A Multilevel Examination of Factors of the School Environment associated with Time Spent in Physical Activity among a sample of Secondary Students in Ontario, Canada

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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ABSTRACT

Background: The high prevalence of children and adolescents not meeting the recommended 60 minutes of physical activity (PA) per day and the associated negative health consequences make it critical to increase PA. Ecological models suggest that the school environment may influence student health behaviour. However, few studies have examined the school environment in relation to student PA. **Purpose:** To examine between-school variability in students' time spent in PA, and identify factors of the school built environment that account for the between-school variability in students' time spent in PA overall as well as by gender and school location, while also considering school physical education (PE) and PA programming and controlling for student-level characteristics and potential environment-level confounders. **Methods:** This thesis consisted of a secondary data analysis of the School Health Action, Planning and Evaluation System (SHAPES) Ontario project, which included self-report data from administrators and 25,416 students in 76 secondary schools across Ontario. The student- and school-level survey data were supplemented with GIS-derived measures of the built environment within 1-km buffers of the 76 schools. Multilevel modeling was used to examine between-school variability in students' time spent in PA, as well as environment-level factors associated with PA. **Results:** There was significant between-school variability in students' time spent in PA overall as well as by gender and school location, respectively. Schools having another room for PA and schools offering daily PE were positively associated with students' PA. Schools located in areas with higher land-use mix diversity and walkability were negatively associated with students' PA. Results of the gender-specific multilevel analyses indicated schools should consider providing another room for PA, especially for offering flexibility activities directed at female students. Schools should also consider offering daily PE to male students in senior grades. Students attending schools in urban and suburban areas that provided another room for PA or were located within close proximity to a shopping mall or fast food outlet spent more time in PA. **Conclusions:** These findings support the ecological notion that the school environment can influence student PA behaviour. A better understanding of the relationship between the school environment and PA will assist in the development of effective school-based policies, programs and interventions to increase PA.

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INTRODUCTION

1.0 Rationale

Physical activity (PA) is a leading health indicator (US Department of Health and Human Services, 2010). There is irrefutable evidence of the effectiveness of regular PA in the primary and secondary prevention of obesity, certain cancers (i.e., breast, colon), depression, osteoporosis, and premature death (Warburton et al., 2006; WHO, 2002). It has been estimated that $5.3 billion, or about 2.6% of health care costs in Canada in 2001 were attributable to inadequate PA. In effect, experts propose even a modest 10% increase in the prevalence of the population being physically active would result in significant health care savings and improved health of Canadians (Katzmarzyk et al, 2004).

Inadequate PA is a dominant public health concern in Canada and one of the most prevalent risk factors for chronic disease in children and adolescents (Alamian and Paradis, 2009). Among children and adolescents, regular PA has health benefits in both the short and long-term. In the short-term, regular PA promotes low adiposity and weight maintenance, and contributes to musculoskeletal health, several components of cardiovascular health (i.e. cardiovascular fitness, flexibility, strength, bone density), and lowering blood pressure in mildly hypertensive adolescents (Malina, 2001; Kimm et al., 2005; Strong et al., 2005; Janssen and LeBlanc, 2010; Jimenez-Pavon et al., 2010). These attributes enable the performance of various personal, school, and other activities associated with healthy functioning in society (Malina and Bouchard, 1991; Baranowski, 1981). Being physically active during childhood and adolescence has also been shown to influence positive self-esteem and body image, fewer bouts of depression, greater self-efficacy, improved academic and cognitive performance, and greater perceived well-being (Veugelers and Fitzgerald, 2005; Keays and Allison, 1995; Larun et al., 2006; Ekeland et al., 2004). In the longer-term, a lifestyle of regular PA protects against obesity and contributes to a reduced risk of several chronic diseases (e.g., diabetes, cardiovascular disease) and premature death, and an overall improvement of quality of life (President's Council on Fitness and Sport, 1999; Bouchard et al., 1994; Herman et al., 2009).

The majority of children and adolescents in industrialized nations do not accumulate adequate amounts of PA for optimal growth and development (Roberts et al., 2004). In a 41-country study, the percentage of 15 year olds who self-reported meeting the international recommendation of 60 minutes of moderate to vigorous PA (MVPA) per day ranged from 8% to 37% (Currie et al., 2008). Specific to Canada, a recent report using direct measures of MVPA among a representative sample of Canadian youth aged 6-19 years showed almost 7% accumulate the Canadian recommended dose of 60 minutes of MVPA on at least 6 days per week (Colley et al., 2011), and the percentages decline with age with the lowest levels occurring in late adolescence (Colley et al., 2011). This is consistent with other findings showing that children engage in progressively less PA as they age (Troiano et al., 2008; Nader et al., 2008). Thus adolescents are often described as being at risk of developing physically inactive lifestyles (Poulsen and Ziviani, 2004).

While very low percentages of youth are sufficiently active for optimal health benefits, it is well established that males are more active than females regardless of age. Internationally, the percentage of 15 year olds who self-reported accumulating 60 minutes of MVPA per day ranged from 11% to 46% among males and 5% to 29% among females (Currie et al., 2008). In Canada, results of direct measures of MVPA indicate 9% of boys and only 4% of girls between the ages of 6-19 years accumulate the recommended 60 minutes of MVPA on at least 6 days per week (Figure 1, Appendix A; Colley et al., 2011). Moreover, the data also demonstrate that PA declines with increasing age as less than 6% of males and 2% of females aged 15 to 19 years meet the 60 minute MVPA criterion (Figure 1; Colley et al., 2011).

In addition to the gender disparities in PA, differences in PA have also been shown by geographic location. Previous studies which included both children and adults suggest that rural residents are not as physically active as their urban counterparts (Parks et al., 2003; Patterson et al., 2004; Reis et al., 2004; Martin et al., 2005). Recent studies also have identified that geographic variations exist in the obesity of Canadians, with rural populations of children and adolescents having higher proportions of overweight and obesity compared to more urban populations (Bruner et al., 2008; Ismailov and Leatherdale, 2010). Lower PA levels among rural children and adolescents may be a contributing factor in the observed prevalence of obesity in rural areas. As low levels of PA become the norm rather than the exception among children and adolescents in Canada, interventions on a large-scale basis must be introduced so that larger improvements in population health can be achieved; however, a better understanding of influences on youth PA behaviours is required to inform the development of population-level strategies and interventions.

Ecological models provide a framework for understanding environmental influences on PA behaviour. These models are premised upon the nesting of individuals within multiple levels of environments (i.e., organizational, community, and public policy) (Sallis and Owen, 2002). These different levels of environment are believed to largely control or set limits on the individual behaviours that occur within it (Sallis and Owen, 2002). Specific to PA, for example, ecological models explain the human-environment relationship in terms of individuals nested within microenvironments (e.g., homes, schools, workplaces) which are embedded within and influenced by the broader macroenvironments (e.g., neighbourhood amenities, health regions, government) (Transportation Research Board Institute of Medicine, 2005; Swinburn et al., 1999). Instead of relying solely on personal responsibility for change, ecological models emphasize the added importance of the environment for influencing behaviours.

