literature would be to examine longitudinal associations using quasi-experimental designs [19, 20]. Examination of naturally-occurring changes that take place in real-world settings over time could reduce some of the potential external validity issues that have been associated with controlled trials [21], and address issues of causality inherit with cross-sectional studies [22, 23, 24]. Furthermore, quasi-experimental designs allow for the simultaneous observation of multiple interventions that occur in diverse settings. Such observations can be useful for identifying the most effective interventions for increasing adolescent MVPA. Therefore, the purpose of this study is to examine how naturally-occurring changes to secondary school physical activity (PA) policies, recreational programming, public health resources, and the physical environment, impact secondary student MVPA over a one-year period.

## Methods

### *Design*

The cohort for obesity, marijuana use, physical activity, alcohol use, smoking, and sedentary behaviour (COMPASS) is an ongoing quasi-experimental study that collects annual data regarding multiple health behaviours from secondary school students in grades 9 to 12 (aged 13 to 18 years), and the schools they attend in Ontario and Alberta, Canada [25]. COMPASS

follows a cyclical process where student and school data is collected and used to generate school health profiles. The school health profiles are given back to the schools with feedback on their students' health status, as well as information and resources that can be used to target identified problem areas. Schools then have the option to make a change themselves or contact a COMPASS knowledge broker for assistance with targeting identified problem areas. For all changes that occur, the COMPASS research team evaluates their impact on student health outcomes to generate practice-based evidence. The current study used longitudinal student- and school-level data from Ontario and Alberta schools in year two ($Y_2$: 2013–2014) and year three ($Y_3$: 2014–2015) of the COMPASS study. Data was collected using the COMPASS Student Questionnaire (Cq) [26], the COMPASS School Policies and Practices Questionnaire (SPP) (based off of the Healthy School Planner tool; [27]), and the COMPASS School Environment Application (Co-SEA) [28]. A full description of the study methods is available in print [25] or online [29]. Ethical approval was obtained from the University of Waterloo Office of Research Ethics and University of Alberta Research Ethics Board. All school boards and schools approved study procedures. Active-information passive-consent was sought from parents, and assent was obtained from participants on the data collection date. Parents or students could decline to participate at any time.

***Procedures***

Each year students completed the Cq during class time, school principals filled out the SPP, and a COMPASS staff member performed an audit of the physical environment using the Co-SEA. The Cq collects individual student data on health behaviours, including MVPA, and demographic characteristics [25]. The SPP is a shorter, modified version of the previously

validated Healthy School Planner tool [27] and captures information on school policies, programs, resources, and the environment related to student health [25]. The Co-SEA is a software application that can be downloaded to most mobile devices (e.g., cellular phone) and allows for pictures to be taken, stored, and assigned rankings. The Co-SEA was used by a COMPASS staff member to take pictures of PA facilities present within the school [28].

***Participants***

In $Y_2$, data from 79 Ontario and 10 Alberta schools was collected. A total of 57,229 students were enrolled in the 89 secondary schools with 79.15 % ($n = 45,298$) of eligible students completing the Cq. In $Y_3$, data was collected from 78 Ontario and 9 Alberta schools. A total of 53,846 students were enrolled in the 87 secondary schools with 78.66 % ($n = 42,355$) of eligible students having completed the Cq. Missing respondents due to parental refusal accounted for 1.2 %, and 0.78 %, of the eligible sample in $Y_2$, and $Y_3$, respectively. The remainder of missing respondents were due to absenteeism or students being on a spare (i.e., unscheduled class) during the data collection, or student refusal. Furthermore, three schools dropped out from $Y_2$ to $Y_3$ due to administration changes and questionnaire length. Though one school was added in $Y_3$ resulting in a sample of 87 secondary schools, this school was not included in the present study because it did not have any $Y_2$ data. Therefore, 86 schools with complete data were included in this study.

To explore longitudinal changes among respondents, we paired $Y_2$ and $Y_3$ student-level data within schools, creating a longitudinal sample of 19,854 students from 86 schools. The paired sample accounted for 35.2 % of eligible $Y_2$ respondents ($n = 56,356$), and 37.1 % of eligible $Y_3$ respondents ($n = 53,426$). As expected, the 10,233 grade 12 students in $Y_2$ that

graduated were not in school in $Y_3$, and the 11,070 grade 9 students that were newly admitted to participating schools in $Y_3$ were not paired and were excluded. Other reasons for non-paired data included students who transferred schools, students who were had spare classes or were absent during the time of $Y_2$ or $Y_3$ data collection in their school, early school leavers, or inaccurate data provided in the data pairing measures on the Cq. Methodological details on the COMPASS data pairing procedures are available [30].

***Exposures***

*Subjective school-level changes.* Changes to PA policies, recreational programming, use of public health units (i.e., a government health agency that carries out community health programs), and environment/equipment were assessed via single items on the SPP. Principals were provided with their previous year's responses and were asked to report if any changes had occurred since the previous school year. If changes were made, they were then prompted to provide additional details about the change.

*Objective school-level changes.* Changes to quantity and condition of PA facilities were measured using the Co-SEA. Quantity of school PA facilities were recorded in both years by COMPASS research staff performing a school audit. Quantity changes were determined by subtracting the number of facilities present in $Y_2$ from the number of facilities present in $Y_3$. Condition of the PA facilities were measured each year on a 3-point scale (1='poor', 2 = 'adequate', 3 = 'good'). Condition changes were determined by subtracting conditions scores in $Y_2$ from condition scores in $Y_3$.

### *Outcome*

MVPA was measured by two questions on the Cq. Students were required to complete the following item "Mark how many minutes of vigorous 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." The same item was used to measure moderate physical activity, but instead of "vigorous," the term "moderate" was substituted into the sentence. Responses were recorded in hours (0–4) and minutes (0, 15, 30, 45) for each day of the week. To help students better understand the questions they were given examples of vigorous (i.e., jogging, team sports, fast dancing, jump-rope, and any other physical activities that make you breathe hard and sweat) and moderate (i.e., lower intensity activities such as walking, biking to school, and recreational swimming) physical activities. Responses to these questions were added and averaged over the seven days to calculate daily MVPA. These items have demonstrated moderate test-retest reliability (ICC = 0.75); and slight criterion validity for MVPA (ICC = 0.25) against accelerometers [31], which is comparable to other self-reported measures used with adolescents [32, 33, 34, 35, 36, 37].

### *Covariates*

*Student-level covariates.* Age, sex, ethnicity, weekly spending money, and physical education enrollment were considered covariates based on previous research examining their influence on MVPA [8, 38, 39, 40]. In addition, typical MVPA was also considered as a covariate, given its potential impact on MVPA. These variables were measured via single items on the Cq. There were seven response options for ethnicity. Based on frequency distributions, ethnicity was collapsed into two groups ("White," and "non-White"). There were eight response

options for weekly spending money ranging from "zero" to "$100+", and "I do not know how much money I get each week." To maximize sample size, participants who reported "I do not know" or who had missing data for this item were collapsed into one group [41]. There were three response options for physical education enrollment: (1) "Yes, I am taking one this term;" (2) "Yes, I will be taking one or have taken one this school year, but not this term;" and (3) "No, I am not taking a physical education class at school this year." Students who reported different statuses from $Y_2$ to $Y_3$ formed one group, and students who reported the same status for each year formed the referent group. There were three response options for typical MVPA: (1) "Yes," (2) "No, I was more active in the last 7 days;" and (3) "No, I was less active in the last 7 days." Students who reported different responses in $Y_2$ and $Y_3$ formed one group, and students whose response was the same in each year formed the referent group.

*School-level covariates*. School size, school area level socioeconomic status, and school location were considered covariates based on previous research examining their influences on school PA facilities and program offerings [23, 24, 42]. School size was determined via school enrolment records and was entered into the model as a continuous variable. School area level socioeconomic status was constructed using the median household income of census divisions that corresponded with school postal codes, and was collected from 2011 National Household Survey data. School location was determined via school postal code, and Statistics Canada classifications were used to classify schools as "rural," "small urban," "medium urban," and "large urban." Based on frequency distributions, "rural" and "small urban" were collapsed to form one group, and "medium urban" and "large urban" were collapsed to form another group [43].