The increased popularity of an ecological orientation stems from the recognition that many current population-level public health challenges (e.g., encouraging regular PA) are too complex to be understood adequately from an individual-level of influence. Instead, it is believed such complex health issues arise as a result of the dynamic interaction of individuals and their environment (Kreuter, 2004; McLeroy et al., 1988). Studying interactions between individuals and their environment in which PA behaviours occur allows for a more complete understanding of the behaviours being examined (Bronfenbrenner, 1977, 1979). A surge in the use of ecological approaches in the study of environmental influences on health behaviours and conditions is also due to the relatively new statistical procedures available and applied in the social sciences such as multilevel modeling. Multilevel methods accommodate for the clustering of observations of individuals within groups and allow for the appropriate analysis of environment-level influences on individuals (Diez-Roux, 2000).

Experts agree advancement in addressing PA among children and adolescents will require the coordinated and collective efforts of many different stakeholder groups working in multiple sectors and settings (Public Health Agency of Canada, 2010). The school has been identified as one key arena for large-scale PA initiatives among adolescents as they access a large population of youth across board socioeconomic strata (Public Health Agency of Canada, 2010; Pate et al., 2006). Moreover, school settings provide safe and convenient programs and facilities that promote PA (Birnbaum et al., 2005; Johnston et al., 2007). Numerous school-based interventions have been implemented to increase student PA levels; however, recent reviews of such programs reported most interventions focused on individual-level factors (e.g., increasing knowledge) and documented few substantial and sustainable effects (Dobbins et al., 2009; van Sluijs et al., 2007).

Consistent with the tenets of ecological theory, the importance of adopting environmental approaches in school-based PA promotion efforts is now recognized (Lee, 2009; Veugelers and Schwartz, 2010; Naylor and McKay, 2009). Environmental approaches for increasing PA involve moving beyond practices that rely on traditional curriculum-based classroom models to a more holistic approach that reinforces PA at many levels in many ways (Lee, 2009; Veugelers and Schwartz, 2010; Naylor and McKay, 2009). Past studies have identified offering school PA programming and physical education (PE) class to positively associate with student PA (Veugelers and Fitzgerald, 2005; Barnett et al., 2009; Sullivan, 2002; Myers et al., 1996). More recently, facets of the built environment on school grounds and within school neighbourhoods have come under scrutiny as an important potential contributor to environmental approaches for improving student PA (Ferreira et al., 2007; Cooper et al., 2010; van Sluijs et al., 2008; Tester, 2009); however, research examining the relationship between student PA and the school built environment is scarce. Consequently, PA experts are increasing calls for such studies, especially research examining moderators of built environment-PA associations and reporting environmental correlates of PA for population subgroups of youth (e.g., female) in environments outside residential neighbourhoods such as schools and places of work (Ding et al., 2011; Boone-Henione et al., 2010). With the known health benefits of PA and the exceptionally low levels of PA among adolescents it is essential that school environments are designed to facilitate active lifestyles for students as much as possible. Identifying factors of the school built environment that influence student PA can inform health professionals, policy-makers, and planners about how to design or modify school environments to facilitate PA.

1.1 Objectives

With the overall goal of creating healthy school environments for PA promotion among students, this research aims to extend previous studies by determining whether the features of the built environment on school grounds and within the school neighbourhood contribute to students' time spent in PA overall, as well as examine if the associations between factors of the school environment and student PA vary by gender or school location. Three studies were completed. Each is described in turn.

1.1.1 Study #1

This study is the first of a series of studies that investigated the association between features of the built environment on school grounds and within the school neighbourhood and students' time spent in PA. The primary purpose of Study #1 was to better establish the potential associations between the school built environment and students' time spent in PA, in order to guide subsequent examinations of the built environment-student PA relationship and inform school-based interventions for promoting student PA.

Objective #1: To determine the proportion of between-school variability in students' time spent in PA across the 76 secondary schools in the SHAPES-Ontario study.

Objective #2: To determine if school built environment factors located on school grounds and within the school neighbourhood are associated with students' time spent in PA when also considering school physical education (PE) and PA programming initiatives, and while also controlling for student-level differences and potential environment-level confounders.

1.1.2 Study #2

Study #2 examined gender differences in the association between features of the built environment on school grounds and within the school neighbourhood and students' time spent in PA.

Objective #1: To determine the proportion of between-school variability in students' time spent in PA across the 76 secondary schools in the SHAPES-Ontario study by gender.

Objective #2: To determine if there are gender differences in the association between students' time spent in PA and school built environment factors located on school grounds and within the school neighbourhood when also considering school PE and PA programming initiatives, and while also controlling for student-level differences and potential environment-level confounders.

1.1.3 Study #3

The final study investigated school location differences in the association between students' time spent in PA and factors of the school built environment.

Objective #1: To determine the proportion of between-school variability in students' time spent in PA across the 76 secondary schools in the SHAPES-Ontario study by geographic location (i.e., urban, suburban, rural).

Objective #2: To determine if there are school location differences in the association between students' time spent in PA and school built environment factors located on school grounds and within the school neighbourhood when also considering school PE and PA programming initiatives, and while also controlling for student-level differences and potential environment-level confounders.

1.2 Organization of Thesis

The first chapter of this thesis presents three frameworks consistent with ecological models which have been applied to school settings and student PA. Chapter 1 also includes a review of school-based multilevel studies examining associations between student PA and environment-level factors, designed to highlight the findings and limitations within the current literature. Chapter 2 provides a comprehensive description of the study methodology. Chapters 3, 4, and 5 are based on manuscripts that have been submitted for publication in scholarly, peer-reviewed journals. Chapter 3 summarizes Study #1, a multilevel examination of factors of the school environment and time spent in PA among a sample of secondary school students in grades 9 to 12 in Ontario, Canada. Chapter 4 describes Study #2, gender differences in the associations between features of the school environment and time spent in PA among a sample of grades 9 to 12 students in Ontario, Canada, and Chapter 5 describes Study #3, school location differences in the school environment factors associated with time spent in PA among secondary school students in grades 9 to 12 in Ontario, Canada. Chapter 6 provides a general discussion and interpretation of the overall study results, limitations, and implications for policy, practice and research.

The content of Chapter 3 has been submitted for publication to the *International Journal of Public Health*, with authors and title as follows:

Hobin, E., Leatherdale, S., Manske, S., Dubin, J., Elliott, S., Veugelers, P. A multilevel examination of factors of the school environment and time spent in moderate to vigorous physical activity among a sample of secondary school students in grades 9 to 12 in Ontario, Canada.

The content of Chapter 4 has been submitted for publication to the *BMC Public Heath*, with authors and title as follows:

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The content of Chapter 5 has been submitted for publication in the *Journal of Urban Health*, with authors and title as follows:

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CHAPTER 1: BACKGROUND

1.1 Theoretical Frameworks

1.1.1 Ecological Models

An ecological model can provide a framework for studying school environments and student PA behaviours. The basic premise of an ecological perspective is the interrelations between individuals and their environment, particularly the physical or built environment (Stokols, 1992). As they have evolved, ecological frameworks are distinguished by their focus on intra-individual (person) and extra-individual (environment) influences and how these proximal and more distal influences can interact, act interdependently (Kelly, 1990), or exert direct effects on behaviour (Sallis and Owen, 1997). Several ecological models have been proposed for health generally (Bronfenbrenner, 1977; Kelly, 1990; Stokols, 1992) and PA or PA–related health outcomes (e.g., obesity) more specifically (Spence and Lee, 2003; Welk, 1999; Kremers et al., 2006). Each of these models uses different typologies, but all posit the nesting of individuals within multiple environments, illustrate the hierarchical nesting of proximate within more extensive environments (e.g., schools within neighbourhoods), and include both the social and built environments. The five levels of environmental influences often cited include intrapersonal factors, interpersonal processes and primary groups, organizational factors, community factors, and public policy (McLeroy et al., 1988; Figure 2, Appendix B).

In addition, ecological models commonly describe “behaviour settings” as regions of the built environment that are associated with recurring patterns of organized social activities (Barker, R, 1968; Wicker, 1979). An implicit premise in the ecological approach is that determinants of behaviour are hypothesized to be context specific and to vary according to the behaviour settings in which they occur (Dishman and Sallis, 1994; Ommundsen et al., 2006; Giles-Corti et al., 2005). In other words, the relationships between environmental factors and PA are likely to vary according to characteristics of the setting. Identifying access to settings and the opportunities offered by different settings (e.g., schools) for promoting health among target populations is of paramount importance. Consequently, setting-specific ecological models for PA behaviours are becoming more commonly applied in guiding analytical research, developing intervention strategies, and communicating health promotion programs to communities (Giles-Corti et al., 2005).

1.1.2 An Ecological Approach to School Health Promotion

The tenets of an ecological approach have been specifically applied to school-based health promotion (Allensworth and Kolbe, 1987; Parsons et la., 1996; Lister-Sharp et al., 1999; Miller, 2003). Unlike traditional school health promotion strategies focused only on individual-level factors, ecological approaches to school-based health promotion recognize the need to change students' health behaviours by complementing interventions directed at individual students with efforts to create supportive school environments. Building on principles outlined in the Ottawa Charter of Health (WHO, 1986), creating supportive school environments extends school health promotion approaches beyond classroom instruction to include factors within the whole school. This broader perspective includes multiple components within schools' social networks, organizational norms and policies, the built environment, curriculum, resources, and facilities. It is intended to promote a more holistic health promotion approach that encompasses all aspects of school life and recognizes how individual factors and multiple influences within the school environment shape student behaviours (Lister-Sharp et al., 1999; Miller, 2003; Joint Consortium for School Health, 2010).

Several regional and national governments in Europe, Australia, and North America have adopted ecological approaches to school health promotion. Many variations in terminology exist when referring to ecological approaches to school health promotion (e.g., health promoting schools, coordinated school health) with most Canadian governments adopting the terminology of Comprehensive School Health (Joint

Consortium of School Health, 2010). In December 2006, the Ontario Ministries of Education and of Health Promotion released the Foundations for a Healthy School (Ontario Ministry of Education, 2009). Consistent with ecological approaches to school health promotion and similar to Canada's Comprehensive School Health framework, Ontario's framework includes four elements designed to modify multiple components of the broader school environment: 1) High quality instruction and programs; 2) Healthy built environment; 3) Supportive social environment; and, 4) Community partnerships (Ontario Ministry of Education, 2009). Quality instruction and programs provide students with curricular (e.g., health and PE classes) and non-curricular (e.g., interschool and intramural sports programs) opportunities to learn, practice, and demonstrate knowledge and skills related to living a healthy life. A healthy built environment improves the availability of, access to, and adequacy in meeting students' needs for indoor and outdoor facilities, equipment, and resources for safe, quality PA on or near school grounds, both during and outside schools hours. Fostering a supportive social environment encompasses both formal (e.g., school policies, rules, clubs, or support groups) or informal (e.g., unstructured peer interaction or free play) school factors that have a positive impact on student learning. Community partnerships provide access to resources and services available to support staff, students, and families in the development and implementation of healthy school initiatives.

The evidence base for school-based ecological approaches has grown over the years. Evaluations of varying degrees of rigour have been conducted to investigate interventions guided by these school-based ecological models for improving student PA behaviours (Miller, 2003; Stewart-Brown, 2006). A review of 14 studies examining the results of school-based ecological approaches in PA promotion found most interventions targeted students in upper elementary school grades and focused changes on the content, frequency, and format of school PE classes (Stone et la., 1998). In addition to changing school PE classes, some interventions have also modified one or more elements of the schools' environment by improving the playground equipment (e.g., painted markings in playground) available at recess (built environment), providing supervision for PA (social environment), and sending PA information home to parents (community) (Sallis et al., 2003; Pate et al., 2005; Veugelers and Fitzgerald, 2005). Although there is no conclusive evidence that a school-based ecological approach in its entirety is more effective than other approaches to health promotion in schools, small but positive effects were observed among sustained, multifactorial approaches that involve modifications to more than one domain in the school's environment (Veugelers and Fitzgerald, 2005; Mukoma and Flisher, 2004; Bargh and Chartrand, 1999).

While ecological oriented frameworks such as Ontario's Foundations for a Health School framework are useful in guiding examinations of environmental influences on PA behaviours more broadly, these conceptual frameworks lack theory articulating the specific mechanisms linking environments and PA behaviour. Like other ecological-based models, additional theories are often integrated with school-based ecological approaches in order to provide specific constructs and variables as well as to delineate the pathways linking environmental and individual factors influencing PA behaviours (Smedley and Syme, 2000).

1.1.3 Environmental Research Framework for Weight Gain Prevention

There are few evidence-based models for theorizing and testing the mechanisms underpinning the association between environmental exposures and individual PA (Ball et al., 2006). The Environmental Research Framework for Weight Gain Prevention (EnRG) is a relatively new framework designed to guide investigations examining the mechanisms underlying the environment-behaviour relationship (see Figure 3, Appendix C; Kremers et al., 2006). According to Kremers and colleagues (2006, 2010), the EnRG framework was developed with the specific intention of informing hierarchical models of intervention research in the domains of diet and PA by providing hypothesized pathways linking environmental and individual influences.

Based on a dual-process model, the EnRG framework conceives information processing as happening simultaneously along a continuum (Moskowitz et al., 1999). On one end of the continuum, individuals are thought to consciously invest time and effort in systematically building beliefs and decisions to guide their health behavioural choices. The opposite end of the continuum suggests behaviour is the result of direct 'automatic' responses to environmental cues (Bargh and Chartrand, 1999). PA behaviour, therefore, is thought to be an action that can be influenced by unidirectional environmental determinism whereby PA is spontaneously performed as a result of direct environmental influences.