### *Analysis*

Analyses were completed using SAS version 9.4 (SAS Institute Inc., Cary, NC). Descriptive statistics were calculated for student-level and school-level variables using linear and logistic regressions that accounted for the clustering effect of schools. Likewise, the same procedures were used to compare demographic characteristics between included and excluded participants. To address the main purpose a three level, multi-level growth model was conducted using the MIXED procedure. Data was transposed from wide to long format so that time was nested in students, and students were nested in schools, with random intercepts included for students and schools. Consistent with other quasi-experimental research that looked at change over time [44],*each* school that made a PA related change between $Y_2$ and $Y_3$ was treated as a change group, while schools that made no PA related change between $Y_2$ and $Y_3$ were collapsed into one control group and served as the reference group. The multi-level growth model included time (Year), dummy variables for each change group compared to the reference group, and all student-level and school-level covariates. Additionally, to compare the impact of each change group compared to the reference group on change in student-level MVPA, a time*change interaction term was included in the model for each change group. Statistical significance was set a priori at $p < 0.05$.

## Results

Out of 19,854 students with paired data, students with missing variables were excluded ($n = 808$), and consistent with previous research students with an extreme MVPA change value (±3 SD) were removed ($n = 269$) [45], resulting in a final sample of 18,777 students. The included sample comprised of significantly older participants (Mean age = 15.07 years versus

Mean age =15.01 years), more white participants (73.7 % versus 66.6 %); more female participants, (53.9 % versus 42.71 %), more participants whose typical week of MVPA status remained the same (58.0 % versus 48.5 %), and more participants whose physical education enrolment status remained the same (45.5 % versus 35.6 %) compared to the excluded group. Student and school demographic characteristics are listed in Tables 1 and 2, respectively. In $Y_2$ mean MVPA for females and males was 107.87 min/day and 132.9 min/day, respectively. In $Y_3$ mean MVPA for females and males was 100.6 min/day and 129.53 min/day, respectively. Overall, MVPA declined by 4.86 min/day.

Of the 86 schools included in this study, 61 made PA related changes to at least one feature of the school environment between $Y_2$ and $Y_3$. Detailed descriptions of school changes are presented in Table 3. Briefly, none of the schools made any policy related changes, 15 schools made changes to recreational programming, two schools made changes to their use of public health units, two schools made changes to the subjective environment/equipment, and two schools made changes to both recreational programming and the subjective environment/equipment. Furthermore, 21 schools made changes to the physical environment within their school. Of these 21 schools, quantity changes occurred in five schools, condition changes occurred in 10 schools, and both quantity and condition changes occurred in six schools. Lastly, 19 schools reported multiple changes that encompassed combinations of changes to recreational programming, use of public health units, the subjective environment/equipment (as reported in SPP), and the physical environment (measured by Co-SEA).

As shown in Table 4, of the 61 schools that had PA related changes, a significant change in student MVPA was observed in nine schools. Of these nine schools, four schools' changes

resulted in a significant increase in student MVPA, while significant decreases in student MVPA occurred in five schools. Significant increases in MVPA were observed in School 5, 10, 23, and 49. School 5 had their fitness centre open at lunch (β = 17.1765, 95 % CI: 2.6079 to 31.7451). School 10 started an *out and abouters* club as a result of a focus on health and wellness from the student council, which involved monthly hikes and outings (β = 17.7959, 95 % CI: 7.4354 to 28.1564). School 23 added a bike rack (β = 14.919, 95 % CI: 0.6891 to 29.1488). Lastly, School 49 improved the condition of the outdoor basketball court, provided students with opportunities to join the weight lifting club or the 100 km walk/run club, added archery and figure skating, and enabled access to the sports field at lunch if it was not already occupied by the PE class (β = 15.4671, 95 % CI: 5.2029 to 25.7312).

Significant decreases in student MVPA were observed in School 11, 22, 31 52, 58. School 11 offered the Terry Fox Run (i.e., charity run; β = −14.1243, 95 % CI: −22.4178 to −5.8309). School 22 added a dance studio (β = −8.994, 95 % CI: −17.6915 to −0.2965). School 31 improved the condition of their fitness/weight room (β = −11.0801, 95 % CI: −21.2506 to −0.9096). School 52 improved the condition of their fitness/weight room, and received a grant from which they built an alternate fitness room with additional equipment, after school sessions, and had it open during lunch hour for student use (β = −11.4782, 95 % CI: −22.6037 to −0.3528). Lastly, School 58 improved the condition of their field, and added a dance club and athletic council (β = −10.3547, 95 % CI: −18.7093 to −2.001). No other interventions produced significant results.

## Discussion

The purpose of this study was to examine how naturally occurring changes to PA policy, recreational programming, public health resources, and the physical environment within schools impacted student MVPA over a one-year period. We found that changes to some aspects of recreational programming (e.g., PA-related clubs) and the physical environment (e.g., addition of bike rack, fitness room) were associated with a significant change in student MVPA. Changes to public health resources proved not to be significant. Further, no policy changes occurred in any participating schools between $Y_2$ and $Y_3$, suggesting an opportunity for more targeted action moving forward.

To our knowledge this is the first study that looked at how naturally occurring school PA-related changes impacted student MVPA over time. There were nine schools' changes that resulted in significant student MVPA changes over the one-year period. Considering the current study looked at change over time, it is important to keep in mind that this was not an examination of the presence or absence of policies, recreational programming, public health resources, or features of the physical environment. Therefore, it is quite possible for the control schools ($n = 25$) to have had existing initiatives in place and did not feel the need to make any PA related changes. As a result, this could explain the mixed impacts on student MVPA from what seemed to be positive PA school-level changes. Given the paucity of longitudinal studies examining the impact of school-led changes over time, it is difficult to directly align these findings with evidence from the current literature. However, ecological models [11] and previously identified associations are available to help support and interpret the results of this study.

Changing only aspects of the physical environment resulted in increased MVPA in one school, and decreased MVPA in two schools. The addition of a bike rack by school 23 resulted in increased student MVPA and is of particular interest considering two other schools also made this change, while a third school incorporated it among other changes. However, the addition of a bike rack in these three other schools did not significantly impact student MVPA. In previous research, the presence of bike racks alone have not been associated with student MVPA [22, 23, 24]. However, there is evidence to suggest that bike riding is a popular activity among high school students [46], and that active transportation (e.g., biking to school) is one way for students to engage in MVPA [47]. While this study did account for school-level variability and covariates, it did not observe features of the neighbourhood built environment that may influence MVPA [48]. Therefore, differences within the surrounding community environments of these schools may explain why the addition of a bike rack significantly impacted student MVPA in only one out of four schools. Another physical environment change that significantly impacted MVPA was the addition of a dance studio, which resulted in a decrease in student MVPA. In previous research dance studios typically have not been significantly associated with student MVPA [22, 23, 24]; therefore, it is unclear why student MVPA decreased in school 22. Restructuring space for dance studios has been suggested as a potential way to increase MVPA among low active groups [49]. However, given the results from this study it appears that more research is needed to determine whether adding a dance studio is a viable solution for schools looking to increase student MVPA. Finally, the last physical environment change that impacted MVPA was improving the condition of the fitness/weight room in school 31, which resulted in decreased student MVPA. Previously, facility condition has been positively associated with MVPA in both males and female students [50]. In the current study a change to facility condition

was reported in 10 schools, in which five were specific to the fitness/weight room, yet only one of these significantly impacted student MVPA. Therefore, changing the condition of PA facilities may not be an effective strategy for schools to improve student MVPA as it appears to have a null or negative impact. Given the combined results, it appears that more research is needed examining the impact of objectively measured changes to the physical environment on student MVPA.

Changes to only recreational programming resulted in significant student MVPA changes in three schools. Of these, increased MVPA changes occurred from adding an out-and-abouters club in school 10, and from increasing access to the fitness centre at lunch in school 5. Given that the presence of a room with cardio or weightlifting equipment has previously been associated with increased odds of being physically active during recess [51], it does not seem out of place that students attending school 5 had increased MVPA. Further, it seems intuitive that offering an outdoor club in school 10 stemming from a student leadership initiative would also have a positive influence on student MVPA. However, it is unclear why the addition of a charitable run (Terry Fox Run) in school 11 resulted in a decrease in student MVPA. Although there is little evidence to suggest that one-time events are effective for increasing MVPA [52, 53], it should be noted that it was unknown whether the Terry Fox Run occurred within the recalled week of MVPA (previous week). Therefore, it is possible that some other change not captured in the SPP or Co-SEA was responsible for the observed decrease in student MVPA in this school. Consequently, it appears that more research is needed to examine how one-time events held by schools impact student MVPA over time.