Within the EnRG framework, the Analysis Grid for Environments Linked to Obesity (ANGELO) framework is used to disentangle the numerous potential environmental factors influencing PA and eating behaviours. The ANGELO framework is a 2 x 4 grid which dissects the environment into size by type (Swinburn et al., 1999). In brief, it distinguishes two sizes of environments: micro-environment settings and macro-environment sectors. Individuals interact with multiple micro-environmental settings, including schools, workplaces, homes, and neighbourhoods. In turn, these micro-environmental settings are influenced by the broader macro-environments and include, for example, education and health care systems, governments, and the food industry. Macro-environments are less amenable to the control of individuals than micro-environments. Within these settings and sectors there are four types of environments. The four types of environments are the built, economic, political, and socio-cultural. These environments relate to what is available, what are the costs, what are the rules, and what are the attitudes and beliefs within the local environment. Elements which influence food intake and PA then become subcategories within these cells.

The EnRG framework further posits that factors may mediate or moderate the behaviour-environment relationship (Kremers et al., 2006, 2010). On the indirect path between the environment and behaviour, behaviour-specific cognitions taken from the Theory of Planned Behaviour (i.e., attitudes, behavioural intentions, subjective norms, and perceived behaviour control) are thought to play a mediating role (Ajzen, 1998). For example, measuring an individual's intentions to participate in more PA may help explain all or part of the relationship between access to PA-related facilities and their level of PA participation. Conversely, the direct path between the environment and behaviour is unmediated by individual cognitive factors. Individuals are believed to vary their PA behaviours in direct response to available, changing resources in their environment; thus, access to PA-related facilities would act as an environmental cue prompting individuals to participate in higher levels of PA.

Finally, the EnRG framework suggests that the environment-behaviour relationship might vary according to target group characteristics (Kremers et al., 2006). Person-related characteristics of specific groups and other behaviour-related factors are theorized to potentially moderate both the indirect and direct relationship between the environment and behaviour. The six types of moderating factors specifically proposed are: demographic (e.g., gender, SES), personality (e.g., extraversion), awareness (e.g., awareness of own PA levels), involvement (e.g., level of participation in the behaviour), habit strength (e.g., routine behaviour), and engagement in clustered behaviours (e.g., co-occurrence of smoking and being physically inactive) (Kremers et al., 2006).

1.1.3 Application of the EnRG Framework in Understanding the Associations between Student PA and School Environment Factors

This research will draw on selected constructs of the EnRG framework as well as Ontario's Foundations for a Healthy School to examine the associations between factors of the school environment and student PA (Kremers et al., 2006, 2010; Ontario Ministry of Education, 2009). The EnRG framework suggests environmental factors can influence PA indirectly and directly (Kremers et al., 2006, 2010). The direct or unmediated route between environmental factors and PA behaviour is a unidirectional pathway representing the PA responses of students that are automatically set in motion by environmental stimuli within the school environment without conscious choice or guidance. Inspired by the EnRG framework, this study will exclusively focus on the direct link between the school-environment and student PA. Figure 4 (Appendix D) was developed to illustrate the relationship between student PA and the school environment being examined in this research.

To provide a structured overview of the school environment factors believed to potentially associate with student PA, the ANGELO framework will be replaced in the EnRG model with Ontario's Foundations for a Healthy School framework (see Figure 4, Appendix D). Although specific to school environments, Ontario's Foundations for a Healthy School framework is similar to the ANGELO framework in that it was developed to conceptualize environments, to identify potential environmental influences, and to guide environmental intervention strategies for health promotion. Integrating the Foundations for a Healthy School framework into the EnRG model will ensure important school-based environmental factors that emerge from the literature will be considered and that the evidence will be conceptualized in a way that is consistent with educational approaches to school health promotion.

The EnRG framework also identifies the importance of moderators or interaction variables in studying environment-behaviour processes (Kremers et al., 2006, 2010). Due to the established disparities in PA by gender and school-location among youth, these factors are potentially important moderators of the environment-PA behaviour relationship. The potential moderating effect of gender and school location on the direct relationship between student PA and factors of the school environment is illustrated in Figure 4 (Appendix D). Examining possible interaction effects between school environment factors and gender and school location may guide research investigating the pathways linking specific environmental factors with PA behaviours in distinct populations and inform the design of interventions intended to increase PA and reduce disparities in PA among sub-groups of the population (e.g., females, urban populations).

Based on the conceptualization depicted in Figure 4 (Appendix D), the relationship between school environmental factors and student PA can be translated into a regression model. In the regression model, student's time spent in PA is the dependent variable and various school environment factors are the independent variables, all of which are potentially moderated by gender and school location.

1.2 Review of Literature

To gain insight into the role of the built environment and other environment-level influences on student PA behaviours, a literature review was completed. The purpose of this review was to summarize the literature surrounding built environment factors and other environment-level factors associated with student PA, specifically for adolescents; and, to review the known school-related environment-level influences on student PA.

1.2.1 Review Methods

Only studies employing multilevel modeling, sometimes referred to as hierarchical modeling, were included due to the clear multilevel structure (i.e., students nested within schools) of the data of interest. Multilevel methods accommodate for the clustering of observations of students within schools and allow for the appropriate analysis of environment-level influences on students. Studies also had to be school-based meaning that participants were recruited according to the school attended, and features of the school environment (vs. residential environment) had to be considered in the analysis. Studies using features of the school environment as a proxy measure for the participants' residential environment were also included in the review; however, if students were recruited from schools yet the study uses the students' residential address as the point of reference and exclusively considers features of the students' residential environments, it was excluded in this review.

Any PA outcome measure expressed in terms of duration (e.g., in minutes), frequency (e.g., times per week), intensity (e.g., vigorous), or a combination of these terms in volume (e.g., METS (metabolic equivalents) of kcal (kilocalories)) were primarily considered. Since engaging regularly in more than one type of PA behaviour is necessary for adolescents to achieve and maintain an optimum level of PA recommended for health, studies including an outcome measure that is moderately correlated with PA (e.g., active commute to school, participation in leisure-time sports) were also examined. Sedentary behaviour was not considered as an outcome because PA and sedentary behavior are distinct behaviours with different correlates and determinants (Van Der Horst et al., 2007).

Adolescents were defined as being between the ages of 13 and 19 years. Thus, studies assessing youth with an average age of participants not between 13 and 19 years were excluded. Studies of younger youth were excluded because younger youth have been shown to have distinct PA behaviours from adolescents characterized by shorter more sporadic bursts of PA (Bailey t al., 1995). Moreover, younger youth attend elementary or middle schools (vs. secondary schools) which often have different schedules, schoolyard facilities, and school policies prohibiting students from leaving school grounds unsupervised during school breaks and before or after school. Studies could be experimental or observational. Articles published before January 2000 and after December 2010, not written in English, and not conducted using samples drawn in developed countries were excluded.

A list of school-based multilevel studies examining the association between student PA and school- and neighbourhood-level factors were compiled by searching the public health and education electronic databases from the National Library of Medicine (Pubmed), Education Resources Information Center (ERIC), and Scopus for English review and original research articles. The following terms were searched alone or in combination: *adolescents, youth, girls, boys, students, school (MeSH), environment and public health (MeSH), built environment, physical environment, environment design (MeSH), urban form, geographic information systems, physical education and training (MeSH), physical activity, physical fitness, exercise, commute, walking, running, cycling, sports, recreation, leisure activities, vigorous activity, moderate activity, physically active lifestyle, obesity, overweight, multilevel analysis, multilevel model, hierarchical regression, and hierarchical model.* The search strategy was developed in Pubmed and refined as appropriate in each of the other two databases.