Changes to both the physical environment and recreational programming occurred in three schools. Intuitively, an increase in MVPA was observed in school 49 which added a

weightlifting club, a 100 km run/walk club, archery and figure skating, increased access to the sports field at lunch, and improved condition of the outdoor basketball court. However, surprisingly decreased MVPA was observed in school 52 that had built a fitness room complete with spin bikes, bose balls, ping pong, and shuffle board, provided 10 sessions each of spin, yoga, and Zumba, and increased access to the gym at lunch. A decrease in MVPA was also observed in school 58, which added a dance club and improved the condition of their field. Previous research has found that alternate rooms for PA have been positively associated with MVPA [22, 23, 24]. Therefore, it is interesting that we observed decreased MVPA in school 52 for building a fitness room. One potential explanation could be the timing of data collection, as it was unclear how close the renovations occurred to the actual data collection date. Hence, it will be interesting to see how this change impacts student MVPA in the COMPASS year four data collection. Another potential reason for the difference in results observed between schools could be the extra-curricular activities that were offered. For example, increased MVPA occurred in school 49 from incorporating multiple new activities (e.g., weightlifting, run/walk club, archery, figure skating), which could have appealed to a broader range of male and female students and resulted in a larger proportion of students being active [46]. While there is evidence to suggest that activities offered in school 52, such as spin, yoga, and dance are some of the least preferred activities and may only be of interest to females [46, 54]. Lastly, the observed differences in results could be due to implementation success. Previous research has identified support from school principals, physical space, and scheduling with other school activities (e.g., varsity teams) as factors that can facilitate or impede the ability to offer extra-curricular activities [55, 56]. In addition, student hunger, after-school transportation, and other student commitments (e.g., jobs, tutoring, family) were identified in previous research as potential issues that could influence

participation in extra-curricular activities [55, 56]. Given that the current study did not assess these factors, an examination of the facilitators and barriers experienced by these three schools that made changes to recreational programming could provide a better understanding of the results.

Schools often cited policies that were embedded at the provincial level such as the daily physical activity initiative, and the physical education curriculum. However, these are not school-level policies and therefore were not considered an appropriate exposure for this study. Previous research has found that policies implemented beyond the school-level have experienced implementation issues [57, 58], and that there seems to be a lack of communication between policy makers, school board officials, principals, and teachers [59]. Therefore, future research should continue to examine PA policies and evaluate the relationship between policies developed at the school level and student MVPA.

Piercy et al., 2015 [60] suggested that public health units can encourage schools to adopt health promoting programs and act as a facilitator between the school and local community resources. However, only 4/61 schools changed the way they collaborated with public health units, with none of these changes significantly impacting student MVPA. Of these four schools, three offered PA programs, and one was in the process of working with their public health unit. One potential reason for the lack of significant results stemming from these schools could be that these were new programs being implemented and it could take a while for them to run efficiently. Future research should continue to assess the relationship between schools and local public health units in order to identify the most effective strategies for increasing the amount of time students spend in MVPA.

While the results of this study are mixed, they solidify previous recommendations in which multiple school contexts such as the physical, social, and policy environments need to be examined concurrently in order to better understand how the complete school environment influences student MVPA [17]. Although this study assessed the physical, and policy environments, the social environment was not addressed. Understanding how previously associated factors such as perceived teacher support [61, 62, 63] and feelings of school connectedness [64, 65], could have aided in the interpretation of the results. Schools may have sufficient facilities and a variety of activities to offer, however students may still need to feel supported by school personnel or have a sense of school connectedness before they engage in the opportunities that are provided. Therefore, more research is needed in order to understand how feelings of school connectedness, and teacher support are associated with the amount of time students spend in MVPA.

Strengths of this study included the quasi-experimental design, longitudinal data, objective and subjective measures of the physical environment, and the use of active-information passive-consent parental protocol. The COMPASS study uses active-information passive-consent parental protocol for its capability to reduce school-level variance estimates, increase participation rates to obtain a representative sample of the entire student population within a school, reduce the risk for obtaining a biased sample, obtain accurate information regarding substance use, and ensure student confidentiality [66]. Despite these strengths mentioned, there were limitations that need to be considered. The COMPASS study purposely sampled school boards that met a predetermined inclusion criterion and therefore is not a representative sample of all Ontario and Alberta schools. As a result, this could limit the generalizability to larger, English speaking schools [25, 67]. Another limitation was the use of a self-reported MVPA,

which often results in overestimation of MVPA in adolescents compared to objective measures, such as accelerometers [68]. Further self-report measures are not as accurate in determining different intensities of PA as objective measures. However, given feasibility issues such as cost and time that are associated with objective measurement (e.g., accelerometers), self-reported measures like the Cq are acceptable for use in large samples. Further, if over-reporting did occur, it likely occurred at both times, minimizing the impact on MVPA change over time. Lastly, there are potential limitations regarding the use of the Co-SEA. Although the Co-SEA allows for objective measurement of the quantity of facilities present in physical environment, data collectors are required to subjectively assess the condition of these facilities. While training was provided to ensure a high degree of reliability was achieved, measurement error may still have occurred.

**Conclusion**

This study provided a quasi-experimental observation of how naturally-occurring school changes to PA policy, recreational programming, public health resources, and the physical environment impacted student MVPA over time. Based on the changes' that resulted in increased MVPA, it appears that providing increased access and multiple opportunities to be active may be an effective strategy for increasing MVPA in secondary school students. However, it was also found that the same school-level changes had different impacts on student MVPA. Further, in some schools even intuitively positive changes negatively impacted student MVPA. From an ecological perspective, it is possible that sources of influence at the interpersonal or community level could be interacting with these school-level changes [11]. Considering the dynamic nature of the school and its components (e.g., staff, students, surrounding community), future

observations should assess multiple levels of the ecological model. This would be beneficial for understanding how these school components interact with one another, and the surrounding community to influence the amount of time secondary students spend in MVPA. Given the specificity of these results, it may be important for school principals to consider both the internal (e.g., staff, facilities) and external (e.g., community features) resources they have, as well the interests of the students in order to develop and deliver effective strategies for increasing student MVPA.

## Declarations

### List of abbreviations

PA= physical activity, MVPA= moderate-to vigorous-intensity physical activity

### Ethics approval and consent to participate

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

### Consent for publication

Not applicable

### Availability of data and materials

The data will not currently be shared because this is an ongoing study; however, access to the data supporting the findings of the study can be requested at https://uwaterloo.ca/compass-system/compass-system-projects/compass-study.

### Competing interests

The authors declare that they have no competing interests.

**Funding**

The COMPASS study 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; Grant awarded to ST. Leatherdale) and an operating grant from the Canadian Institutes of Health Research (CIHR) Institute of Population and Public Health (IPPH) (MOP-114875; Grant awarded to ST. Leatherdale). SH is supported by the Women & Children's Health Research Institute (WCHRI) through the generous support of The Stollery Children's Hospital Foundation. VC is supported by a CIHR New Investigator Salary Award.

**Author's Contributions**

STL conceived of the COMPASS study and wrote the funding proposal, developed the study tools, and is leading the study implementation and coordination. VC helped expand the study to Alberta, is leading the study coordination in Alberta. SH performed the analysis and wrote the manuscript and STL, VC, and KS revised the manuscript for important intellectual content. All authors read and approved of the final manuscript.

**Acknowledgements**

The authors would like to thank Chad Bredin (COMPASS study project manager), Dr. Dana Church (COMPASS study recruitment coordinator), and Audra Thompson-Haile (COMPASS school coordinator) for their assistance with this project.

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Table 1. Characteristics of participants enrolled in year 2 (2013-2014) and year 3 (2014-2015) of the COMPASS study.

| Variable | Total (n=18,777) |
|---|---|
| Mean Baseline Age (years) | 15.1 (0.02) |
| | |
| Sex (%) | |
| Male | 46.4% |
| Female | 53.6% |
| Grade | |
| 9 | 37.6% |
| 10 | 33.9 % |
| 11 | 26.4% |
| 12 | 2.1% |
| Ethnicity (% White) | 73.7% |
| Spending Money (weekly) | |
| I don't know, NS | 13.5% |
| Zero | 18.4% |
| $1-$5 | 7.9% |
| $6-$10 | 9.6% |
| $11-20 | 16.7% |
| $21-40 | 12.5% |
| $41-100 | 11.8% |
| $100+ | 9.7% |
| PE enrollment | |
| Change in PE status from $Y_2 – Y_3$ | 54.5% |
| Typical MVPA in previous week | |
| Change in Typical MVPA status from $Y_2 – Y_3$ | 41.9% |
| MVPA | |
| Average Time 1 MVPA (min/day) | 119.5 (1.4) |
| Average Time 2 MVPA (min/day) | 114.1 (1.5) |

*Note*. Continuous variables were expressed as a mean (standard error) and categorical variables were expressed as a percentage. NS = not stated. PE = physical education.

Table 2. Characteristics of schools enrolled in year 2 (2013-2014) and year 3 (2014-2015) of the COMPASS study

| Variable | Total (n= 86) |
|---|---|
| School Size | |
| Small (1-500) | 37.2% |
| Medium (501-1000) | 51.1% |
| Large (1000+) | 11.6% |
| School Location | |
| Rural | 3.4% |
| Small Urban | 45.3% |
| Medium Urban | 15.1% |
| Large Urban | 36.0% |
| School level SES | |
| $25000 – 50000 | 8.1% |
| $50001-75000 | 68.6% |
| $75001-10000 | 19.7% |
| >$100000 | 3.4% |

*Note*. Categorical variables were expressed as a percentage.

Table 3. Description of physical activity related changes implemented between year 2 (2013-2014) and year 3 (2014-2015) of the COMPASS study.

| Description of Intervention | |
|---|---|
| Recreational Programming | |
| School 1 | **SPP: Recreational Programming** − *We have an active [special skills] program focused on Sports and Health. We have had concussion seminars for staff and then students. [Special skills] Sports students have leadership opportunities to lead sports related activities with our feeder schools.* |
| School 2 | **SPP: Recreational Programming**. − *Right to Play, Play Academy. Leaders from the school mentoring elementary students on the role of physical activity. True Sport movement. Archery club added, mountain biking available.* |
| School 3 | **SPP: Recreational Programming.** − *We are in the process of implementing an archery program which we hope will engage students not typically engaged in other physical activities. The most significant change is the establishment and implementation of our Health Champions committee in collaboration with [provincial health services]. This committee is composed of several staff members and has taken on a number of initiatives. The Health Champions organized a school-wide Health Fair during which there were a number of sessions offered to students ranging from hand-washing to archery to managing anxiety. Several community agencies and people were involved in the Fair as presenters. We hope to make this an annual event. Our Health Champions are also promoting healthy choices in the school and lobbying for things such as a bottle filling station. The Health Champions have also organized a number of lunch-time activities for students.* |
| School 4 | **SPP: Recreational Programming**: − *This year, the school leadership class facilitated intramural activities during lunches - dodgeball, Tchuk-ball, dance-off, ping-pong, basketball, floor hockey.* |
| School 5 (+) | **SPP: Recreational Programming**: − *Fitness centre open at lunch as well.* |
| School 6 | **SPP: Recreational Programming**. − *We have 2 full time athletic therapists who help athletes. Have a weight room and strength training coach. Conditioning and strength training available.* |
| School 7 | **SPP: Recreational Programming**: − *Volleyball, badminton, yoga, and intramurals. At school we offer many opportunities for extra-curricular activities; YMCA teen night is free, basketball court is widely used at our school (outdoor). The school offered non-competitive sports clubs such as volleyball, badminton and basketball. Football was added and track. Tennis was offered, but did not run.* |
| School 8 | **SPP: Recreational Programming**. − *[Physical education] classes hire outside instructors (yoga, Zumba, self-defence, etc.) and go to fitness clubs for specialty classes - The [health education] teacher brought in guest speakers as well; non-traditional/individual sports – golf, tennis, etc. Before/afterschool/during lunch students can play inside or outside – floor hockey, basketball, ping pong etc. We fundraise with fitness classes – Zumba. Use outdoor ed to take all grade 9 and "at risk" students Tree Top Trekking. Students adapt sports and instruct students with special needs for an afternoon.* |
| School 9 | **SPP: Recreational Programming**. − *Offering archery club.* |

| | |
|---|---|
| School 10 (+) | **SPP: Recreational Programming**. − *An [outdoor] club was started as a result of a focus on health and wellness from student council – they have been involved in monthly hikes/outings.* |
| School 11 (-) | **SPP: Recreational Programming:** −*Terry Fox Run again this year.* |
| School 12 | **SPP: Recreational Programming:** − *During warm weather connection classes are encouraged to be physically active. Intramural programs are underway.* |
| School 13 | **SPP: Recreational Programming:** − *Encourage [school fitness] activities (6 week period).* |
| School 14 | **SPP: Recreational Programming:** − *Christmas dance had to be cancelled due to lack of ticket sales. Addition of archery.* |
| School 15 | **SPP: Recreational Programming:** − *Almost all the same but as a school this year we did not participate in the Terry Fox Run or Jump Rope for Heart.* |
| Role of Public Health | |
| School 16 | **SPP: Public Health:** − *Working with [public health unit] to pilot some projects [physical education intervention].* |
| School 17 | **SPP: Public Health**: − *This year the grade 9 [physical and health education] students are involved in an intervention study with the [university].* |
| Subjective Measurement of Environment/Equipment Changes | |
| School 18 | **SPP: Environment/Equipment:** − *More opportunities for exercise and increased activity equipment for ALL students.* |
| School 19 | **SPP: Environment/Equipment:** − *Showers now are individual with curtains for more privacy.* |
| Multiple Changes measured by SPP | |
| School 20 | **SPP: Recreational Programming**: − *Offering after school program for students from remote communities. Partnership with [non-profit organization focussed on providing physical activity opportunities for disadvantaged youth] - Looking to install basketball nets for students to use outside. Expansion of non-competitive options like yoga and Crossfit. Classes take kids out for a walk. Equipment available for kids at lunch e.g., balls, hockey sticks.*<br>**SPP: Environment/Equipment:** − *Washrooms renovated.* |
| School 21 | **SPP: Recreational Programming:** − *Intramurals offered at lunch: Well attended - October: [charity run].*<br>**SPP: Environment/Equipment:** − *Yes a change - No secure lockers, could change in private in the washrooms.* |
| Objective Measurement of Environmental Changes measured by Co-SEA | |
| Quantity | |
| School 22 (-) | **Co-SEA:** Added a dance studio. |
| School 23 (+) | **Co-SEA:** Added a bike rack. |
| School 24 | **Co-SEA:** Added a bike rack. |
| School 25 | **Co-SEA:** Added a bike rack. |
| School 26 | **Co-SEA:** Added a bike rack, tennis court, and outdoor basketball court. Removed the fitness/weight room. |
| Condition | |
| School 27 | **Co-SEA:** Condition of the tennis court improved. |
| School 28 | **Co-SEA:** Condition of the outdoor track improved. |

| | |
|---|---|
| School 29 | **Co-SEA:** Condition of the gym improved. |
| School 30 | **Co-SEA:** Condition of the fitness/weight room improved. |
| School 31 (-) | **Co-SEA:** Condition of the fitness/weight room improved. |
| School 32 | **Co-SEA:** Condition of the fitness/weight room improved, and condition of the gym worsened. |
| School 33 | **Co-SEA:** Condition of the field worsened. |
| School 34 | **Co-SEA:** Condition of the outdoor track worsened. |
| School 35 | **Co-SEA:** Condition of the fitness/weight room worsened. |
| School 36 | **Co-SEA:** Condition of the fitness/weight room worsened. |
| Quantity &Condition | |
| School 37 | **Co-SEA:** Added 2 fitness/weight rooms, and the condition of gym improved. |
| School 38 | **Co-SEA:** Added baseball diamond, removed outdoor basketball court, and the condition of the fitness/weight room improved. |
| School 39 | **Co-SEA:** Added dance studio, and the condition of the indoor facility [not specified] improved. |
| School 40 | **Co-SEA:** Added fitness/weight room, removed yoga room, and the condition of fitness/weight room improved. |
| School 41 | **Co-SEA:** Added two fitness/weight rooms and the condition of outdoor basketball court improved. |
| School 42 | **Co-SEA:** Added field, and the condition of the field, and the outdoor track worsened. |
| Multiple School Changes (Measured by Co-SEA & SPP) | |
| School 43 | **Co-SEA:** Added other outdoor facility (crossfit, foobtall equipment), removed a bike rack, and the condition of the field worsened.<br>**SPP: Recreational Programming:** − *Hockey Canada skills academy a 2 credit physical education program. 5 days out of 10 on ice at a recreation center.*<br>**SPP: Environment/Equipment**: − *Yes, no bike racks due to school renovations.* |
| School 44 | **Co-SEA:** Added an outdoor basketball court, added a closed road for hockey, biking; and the condition of fitness/weight room improved.<br>**SPP: Public Health**. − *Walking program became defunct over the past year, we are examining ways to get it started up again as well as implementing a house system pedometer walking challenge as recommended in 13/14 COMPASS results.*<br>**SPP: Recreational Programming**. − *"house" system has been implemented, gr. 9–12 students now have additional opportunities to participate in friendly grade by grade sports competitions on a monthly basis Grade 7/8 students practiced after school and participated in [community kids marathon].*<br>**SPP: Environment/Equipment***: − Major renovation in the school allowed the creation of a cross-fit space, being well utilized by phys. ed department and as part of the after school fitness program.* |
| School 45 | **Co-SEA:** Added a long jump pit.<br>**SPP: Recreational Programming***: − Students have access to basketballs during non-instructional times.* |
| School 46 | **Co-SEA:** Added an outdoor volleyball court.<br>**SPP. Recreational Programming:** − *No [health] walks.* |
| School 47 | **Co-SEA:** Condition of the gym, and fitness/weight room worsened.<br>**SPP. Recreational Programming**. − *[Jane] did less this year because she was so busy.* |