From the list of titles and abstracts generated by the literature search, almost 200 papers were reviewed, of which thirteen met the criteria above (i.e., school-based multilevel studies examining the environment-level influences on student PA). Of the thirteen studies included in this review, seven studies investigated the association between student PA and environment-level influences within school buildings and campuses. Three additional school-based multilevel studies examined environment-level factors within the neighbourhood surrounding schools and student PA. Finally, three studies included in this review investigated the association between environment-level factors on both school grounds and within the neighbourhood surrounding schools and student PA.

An appraisal of the papers was completed using a modification of the criteria developed by the Public Health Research, Education, and Development group (PHRED) for the Effective Public Health Practice Project and best practices reviews (Public Health Research, Education, and Development group, 2003; Cameron et al., 2001). Although observational study designs would normally be classified as weak according to the PHRED guidelines, observational studies were the only available school-based studies employing multilevel methods to examine environment-level influences associated with student PA. Therefore, to allow the appraisal to discriminate within the selected studies, effectiveness was rated (weak to strong) using sample size, representativeness, and response rate as criteria. Other strength of evidence assessment criteria considered were selection bias, confounders, data collection methods, intervention integrity, and analyses, as per PHRED guidelines. Finally, plausibility (the likeliness to be true) was evaluated based on formative evaluations/pilot testing and the theoretical foundation for the study. Overall, based on strength of evidence and plausibility, studies were identified as weak, moderate, or strong.

1.2.2 School-based Multilevel Studies examining associations between Student Physical Activity and School Predictors

Seven studies attempted to identify environment-level factors within school buildings and on school grounds that associate with student PA (Table 1, Appendix E). The first study was conducted in Canada using data from the 2005/06 Health Behaviour in School-aged Children (HBSC) Survey (Nichol et al., 2009). Data from 154 schools and 7,638 grade 6 to 10 students were obtained through validated self-administered surveys to school administrators and students. Results of the multilevel logistic analysis indicated the proportion in the two PA outcomes (i.e., students' participation in ≥2h/week or <2h/week of school class-time in MVPA and free-time MVPA) varied significantly between schools ($p<0.001$). Using only the data from 3,242 students in grades 9 and10, Nichol and colleagues (2009) investigated the individual and cumulative effects of schools policies, varsity and intramural athletics, presence and condition of fields, and condition of gymnasiums on students' class-time and free-time MVPA while adjusting for family affluence, school population size, and school safety. Findings indicate none of the single environment-level characteristics was significantly associated with either class-time or free-time MVPA among students in grades 9 and 10; however, the cumulative effect of PA facilities, PA opportunities, and policies was significantly associated with both PA outcomes. In particular, this environmental index was most strongly related to class-time MVPA of boys ($p=0.004$), as boys' participation in class-time PA was 53% higher in secondary schools with five to six PA features (N=42, 28.9% of schools) than in schools with none or one feature (N=4, 2.8% of schools). Conversely, the effect of a greater number of school PA features was most strongly related to girls' free-time PA at school ($p=0.049$); girls attending schools with five to six PA features were 62% more likely to be physically active than girls at schools with zero or one feature.

The next study used baseline data from a Norwegian nationwide project aimed at developing a PA promotion intervention (Haug et al., 2010). Data from 130 schools and 16,471 students in grades four through 10 were obtained through validated self-administered surveys to school administrators and students. Using only the data from the students in grades 8 - 10 attending 31 secondary schools (grades 8 – 10) and 37 combined schools (grades 1- 10), Haug and colleagues (2010) investigated the availability of a variety of PA facilities at schools and the associations with students' participation in MVPA during the 1hr daily school recess and lunch break. The environment-level factors considered included 11 features assumed to be relevant for PA in a Nordic school setting. Since a hall for gymnastics or a sports hall was available in all schools, and a swimming hall was not considered relevant for school break, these items were excluded from analyses leaving eight school PA facilities. A PA facility index was also computed and standardized to compare schools with the maximum number of PA-related facilities (n=8) available at the schools with the lowest number of PA-related facilities available (n=0). In separate analyses for males and females, bivariate multilevel logistic regressions were calculated for PA against each of the PA facilities and the PA facility index. Higher odds for recess and lunch break MVPA were observed for boys with a soccer field (OR=1.68, 95%CI:1.15-2.45, $p<0.05$), playground equipment (OR=1.66, 95%CI:1.16-2.37, $p<0.05$), sledding hill (OR=1.70, 95%CI:1.23-2.35, $p<0.05$) and an area for hopscotch/skipping available (OR=2.53, 95%CI:1.55-4.13, $p<0.05$), compared with those without each of these facilities. Access to a sledding hill also had a direct influence on recess and lunch break MVPA among girls (OR=1.58, 95%CI: 1.11-2.24, $p<0.05$). The strongest relationship was seen between student PA and the PA facility index; both male and female students attending schools with eight PA facilities available had higher odds of being active during recess and lunch break (males= OR: 2.69, 95%CI: 1.21- 5.98, $p<0.05$; females= OR: 2.90, 95%CI: 1.32- 6.37, $p<0.05$) compared with students attending schools with no facilities.

Using data from the US's National Longitudinal Study of Adolescent Health, the third study examined whether racial and income disparities in student PA were associated with the schools that students attend (Richmond et al., 2006). Self-reported PA data were collected from a nationally representative sample of adolescents (n=17,007) enrolled in grades 7 through 12 (16.1±1.7 years). The environment-level factors that were considered included the percentage of white students attending the school and school-level median household income. Student-level factors included in the model were ethnicity, family SES, father present in the home, student smoking status, body mass index (BMI), and age. Stratified by gender, results from the fully adjusted linear regression model indicate school-level median household income of the student population to be predictive of PA participation among both males ($\beta=0.30$, $p<0.001$) and females (β=0.36, $p<0.001$), suggesting that students attending schools located in higher SES neighbourhoods participate in greater amounts of PA than students attending schools located in lower SES neighbourhoods. Among males, results of the full model also indicated the racial composition of the school (β=0.21, $p<0.05$) to be predictive of PA participation; black and Hispanic adolescent males were less active than white students when attending schools that were less racially diverse but were more active than white students when attending the same schools as their white counterparts.

A fourth study investigated the between-school variation in active commuting to school rather than PA (Robertson-Wilson et al., 2007). Using the SHAPES-Ontario data, the sample consisted of 21,345 students in grades 9 - 12 from 76 schools in Ontario, Canada. Environment-level factors considered included school type, school location, and season in which data were collected. Several explanatory factors were considered at the student-level including gender, grade, body mass index (BMI), PA levels, smoking behaviour, sedentary behaviour, perceived athletic ability, perceived weight status, and parental encouragement and support. Active commuting to school varied significantly across schools (X^2 =2001.41, $p<0.001$), ranging from 12% to 77% of the student population. Results of the two-level hierarchical logistic regression model indicate the students attending separate schools (OR= 0.51, 95%CI: 0.33, 0.79, $p<0.01$) located in rural settings (OR=0.54, 95%CI: 0.33, 0.89, $p<0.05$) were significantly less likely to actively commute to school compared to students attending public schools located in urban settings. Given the significant association between school location and students actively commuting to school, separate models were also run to examine active commuting among students attending rural compared to urban schools. Results indicated students attending rural schools were less likely to actively commute to school if they were in grade 12 compared to grade 9 whereas students attending urban schools were less likely to actively commute to school if they were female versus male.