| | |
|---|---|
| | **SPP: Environment/Equipment:** − *Newer curtains were added to shower stalls in girls' change room.* |
| School 48 | **Co-SEA:** Added a fitness/weight room and two fields.<br>**SPP: Recreational Programming**: − *No intramurals.* |
| School 49 (+) | **Co-SEA:** Condition of the outdoor basketball court improved.<br>**SPP: Recreational Programming**: − *All students can join the weight lifting club or the 100 km walk/run club. Added archery and figure skating.*<br>**SPP: Environment/Equipment**: − *Students have access to the sports field at lunch in there is no physical education class using it.* |
| School 50 | **Co-SEA:** Added a yoga room<br>**SPP: Recreational Programming**: − *School uses a program called Kids Sport to help fund underprivileged students who cannot afford to be a part of school programs.* |
| School 51 | **Co-SEA:** Added an outdoor basketball court, and condition of the outdoor track improved.<br>**SPP: Recreational Programming**: − *No longer host relay for life -Shine On program has been added for self-esteem/self-awareness. Yoga and nutrition for female students 1x week.*<br>**SPP: Environment/ Equipment:** *New rubberized track and outdoor basketball court.* |
| School 52 (-) | **Co-SEA:** Condition of the fitness/weight room improved.<br>**SPP: Recreational Programming**: − *[Received fitness grant] from the Ministry of Education - Built fitness 101 room with spin bikes, bose balls, ping pong, and shuffleboard. Also provided 10 sessions each after school for spinning, yoga, Zumba. Gym open every lunch for student use.* |
| School 53 | **SPP: Recreational Programming**. − *Wellness Week - One week of Wellness Week 2015 focused on Play or physical activity. A Wii Dance-off competition against another secondary school was held with 175 students and staff dancing together for 20 min. Terry Fox Run, Inside Ride, intramural programming, Semi Pro Basketball league - only open to students who didn't play on a HC team. Dodge ball competition, flag football league, varsity sports programs, and weight room memberships. Membership for students and staff in a fully equipped weight room; money raised from memberships used to purchase equipment.*<br>**SPP: Public Health:** − *Involvement in Wellness Week.*<br>**SPP: Environment/Equipment:** − *Construction of an outdoor basketball court for students and community members to use.* |
| School 54 | **SPP: Recreational Programming:** − *Partnership with Recreation Centre to allow free access to weight room. Archery club added -Outdoor Education instead of just canoe activities -Unsure if the school participated in the Terry Fox Run.*<br>**SPP: Environment/Equipment:** − *Girls' showers all have private stalls and curtains - Students also access physical activity facilities at [another school].* |
| School 55 | **Co-SEA:** Added a yoga room.<br>**SPP**: **Recreational Programming**. − *Supervised gym time during lunch hours, hopefully supervised fitness room during lunch hours, and supervised fitness room after school hours.*<br>**SPP: Environment/Equipment**. − *Curtains in female shower stalls.* |
| School 56 | **Co-SEA:** Added a fitness/weight room. |

| | |
|---|---|
| | **SPP: Recreational Programming:** − *Continued building relationships with community partners (i.e., with senior league golf and the curling club). Hockey academy (a 2 credit physical education package) is now available and is a focused course emphasizing specific activity skill development and conditioning. Soccer academy will be available next year. Healthy active living education courses are now 14 sections. Intramural expansion continues. Badminton club is growing.* |
| School 57 | **Co-SEA:** Removed 2 fitness/weight rooms, and condition of the field improved.<br>**SPP: Recreational Programming**: − *Boarding students have increased access to use fitness studio (now can use without adult supervision) if they go with a buddy.* |
| School 58 (-) | **Co-SEA:** Condition of the field improved.<br>**SPP: Recreational Programming:** −*Added dance club, athletic council to sports selection.* |
| School 59 | **Co-SEA:** Condition of the field worsened<br>**SPP: Recreational Programming:** − *Added outdoor education and a walking club. Ultimate Frisbee. Added a new girls' only fitness club and there will be 2 sections running next year.* |
| School 60 | **Co-SEA:** Added a yoga room, condition of the fitness/weight room improved.<br>**SPP: Recreational Programming:** − *No [charity walk] this year.* |
| School 61 | **Co-SEA:** Condition of the fitness/weight room worsened, and condition of the field worsened.<br>**SPP: Recreational Programming:** − *The school has not offered intramurals so far this year (completed Nov/Dec 2014).* |

*Note*. *Italicized text* represents qualitative response from school staff/principals, **bold text** indicates measurement tool. (+) indicates change resulted in significant increase in student MVPA, (-) indicates change resulted in significant decrease in student MVPA

Table 4. Multilevel modeling examining the impact of school physical activity related changes on student self-reported MVPA between year 2 (2013-2014) and year 3 (2014-2015) of the COMPASS study.

| Parameter | β | 95% CI | | Standard error | T value | P value |
|---|---|---|---|---|---|---|
| | | lower | upper | | | |
| Intervention* Year | | | | | | |
| Control Schools (n=25) | **Ref** | **-** | **-** | **-** | **-** | **-** |
| School 1 | -1.4126 | -20.8311 | 18.0059 | 9.907 | -0.14 | 0.8866 |
| School 2 | -3.3077 | -11.159 | 4.5435 | 4.0056 | -0.83 | 0.4089 |
| School 3 | -4.6045 | -19.8508 | 10.6419 | 7.7784 | -0.59 | 0.5539 |
| School 4 | -3.5289 | -11.6699 | 4.6122 | 4.1534 | -0.85 | 0.3955 |
| School 5 | **17.1765** | **2.6079** | **31.7451** | **7.4326** | **2.31** | **0.0208** |
| School 6 | -6.0454 | -14.6058 | 2.5149 | 4.3673 | -1.38 | 0.1663 |
| School 7 | -5.6419 | -19.4357 | 8.1518 | 7.0373 | -0.8 | 0.4227 |
| School 8 | -3.4567 | -10.1445 | 3.2312 | 3.412 | -1.01 | 0.311 |
| School 9 | 1.0997 | -10.2788 | 12.4782 | 5.8051 | 0.19 | 0.8497 |
| School 10 | **17.7959** | **7.4354** | **28.1564** | **5.2857** | **3.37** | **0.0008** |
| School 11 | **-14.1243** | **-22.4178** | **-5.8309** | **4.2312** | **-3.34** | **0.0008** |
| School 12 | -8.0511 | -18.1531 | 2.0509 | 5.1538 | -1.56 | 0.1183 |
| School 13 | -1.7797 | -17.3599 | 13.8005 | 7.9487 | -0.22 | 0.8228 |
| School 14 | 8.0656 | -8.8876 | 25.0187 | 8.6492 | 0.93 | 0.3511 |
| School 15 | -4.0273 | -13.2666 | 5.212 | 4.7137 | -0.85 | 0.3929 |
| School 16 | 2.2906 | -4.6181 | 9.1993 | 3.5247 | 0.65 | 0.5158 |
| School 17 | -0.6574 | -12.0688 | 10.754 | 5.8219 | -0.11 | 0.9101 |
| School 18 | 15.3825 | -1.4601 | 32.2251 | 8.5928 | 1.79 | 0.0734 |
| School 19 | 2.3569 | -8.0037 | 12.7174 | 5.2857 | 0.45 | 0.6557 |
| School 20 | -1.9814 | -12.2218 | 8.2591 | 5.2245 | -0.38 | 0.7045 |
| School 21 | 4.6348 | -5.9797 | 15.2493 | 5.4153 | 0.86 | 0.3921 |
| School 22 | **-8.994** | **-17.6915** | **-0.2965** | **4.4373** | **-2.03** | **0.0427** |
| School 23 | **14.919** | **0.6891** | **29.1488** | **7.2598** | **2.06** | **0.0399** |
| School 24 | 0.9965 | -10.0384 | 12.0314 | 5.6298 | 0.18 | 0.8595 |
| School 25 | -7.8715 | -15.8157 | 0.07262 | 4.0529 | -1.94 | 0.0521 |
| School 26 | -2.8055 | -16.3117 | 10.7007 | 6.8906 | -0.41 | 0.6839 |
| School 27 | 2.4335 | -4.6778 | 9.5449 | 3.6281 | 0.67 | 0.5024 |
| School 28 | -1.057 | -11.159 | 9.045 | 5.1538 | -0.21 | 0.8375 |
| School 29 | -1.7557 | -12.5323 | 9.0209 | 5.498 | -0.32 | 0.7495 |
| School 30 | 5.2861 | -4.8614 | 15.4336 | 5.1771 | 1.02 | 0.3072 |
| School 31 | **-11.0801** | **-21.2506** | **-0.9096** | **5.1888** | **-2.14** | **0.0327** |
| School 32 | -11.3142 | -26.8944 | 4.266 | 7.9487 | -1.42 | 0.1546 |
| School 33 | 1.5632 | -10.6565 | 13.783 | 6.2343 | 0.25 | 0.802 |
| School 34 | -1.6234 | -11.7938 | 8.5471 | 5.1888 | -0.31 | 0.7544 |
| School 35 | -6.9064 | -18.7374 | 4.9246 | 6.0359 | -1.14 | 0.2525 |
| School 36 | -9.0054 | -19.866 | 1.8552 | 5.5409 | -1.63 | 0.1041 |

| | | | | | | |
|---|---|---|---|---|---|---|
| School 37 | -0.2115 | -8.7585 | 8.3356 | 4.3605 | -0.05 | 0.9613 |
| School 38 | 8.741 | -12.6266 | 30.1085 | 10.9013 | 0.8 | 0.4227 |
| School 39 | 7.437 | -4.8238 | 19.6978 | 6.2552 | 1.19 | 0.2345 |
| School 40 | -6.0121 | -15.6917 | 3.6675 | 4.9383 | -1.22 | 0.2235 |
| School 41 | -2.1108 | -14.9006 | 10.679 | 6.5251 | -0.32 | 0.7463 |
| School 42 | -5.9664 | -16.9423 | 5.0094 | 5.5997 | -1.07 | 0.2867 |
| School 43 | 0.7273 | -6.5046 | 7.9592 | 3.6896 | 0.2 | 0.8437 |
| School 44 | -0.9814 | -18.5225 | 16.5598 | 8.9492 | -0.11 | 0.9127 |
| School 45 | 8.9158 | -6.4947 | 24.3263 | 7.8621 | 1.13 | 0.2568 |
| School 46 | 5.7191 | -3.9605 | 15.3987 | 4.9383 | 1.16 | 0.2468 |
| School 47 | 5.416 | -8.6849 | 19.517 | 7.194 | 0.75 | 0.4515 |
| School 48 | 9.2006 | -0.02176 | 18.4229 | 4.705 | 1.96 | 0.0505 |
| School 49 | **15.4671** | **5.2029** | **25.7312** | **5.2366** | **2.95** | **0.0031** |
| School 50 | -5.675 | -19.6505 | 8.3006 | 7.1301 | -0.8 | 0.4261 |
| School 51 | -2.9709 | -12.5342 | 6.5924 | 4.879 | -0.61 | 0.5426 |
| School 52 | **-11.4782** | **-22.6037** | **-0.3528** | **5.676** | **-2.02** | **0.0432** |
| School 53 | 3.1128 | -4.507 | 10.7326 | 3.8875 | 0.8 | 0.4233 |
| School 54 | 20.6528 | -0.2776 | 41.5831 | 10.6783 | 1.93 | 0.0531 |
| School 55 | 4.5232 | -6.1178 | 15.1642 | 5.4288 | 0.83 | 0.4048 |
| School 56 | 2.3501 | -15.3163 | 20.0164 | 9.013 | 0.26 | 0.7943 |
| School 57 | -6.0286 | -15.0386 | 2.9814 | 4.5967 | -1.31 | 0.1897 |
| School 58 | **-10.3547** | **-18.7093** | **-2.0001** | **4.2624** | **-2.43** | **0.0151** |
| School 59 | 11.0406 | -0.3379 | 22.4191 | 5.8051 | 1.9 | 0.0572 |
| School 60 | 0.03211 | -7.9226 | 7.9868 | 4.0583 | 0.01 | 0.9937 |
| School 61 | -8.2886 | -22.928 | 6.3508 | 7.4687 | -1.11 | 0.2671 |

*Note*. **Bolded** values are significant ($p < 0.05$). Adjusted for age, sex, ethnicity, physical education enrolment, weekly spending money, typical PA, school size, school location, and school area-level SES. *Represents an interaction.

## Chapter 4: Conclusion

Schools represent an ideal setting for initiating and promoting regular PA behaviour (Lounsbery et al., 2013; Naylor & McKay, 2009; Stewart-Brown, 2006; Wechsler et al., 2000; Winter, 2009). However, research to date has lacked the necessary methodological designs to truly understand how aspects of the school impact adolescent PA over time. While there is evidence showing that school-based interventions can improve PA among children, there is less support for their effectiveness for adolescents (Dobbins et al., 2013). Furthermore, their sustainability, and generalizability remains limited as they are often researcher-led, and do not reflect the changes that occur in natural settings (McGoey et al., 2015; Naylor et al., 2015). Further, cross-sectional designs have provided a starting point as to what features of the school may be associated with adolescent PA; however, it is difficult to establish causal relationships. The quasi-experimental, longitudinal data that was used in this thesis was able to strengthen the current body of literature by addressing previous limitations associated with controlled trials and cross-sectional research. Further, this thesis represents the first study to comprehensively examine how naturally occurring changes to policy, recreational programming, public health resources, and the physical environment impact student MVPA over time. As a result, the findings of this thesis provide valuable insight into what school-level changes may be most effective for increasing adolescent MVPA.

Based on the positive findings of this thesis, it appears that increased access and the provision of multiple opportunities to be active may be effective strategies for increasing adolescent MVPA. Specific examples of the types of single changes that resulted in increased MVPA included increased access to the fitness center at lunch, adding an outdoor club, and adding a bike rack. In addition, one school made multiple changes that included improving the condition

of the outdoor basketball court, adding a run/walk club, adding a weightlifting club, and increased access to the sports field at lunch. Therefore, these results suggest that elaborate modifications, such as renovations to the physical environment and the addition of expensive equipment, may not be necessary for improving student PA. Instead, a more appropriate course of action could be for schools to utilize the strengths of their current staff and resources to develop programs and provide opportunities that are appealing to a broad student audience.

Although specific examples were identified that had positive associations with MVPA, it should be noted that a tailored approach is still important to consider. More specifically, previous research has shown that within the adolescent population, there are differences in the types of physical activities that are preferred (Brener et al., 2013; Gavin et al., 2015). Therefore, identifying what these preferred activities are in the student population of interest, and how to incorporate them into school initiatives could be an essential step that administrators and researchers need to consider. For administrators this will require communication with students to obtain critical feedback about current PA practices that can then be used to guide and develop future initiatives. For researchers, this may require more qualitative assessments during both the development, and implementation stages of the intervention process (Van Sluijs & Kriemler, 2016). Overall, the evidence from this thesis suggests that schools are complicated settings, with multiple variables (e.g., teachers, administrators, students, resources) that need to be considered when coming up with strategies to promote regular PA behaviour.