The fifth study examining environment-level predictors associated with student PA was focused on the role of self-efficacy in explaining gender differences in PA among adolescents (Spence et al., 2010). A web-based tool was used to survey a regionally diverse sample of 2,222 boys and 2,557 girls in grades 7 - 10 (age=13.6 years ±1.2) attending 117 schools. The Physical Activity Questionnaire for Children was used to assess students' overall PA over the previous 7-day period (Kowalski et al., 1997). The only explanatory variables included in the model were measured at the student-level and included age, grade level, gender, BMI, and self-efficacy. The multilevel linear regression results of the intercept only model for PA indicated 8% of the variance in PA was at the environment-level. In the analysis to determine whether gender moderated the self-efficacy-PA relationship, the interaction between gender and self-efficacy significantly predicted PA (β=0.04, $p<0.05$); the self-efficacy-PA relationship was significantly stronger for female students compared with male students. Whereas, in the mediation analysis it was shown that self-efficacy partially mediated on the gender-PA association (β=-0.07, $p<0.0001$) such that males had significantly higher self-efficacy compared with females which resulted in significantly more PA.

The sixth study assessed the differences in the correlates of student PA between students attending urban and rural schools in Canada (Loucaides et al., 2007). The sample consisted of 1,398 students from 4 urban schools and 1,290 students from 4 rural schools. Although no environment-level variables were examined beyond school location, hierarchical regression analyses were used to examine the association between a validated self-reported measure of total PA and a number of demographic, psychological, behavioural, and social correlates (Godin and Shepherd, 1985; Sallis et al., 1993). Significant between school variation in student PA was identified for both urban and rural schools, and the variance explained in PA ranged from 43% for urban schools and 38% for rural schools. Among urban schools, student PA was significantly associated with gender (β=-0.99, $p<0.001$), perceptions of PA ability (β= 0.75, $p<0.05$), perceptions of health (β= 0.62, $p<0.05$), self-efficacy (β=0.170, $p<0.001$), interest in organized groups activities (β=0.274,

$p<0.001$), concern about gaining weight ($\beta=-0.055$, $p<0.05$), traveling to school ($\beta=0.101$, $p<0.001$), use of recreational time for PA ($\beta=0.145$, $p<0.001$), friends' PA ($\beta=0.085$, $p<0.01$), and families' PA ($\beta=0.082$, $p<0.01$). In the rural school analyses, student PA was significantly associated with gender ($\beta=-0.067$, $p<0.05$), perceptions of PA ability ($\beta=0.209$, $p<0.001$), interest in organized group activities ($\beta=0.091$, $p<0.01$), interest in individual small-group activities ($\beta=0.068$, $p<0.05$), taking PE class ($\beta=0.154$, $p<0.001$), use of recreational time for PA ($\beta=.111$, $p<0.001$), hours per day doing part-time work ($\beta=0.066$, $p<0.05$) and homework ($\beta=0.054$, $p<0.05$), friends' PA ($\beta=0.121$, $p<0.001$), and families' PA ($\beta=0.096$, $p<0.001$).

The final study is the doctoral dissertation project conducted by Wong (University of Waterloo, 2007). Examining the same data set as the one used for the current thesis, Wong's project was a secondary data analysis conducted on data collected from 51,222 students in grades 9 - 12 attending 76 secondary schools in Ontario, Canada through self-administered PA surveys as part of the SHAPES-Ontario project (University of Waterloo, 2007). Using aggregated student data and data collected from schools during study recruitment, the environment-level factors that were considered included school rates of student PE enrollment, intramural participation, student participation in other PA opportunities at school, student satisfaction with indoor and outdoor PA facilities, size of school population, school setting (e.g., rural), and school-level SES (i.e., average household income for census tract school is located). Student-level characteristics included were gender, grade, and module completed (tobacco vs. PA module). Using multilevel linear modeling, the null model estimated 1.9% of the variance in students' MVPA was attributable to between-school variation. Controlling for age, gender, and school demographics, results of the final model indicate the school rate of student PE participation (PE was defined in analysis as PE non-participation rate, $\beta=-10.92$, $p<0.01$) and school-level SES ($\beta=-0.06$, $p<0.05$) had a direct association with student MVPA. Moreover, there was also a significant interaction between PE participation rate and gender

(β= 5.29, p=0.009), such that the association between PE participation rate and PA was stronger for males than females.

1.2.3 School-based Multilevel Studies examining associations between Student Physical Activity and School Neighbourhood Predictors

Three school-based multilevel studies examined associations between student PA and neighbourhood features in school environments (Table 2, Appendix F). Each of these studies assumed students live within close proximity to the school they attend and used the neighbourhood surrounding the school as a proxy measure for students' residential neighbourhoods. The first study investigated the association between student PA outside of school hours (≥4h/week vs. <4h/week), the safety of neighbourhoods, and the availability of parks and PA facilities within the neighbourhood surrounding schools (Nichol et al., 2010). As part of the 2005/06 HSBC survey, PA data were collected from a nationally representative sample of 9,114 students in grades 6 - 10 attending 182 schools (i.e., elementary, middle, or secondary schools). Aggregated survey data were also used to create a measure of group perceptions of neighbourhood safety. To supplement survey data, GIS were used to obtain geospatial data within a 5-km circular buffer of each school to track the number of parks, trails, and recreation facilities (i.e., arenas, community centres, sports-plexes/stadiums, and swimming pools). A composite scale that considered the overall neighbourhood PA environment was also constructed by combining ranked scores for PA facilities, parks, and trails. Potential covariates considered at the student-level included gender, grade, family SES, perceived neighbourhood aesthetics, and individual students' perception of neighbourhood safety. Neighbourhood confounders under consideration were school-level SES and the geographic location of the school. When adjusted for group perceptions of neighbourhood safety and potential covariates, results indicated the availability of parks and recreational facilities in school neighbourhoods were not associated with PA among school-aged youth; however, higher levels of neighbourhood safety were significantly associated with more PA participation outside of school among all students, especially younger students (grades 6 and 7) and students attending schools located in urban areas.