Given this complexity of schools, future research should consider using an ecological model to identify multiple sources of influence that shape PA behaviour in adolescents. From an ecological perspective, it is posited that behaviour change is maximized when multiple sources of influence are targeted (Sallis, Owen, & Fisher, 2008). Although this thesis did not focus on

manipulating any variables, the ideology can still be applied when trying to explain why behaviour change occurred. In this thesis, the focus was on changes that occurred at the organizational level and the resulting impact on MVPA. Incorporating potential influences occurring at other levels of the ecological framework may help further explain what contributes to PA behaviour change in adolescents. For instance, at the intrapersonal level school connectedness (i.e. belief by students that adults in the school care about their learning; Blum, Libbey, Bishop, & Bishop, 2004) has been previously associated with student engagement in PA (Faulkner, Adlaf, Irving, Allison, & Dwyer, 2009; Trinh, Wong, & Faulkner, 2015; Yan et al., 2014; Yang, Tan, & Cheng, 2014). Likewise, at the interpersonal level associations between support from parents, peers, and teachers have been linked with PA in adolescents (Birnbaum et al., 2005; Graham et al., 2014; Hohepa, Scragg, Schofield, Kolt, & Schaaf, 2007; McLellan et al., 1999). Lastly, at the community level, features of the built environment such as sidewalks, recreation facilities, and neighborhood aesthetics (Fein, Plotnikoff, Wild, & Spence, 2004; Mota, Almeida, Santos, & Ribeiro, 2005; Norman et al., 2006; Zakarian, Hovell, Hofstetter, Sallis, & Keating, 1994) have shown associations with adolescent PA.

Other sources of influence (e.g., school-connectedness, school support, built environment) embedded within multiple levels of the ecological framework (e.g., intrapersonal, interpersonal, and community) may also explain some of the results for this thesis. For instance, bike racks were added by four schools; however, a significant increase in MVPA was only observed in one school. Through an ecological lens, it is possible that although all schools added a bike rack, adolescents at this school in particular had a supportive infrastructure (e.g., positive influences at interpersonal and community levels) that facilitated their bike riding to school, and in turn resulted in increased MVPA. A similar explanation can be said about the results pertaining to recreational programming.

Previous research has found that multiple hurdles exist at both staff and student levels when trying to implement extra-curricular physical activities, ranging from student recruitment and scheduling conflicts to student hunger, participation, and features in the surrounding built environment (Garn et al., 2014; Maljak et al., 2014). Therefore, it is quite possible that observed increases in student MVPA through recreational programming (e.g., outdoor club, run/walk clubs) occurred in schools that also had a supportive infrastructure for these programs. Future research that incorporates these other sources of influence can help to shed light on these speculations.

Through the methodological rigor of the COMPASS study, sources of influences embedded within intra-, inter-, and community levels have been annually collected since its inception. For instance, feelings of school connectedness (intrapersonal), and support from parents (interpersonal) surrounding PA have been annually collected through the Cq. Furthermore, objectively measured community level influencers such as the distribution of recreational centers, street networks, and land use, are also collected on an annual basis. Though incorporating these other levels of the ecological model were beyond the scope of this thesis, a logical next step for future research would be to explore how these variables that are routinely measured in the COMPASS study impact student MVPA and how they interact with the naturally occurring PA changes that were examined in this thesis.

In summary, this thesis provided a comprehensive view of how naturally-occurring school-level changes impacted student MVPA over a one-year period. In doing so, it has strengthened the current literature through its methodological design, as well as identified key areas that should be examined in the future. Although the results from this thesis are mixed, increased access to fitness centres and fields at lunch, and providing multiple opportunities to be active emerged as school changes that resulted in increased student MVPA. While similar changes occurred in other schools

and did not yield the same effect, these changes seem to be low risk from both a financial and feasibility perspective, and should be encouraged. Furthermore, it became apparent that the school is a complex setting that may benefit from broadening the scope to incorporate multiple levels of the ecological framework to understand how they interact with school changes. Nonetheless, these findings provide school administrators with empirical evidence that can be used to inform their decisions when trying to increase the PA of their students.

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## Appendix 1: Detailed methods of the COMPASS study

### *The COMPASS framework*

The COMPASS framework is characterized by a cyclical process between schools and researchers that facilitates evaluation and knowledge exchange. The COMPASS research team collects and analyzes student and school data on annual basis. As a part of the knowledge translation and exchange, school health profiles are developed, and are designed specifically for each school. These profiles provide schools with feedback about their current initiatives, and the status of their students in regards to obesity, marijuana use, physical activity, alcohol use, smoking, sedentary behaviour, and bullying. Also included in the school health profile are comparisons to national benchmarks, which allows for problem areas to be identified. In addition to the school health profile, COMPASS provides knowledge broker services to actively work with schools in the development and implementation of strategies targeting identified problem areas. As the cycle repeats, these newly implemented strategies are then evaluated to determine their effectiveness. This cyclic process allows for a balance between research and practice, and provides the unique opportunity to examine various school-led changes targeting multiple health behaviours simultaneously over time. In doing so, COMPASS presents the opportunity to determine which school-based interventions are most effective for facilitating and reducing health behaviours, and increasing overall student health.

### *Study design*

COMPASS is an ongoing prospective cohort study (2012-2016) that collects annual data from grade 9-12 students, administrators, the school physical environment, and the surrounding

built environment. Year one of the COMPASS study (2012/2013) began with 43 schools in Ontario and 24,173 students. In year two (2013/2014) COMPASS expanded in Ontario as well as to Alberta, where data was collected from 89 schools (79 Ontario, 10 Alberta), and 45, 298 students. In year 3, data was collected from 87 schools (78 Ontario, 9 Alberta) and 42 355 students. Year 4 of COMPASS data collection is currently being wrapped up, once complete it will allow for tracking of the original COMPASS grade 9 students over the course of four years. The current thesis used longitudinal data collected from year 2 (2013/2014) and year 3 (2013/2014) in the COMPASS study to examine how naturally occurring school PA related changes impact student MVPA over time. These years were selected because they represented the most recent data available for this thesis with the maximum amount of participating schools and students.

***School board and school recruitment***

In order for a school board to be included in the COMPASS study they needed to be English speaking and permit the use of active information passive consent parental permission protocol. In order for a school to be included in the study they needed to have at least 100 students in each grade from grades 9-12 (90 students for each grade in Alberta); and permit the use of active information passive consent parental permission protocols. The recruitment process occurred in two phases to reach the target goal of 90 schools. In the initial phase, the participation rate at the board level was 17 out of 40 (43%), and the participation rate at the school level was 49 out of 111 (44%) in Ontario (Thompson-Haile & Leatherdale, 2013). The second phase included re-contacting school boards who initially declined in year 1 ($Y_1$), as well as expanding to include school boards from Alberta (Bredin, Thompson-Haile, & Leatherdale,

2015). In $Y_2$ the participation rate at the board level was 5 out of 12 (42%). At the school level, the participation rate was 36 out of 100 (36%). In total, this equated to 79 Ontario schools (43 from year 1, 36 from $Y_2$) enrolled for COMPASS in $Y_2$ (Bredin et al., 2015). In Alberta, the participation rate at the board level was 21 out of 38 (55%). At the school level, the participation rate was 10 out of 31 (32%) (Wagner et al., 2015).

The most common reasons for refusal in $Y_1$ included competing research, consent protocol, schools/school boards were too busy, and ongoing labour issues (Thompson-Haile & Leatherdale, 2013). The most common reasons for refusal in $Y_2$ were competing research and schools were too busy (Bredin et al., 2015; Wagner et al., 2015).

Overall, $Y_2$ COMPASS data was collected from 89 schools. In $Y_3$ data was collected from 87 schools. Due to two schools dropping out, and one being added, linkable data was available for 86 schools from $Y_2$ to $Y_3$.

***Student recruitment***

Parents or guardians whose child attended a COMPASS school were mailed an information letter about the COMPASS study and were asked to contact the regional COMPASS coordinator by phone or email if they wished to have their child withdrawn (Leatherdale et al., 2014a). All students were included if their parents or guardians did not contact the recruitment coordinator. This process is known as active information passive consent permission protocol, and was chosen for its capability to reduce school-level variance estimates; increase participation rates to obtain a representative sample of the entire student population in a school; reduce the

risk for obtaining a biased sample; obtain accurate information regarding substance use; and ensure student confidentiality (Thompson-Haile, Bredin, & Leatherdale, 2013).

In $Y_2$, a total of 45, 298 out of 57,229 eligible students (79.15%) students who were enrolled in the 89 secondary schools participated on the scheduled data collection date. In $Y_3$, 42,355 out of the eligible 53, 846 eligible students (78.66%) enrolled in the 87 secondary schools participated on the scheduled data collection. Missing respondents due to parental refusal accounted for 1.2%, and 0.78%, of the eligible sample in $Y_2$, and $Y_3$, respectively. The remainder of missing respondents were due to absenteeism/classroom spares during the data collection or student refusal

To explore longitudinal changes among respondents, a self-generated code was created from the following five questions: (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 first letter of the month in which you were born, (3) The last letter of your full first name, (4) The second letter of your last name, and (5) The number of older brothers you have (alive and deceased) that were placed on the front of the COMPASS Student Questionnaire. Answers from these questions were combined to create personalized student identifiers that allowed for tracking of student data over time (Qian et al., 2015). Using this procedure, linkable student-level data from $Y_2$ and $Y_3$ resulted in a longitudinal sample of 19,854 students from 86 schools that participated in both $Y_2$ and $Y_3$ surveys. The linked sample accounts for 35.2% of eligible $Y_2$ (n=56,356), and 37.1% of eligible $Y_3$ respondents (n=53,426). As expected, the 10,233 grade 12 students in $Y_2$ that graduated were not in school in $Y_3$, and the 11,070 grade 9 students that were newly admitted to participating schools in $Y_3$ were not linked and were thus excluded. Other

primary reasons for non-linkage of included students transferring schools, students on spare or absents on the time of the $Y_2$ or $Y_3$ data collection in their school, early school leavers, or inaccurate data provided in the data linkage measures on the student questionnaire.

All school boards, schools, and students enrolled in COMPASS were allowed to withdraw from the study at any point during the consent process and data collection period. All procedures within this research have received ethical approval from the University of Waterloo Office of Research Ethics, the University of Alberta Research Ethics Board, and the appropriate school board committees (Leatherdale et al., 2014).

***Procedures***

In each data collection year, a COMPASS research coordinator contacts school administrators to schedule a date for data collection. On this date, students are administered the COMPASS Student questionnaire (Cq), administrators are given the School Programs and Policies questionnaire (SPP), and an assessment of the school physical environment is conducted. The Cq collects individual student data regarding obesity, sedentary behaviours, physical activity, alcohol and marijuana use, bullying, academic outcomes, amount of sleep, and demographic characteristics (Leatherdale et al., 2014a) (The SPP is a shorter, modified version of the previously validated Healthy School Planner tool (Healthy School Planner, 2016) and measures the presence of school policies, resources, and programs; and changes to school policies, resources, and programs that are related to student health in each of the COMPASS behavioural domains (Leatherdale et al., 2014).

The school physical environment is assessed using the Compass School Environment Application (Co-SEA). Co-SEA is a software application that can be downloaded onto a variety

of mobile devices with built in camera technology (Leatherdale, Bredin, & Blashill, 2014b). It uses a previously validated automated computer-based version of the within-school audit questions for measuring the PA environment (Jones et al., 2010); Co-SEA has the ability to take pictures of items measures in the audit and automatically archives the pictures to the corresponding audit measures for future reference (Leatherdale et al., 2014b). Co-SEA was piloted in COMPASS schools to identify and address any programming bugs or limitations that may occur with its use in the field. These technical programs were updated, and Co-SEA was retested until it had reached a degree of quality deemed acceptable by the COMPASS staff (Leatherdale et al., 2014b).

Student responses from the Cq are tracked over time through the use of self-generated codes (Leatherdale et al., 2014). After each year data from the Cq is used to create COMPASS School Health Profiles. These school health profiles are school specific and provide administrators with information about the health status of their students, comparisons to provincial and national guidelines, and multiple strategies to improve student health (Church & Leatherdale, 2013). Knowledge brokers then work with administrators to develop and implement school level changes to enhance the health of their students in the desired COMPASS domain(s). Each year data from the SPP is saved and provided to administrators in the following year, which allows for the accurate assessment of whether school level changes have taken place over the one-year period.

***Exposure variables***

*Subjective school-level changes.* Changes to physical activity policies were assessed via one question from the SPP. Administrators were given a dichotomous yes or no question: “Have

any changes been made since last school year?" Administrators who checked "yes" were then prompted to provide details on: a) whether past policies are still in place and b) whether new policies are planned or being implemented. Changes to recreational programming, public health resources, and the subjective physical activity environment/equipment were each assessed by one question on the SPP: "Have any changes been made since last school year?" Administrators who checked "yes" were then prompted to provide more details about the change.

*Objective School-level changes.* Quantity and condition of the physical activity environment were measured using Co-SEA. Changes to the school physical environment was determined from the Co-SEA application in relation to the quantity and condition of PA facilities. Quantity was assessed via school audits in which a COMPASS staff member records the quantity of each facility according to a pre-generated checklist. These facilities were (1) gymnasiums or large rooms for PA, (2) fitness/weight rooms, (3) squash courts, (4) swimming pools, (5) dance studios, (6) ice rinks, (7) other minor facilities, (8) fields, (9) running tracks, (10) baseball diamonds, (11) tennis courts, (12) basketball courts, (13) rowing facilities, (14) beach volleyball courts, (15) bike racks, and (16) other minor facilities. Quantity of facilities in year 2 was subtracted from quantity of facilities in year 3 to determine what kind of change (positive or negative) occurred.

Condition of facilities was assessed via school audits. A COMPASS staff member recorded the condition of each PA facility according to a 3 item scale "poor," "adequate," and "good;" these were coded as 1, 2, and 3 respectively. Condition scores of each facility in $Y_2$ was subtracted from the condition scores of each facility in $Y_3$ in order to determine if change

occurred. To reduce measurement error in this process, the same COMPASS staff member is required to conduct the same audits for the same school in each year.

### *Outcome variable*

*Change in student self-reported MVPA*. The main outcome was change to student self-reported MVPA from 2013 to 2014. Self-reported MVPA was measured by two questions on the COMPASS student questionnaire. Students were required to report their vigorous physical activity with the following statement: "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." Secondly, students were required to report their moderate physical activity with the following statement: "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." These items have demonstrated moderate test-retest reliability (ICC= 0.75; and slight criterion validity for MVPA (ICC=0.25) against accelerometers (Leatherdale et al., 2014c), which is comparable to other self-reported measures used with adolescents (Booth et al., 2001; Booth et al., 2002; Brener et al., 2002; Kowalski et al., 1997; Mota et al., 2002; Singh et al., 2011).

### *Covariates*

*Student-level covariates.* Sex, age, ethnicity, weekly spending money, physical education enrolment, and typical physical activity were measured via single items on the COMPASS student questionnaire. Students were required to report their age in response to one question: "How old are you today?" and were provided with six response options ranging from "13 years

or younger" to "18 years or older." Sex was assessed with a dichotomous question: "Are you female or male?" with two response options for "male" and "female." Ethnicity was assessed with one question: "How would you describe yourself?" with six response options available (1) "White," (2) "Black," (3) "Asian," (4) "Aboriginal (First Nations, Metis, Inuit)," (5) "Latin America/Hispanic," and (6) "Other." Due to frequency distributions ethnicity was collapsed into two groups ("White," and "non-White"). Weekly spending money was assessed with the question: "About how much money do you usually get each week to spend on yourself or to save?" There were eight response options ranging from "zero" to "$100+", and "I do not know how much money I get each week." Participants who reported "I do not know" or who had missing data were collapsed into one group. For physical education enrolment, students were asked one question: "Are you taking a physical education class at school this year?" Three response options were available: (1) "Yes, I am taking one this term;" (2) "Yes, I will be taking one or have taken one this school year, but not this term;" and (3) "No, I am not taking a physical education class at school this year." Students who reported a different status between $Y_2$ and $Y_3$ formed one group, and students who reported the same status for each year formed the referent group. Typical physical activity was assessed with one question: "Were the last 7 days a typical week in terms of the amount of physical activity that you usually do?" There were 3 response options; (1) "Yes," (2) "No, I was more active in the last 7 days;" and (3) "No, I was less active in the last 7 days." Students who reported a different response between $Y_2$ and $Y_3$ formed one group, and students whose response was the same in each year formed the referent group.

*School – level covariates*. Previous research has identified school size, school area level SES, and school location to have a statistical relationship with the quantity and type of programs offered (Cameron et al., 2007; Hobin et al., 2013; Hobin et al., 2012). School size was

determined using complete student enrolment reported from each school and entered into the model as a continuous variable. School area level socioeconomic status was constructed using the median household income that corresponded to each school's postal code. Median household income was obtained from 2011 National Household Survey data. School location was determined via school postal code and Statistics Canada (2015) classifications were used to classify schools as "rural" (population less than 1,000 or population density less than 400 per square kilometer), "small urban" (populations between 1,000 to 29,000 and a population density of at least 400 per square kilometer), "medium urban" (populations between 30,000 to 99,999 and a population density of at least 400 per square kilometer), and "large urban" (populations from 100,000 and greater and a population density of at least 400 per square kilometer). Based on frequency distributions, "rural" and "small urban" were collapsed to form one group, and "medium urban" and "large urban" were collapsed to form another group.