In the study by Cradock and colleagues (2009), data were collected from 152 students (average age= 13.7 years) from 10 middle schools participating in a randomized controlled trial of a school-based curriculum intervention (Cradock et al., 2009). The curriculum lessons focused on reducing students' television viewing time and increasing MVPA. The purpose of the study was to examine associations between objective measures of the neighbourhood environment and students' total MVPA on weekends. In addition to a self-administered survey, objectively measured PA data were collected using accelerometers over a 4-day period. Neighbourhood characteristics (i.e., open space, housing density, density of employees in destinations for youth) located within 800 meter buffers of schools were mapped using GIS methods. The daily average temperature, total precipitation, and average daily traffic for the 4-day measurement period were also considered as neighbourhood factors. Student-level factors considered included gender, ethnicity, and intervention or control status. Students' age and weight status were included as continuous covariates. Adjusting for age, BMI, gender, ethnicity, precipitation, and temperature, the only neighbourhood factor found to be associated with weekend MVPA was greater densities of employees in neighbourhood destinations serving youth; students attending schools in neighbourhoods with more destinations of interest to youth accumulated an estimated 30 minutes more of MVPA per weekend day.

Deforche and colleagues (2010) investigated associations between students' perceptions of the neighbourhood environment and student PA (Deforche et al., 2010). More specifically, data were collected from 1,445 grade 12 students (17.4±0.6 yrs) attending 20 randomly selected Belgian secondary schools. Validated self-administered surveys were used to assess psychosocial and environmental factors as well as the two outcome variables, active transportation and leisure-time sports participation. Using the Flemish

Neighbourhood Environment Walkability Scale (NEWS), perceived neighbourhood environmental factors considered included land use mix diversity (e.g., specific amount of time to walk to 23 local facilities such as local shops, library, video store, public transport, school), access to six neighbourhood services within a 10-15 minute walk (e.g., local shops, public transport), 3 measures of street connectivity (e.g., amount of four-way intersections), availability of sidewalks (e.g., availability and quality of sidewalks), availability and quality of cycling infrastructure, 4 measures of neighbourhood aesthetics, safety from traffic and crime, access to 19 recreational facilities within 10-15 minute walk, satisfaction with neighbourhood services, and emotional satisfaction with the neighbourhood. Student-level factors considered in the analyses included gender, parental education, self-efficacy, and the social support and modelling of family and friends. Using the null model, analysis showed that 5.5% of the variance in active transportation and 1.1% of the variance in leisure-time sports was attributable to differences between schools. Adjusting for family SES and gender, results of the multilevel linear regression analysis indicated measures representing perceptions of higher land use mix diversity, higher street connectivity, more attractive environments, better access to recreational facilities, and higher emotional satisfaction with the neighbourhood as the environment-level factors to associate with active transportation among students. Self-efficacy was found to moderate of the relationship between active transportation and several neighbourhood environmental factors. Controlling for gender and parental education, perceived neighbourhood factors found to associate with leisure-time sports participation among students were higher perceived safety from traffic, and shorter distances between recreational facilities and students' homes.

1.2.4 School-based Multilevel Studies examining associations between Student Physical Activity and School and Neighbourhood Predictors

Three school-based multilevel studies investigated associations between student PA and both school- and neighbourhood environment factors (Table 3, Appendix G). Using data from the 2005/06 HBSC study, a cross-sectional study based on a nationally representative sample of Norwegian secondary schools (N=68) and 1,347 grade 8 students (13 years of age) explored the associations among students' MVPA during recess, students' interests in school PA, and the PA-related facilities in the school environment (Haug et al., 2008). Students' PA behaviours and interests in PA were assessed using self-administered student surveys. The PA facilities were assessed through school administrator surveys. Environment-level factors considered included the availability of a set of 16 PA facilities in the indoor school area, the schoolyard (within 200m), or in the school neighbourhood (200 to 2000m) as well as a continuous variable labelled the "PA facilities index" was created. Student-level factors included in the analysis were individual SES, interests in school PA, and gender. Using multilevel logistic regression, the null model indicates an intraclass correlation of 7.0%, suggesting some variation in the level of PA between schools. Results of the main effects multilevel logistic model shows that students attending schools with access to more PA facilities (OR=4.49, CI: 1.93-10.44, p<0.01) had considerably higher odds of being active during recess compared with students attending schools with access to fewer facilities. (OR=4.49, CI: 1.93-10.44, p<0.01). In addition, open fields (OR=4.31, CI: 1.65-11.28, *p*<.01), outdoor obstacle course (OR=1.78, CI: 1.32-2.4, p<0.01), playground equipment (OR=1.73, CI: 1.24-2.42, p<0.01), and having a room with cardio and weights (OR=1.58, CI: 1.18-2.1, p<0.01) were also associated with PA during recess when controlling for student-level factors. Lastly, students' interests in school PA were found to moderate the impact of PA facilities on participation in PA during recess. A strong positive regression weight for the interaction between the PA facilities index and students' interests in PA suggests that the association between these resources and PA was stronger for students with high interests in school PA.

Another study conducted by Haug and colleagues (2009) analyzed the same data from the HSBC study to explore the availability of policy practices and facilities to support PA in Norwegian secondary schools and students' participation in PA during recess. Similar to their previous study described above, the first environment-level factor considered was a PA facilities index including the PA facilities in the indoor school area, the schoolyard (within 200m), or in the school neighbourhood (200 to 2000m). To supplement the PA facility data, school administrators also completed a survey to provide school policy information on the schools' involvement in a PA project, if the school had a written PA policy, if the school provides PE five times per week, and if organized PA in non-curricular school time (i.e., intramurals) is provided three to five days per week. These policy variables were used to create a policy index. Student-level factors included in the analysis were individual SES, interests in school PA, and gender. Using hierarchical blockwise modelling, results of the multilevel logistic regression models indicate students' interests in school PA (block 1; β= 2.29, $p<0.001$), the built environment index (block 2; β= 1.24, $p<0.001$), and the policy index (block 3; β= 0.62, $p<0.001$) were significantly associated with students' participation in MVPA during recess time when controlling for gender and SES. Two-way interactions between policies and students interests (p=.22), and policies and the environmental index (p=.42) did not achieve significance. This study extends the authors' previous work described above by demonstrating that policies help explain the variance in student MVPA during recess time at school, and neither students' interests in school PA nor the availability of PA facilities moderates the effect of policies.

Analyzing data from 610 students attending four rural secondary schools in Alberta, Canada, Fein and colleagues (2004) examined the association of perceived availability of built environmental resources, and the perceived importance of these resources, with self-reported student PA (Fein et al., 2004). The environmental factors considered were the availability of space and equipment for PA in the home, neighbourhood, and school as well as the perceived importance of each of these environments. Student-level factors considered in the model included self-efficacy, gender, grade, relationship with PE teacher, and peer and family PA participation. Adjusting for student-level factors, results of the hierarchical regression revealed that environmental variables explained 4% of the variance in student PA but the only environmental variable tested to significantly associate with student PA was the perceived importance of the school environment ($\beta=.14$, $p<0.01$). Separate post-hoc hierarchical regressions conducted on groups with high and low perceived importance of the school environment revealed that gender ($\beta=-0.24$, $p<0.05$) moderated the relationship between perceived importance of the school environment and PA; the built environments of schools are especially important for male students.

1.2.5 Summary of Multilevel Studies examining associations between Student Physical Activity and Factors of the School and Neighbourhood Environment

National and international health guidelines increasingly recognize the impact of the school environment on student PA (Committee on Environmental Health for the American Academy of Pediatrics, 2009; Heart and Stroke Foundation of Canada, 2007; Public Health Agency of Canada, 2010). Evidence from the thirteen school-based multilevel studies in this review suggests environment-level factors can have a modest impact on student PA, typically accounting for between 1.1% and 8.0% of variance. This supports the use of ecological approaches for improving school-based PA intervention. Although the influence of the school environment on student PA may appear trivial, it may still be important as even small shifts in student PA at the school or environment-level could result in a substantial population level impact when applied across a large number of schools (Rose, 1992; Leatherdale and Papadakis, 2010).

In spite of the moderate to strong designs across the studies included in this review, the environment-level factors found to significantly associate with student PA were quite variable. Due to the limited number of studies, it remains unclear if the observed differences in the environment-level factors influencing student PA were due to differences in methodology (self-report PA survey vs. accelerometers) outcomes (MVPA vs. MVPA during school recess vs. MVPA during school free-time vs. MVPA during school class-time vs. active transport vs. leisure-time sports vs MVPA on weekends vs out of school MVPA), setting (schools vs.

neighbourhoods surrounding schools vs. both schools and the neighbourhood surrounding schools), definitions of environmental measures (e.g., land-use mix diversity vs. density of employees in destinations of interest to youth, availability of PA facilities vs. accessibility of PA facilities) sample population (age, single grade vs. multiple grades), sample size (e.g., number of schools, number of students), school level (elementary vs. secondary vs. middle vs. combination) or country (Canada vs. USA vs. Norway vs. Belgium). Moreover, due to a lack of information provided in the studies, it is unclear if the studies in this review are adequately powered at both the school- and student-levels to detect significant differences in variance across schools. For example, the study by Cradock and colleagues (2009) had students from only 10 schools participating and the study by Fein and colleagues (2004) had students from only 4 schools participating, both of which are much less than the minimum number of higher level units (i.e., 30 units) recommended in multilevel analysis (Bell et al., 2008). In future it would be desirable to have sufficient sized samples of schools and students recruited to ensure the study is powered to detect variance between schools. Future research should also consider a common definition of the PA outcome and explanatory variables. Lastly, researchers should also consider the range of possible environmental factors that may influence PA behaviour. Some environmental factors known to relate to adult PA, such as street connectivity and season of data collection, have had very little consideration in research examining student PA and could be potentially significant influences on student PA.

An important finding emerging from the thirteen studies is that both individual and environmental factors can be influential in shaping students’ PA behaviours. School environment factors that emerged from the literature review have been organized by the four components of Ontario’s Foundations for a Healthy School framework (Table 4, Appendix H). Even when controlling for various individual student characteristics, six studies found the provision of school PE and school PA programming, and the availability of PA facilities within the school environment to influence student PA suggesting that application of these environmental features may have far-reaching benefits across the student population (University of Waterloo, 2007; Nichol et al., 2009; Haug et al., 2008, 2009, 2010; Deforche et al., 2010). In fact, results of four studies demonstrate that attending a school with a greater number of school PA facilities available influences students to be more active (Nichol et al., 2009; Haug et al., 2008, 2009, 2010). According to the EnRG framework, providing these PA resources within the school environment may function as a direct cue for students to be physically active irrespective of cognitive mediation factors (e.g., self-efficacy) (Kremers et al., 2006, 2010). In other words, the presence of PA facilities and programming in the school environment acts as a signal that can potentially prompt students exposed to the school PA resources to participate in PA. These results are consistent with the premise that a supportive school environment can be an important contributor to student PA behaviours.

In spite of relatively strong designs, results of the three studies investigating neighbourhood factors within the area surrounding schools reveal few associations with student PA in at least two of the studies (Nichol et al, 2010; Cradock et al., 2009). Two plausible explanations for the lack of association between neighbourhood factors and student PA are the definitions of neighbourhood and the scale of the buffers employed. All three studies used the area surrounding the school as a proxy for the students' residential neighbourhoods. It is possible that students do not live within close proximity to the schools they attend, especially in rural settings, and thus neighbourhood characteristics may have been ascribed to students who in fact do not reside within this area. In addition, two of the three studies constructed buffers surrounding schools to capture factors of the built environment believed to associate with student PA (Nichol et al., 2010; Cradock et al., 2009). However, since no standard method exists for assessing neighbourhood environments in PA research, it is unclear what buffer distance around schools would be appropriate for modeling student PA. One of the studies applied a 5-km circular buffer around the school when measuring the availability of PA-related facilities (Nichol et al., 2010). Five kilometers seems like a far distance to expect students to travel to access neighbourhood PA resources. Indeed, recent studies used Global Positioning Systems (GPS) and accelerometers to assess the location of student PA and found the majority of student PA occurs within 1-km of the school (Maddison et al., 2010; Trilk et al., 2011). As such, the lack of association between student PA and neighbourhood PA resources in these studies may have been the result of poor methodological decisions and should be interpreted with caution.

In addition to the direct influence of individual and environmental factors on student PA, results from the studies in this review also detect interactions between variables. Results of six studies detected significant interactions between gender and various environment-level factors suggesting school environments can influence male and female adolescents differently (University of Waterloo, 2007; Nichol et al., 2009; Richmond et al., 2006; Spence et al., 2010; Fein et al., 2004). For example, Fein and colleagues (2004) found the built environment of schools is especially important for male students while Wong found the school rate of PE enrollment is particularly important for male students. Of the six studies detecting interactions between gender and environment-level factors, three studies conducted gender-specific multilevel models to further examine this relationship and indeed found some features of the school environment to influence male PA but not female PA (Nichol et al., 2009; Haug et al., 2010; Richmond et al., 2006). For example, across the three studies male students' PA was found to associate with the availability of four or more varsity sports, access to playing fields, soccer fields, sledding hills, areas for hopscotch/skipping rope, and playground equipment, as well as the cumulative effects of PA resources. Although the cumulative effects of school PA resources were also associated with female students' PA in two studies (Nichol et al., 2009; Haug et al., 2010), the single school PA resources significantly associated with female students' PA were fewer compared to males. The study conducted by Nichol and colleagues (2009) found the PA of Canadian female students in grades 9 and 10 to associate with schools providing four or more varsity sports and a gymnasium in good or poor condition; whereas, Haug and colleagues (2010) reported the PA of

Norwegian female students' in grades 8 to 10 to associate with schools providing sledding hills. More consistent associations between school PA resources and male student PA could reflect a bias favouring male PA interests and preferences. Thus, although school PA programming and PA facilities are available to all students, current school PA environments may be more attractive to male students and insufficient to engage female students in PA. Recognizing gender differences in student PA and identifying school PA resources associated with student PA separately for male and female students may improve our understanding of the factors associated with PA and allow for the development of more effective gender-focused PA promotion strategies in schools.

In this review, school-based multilevel studies considering student PA across schools located in neighbourhoods in urban, suburban, and rural areas were limited and the results mixed (Loucaides et al., 2007; Fein et al., 2004). Moreover, the influence of school environment factors on student PA by school location was not explored. The paucity of evidence makes it difficult to declare the influence of school location on student PA, to discern the distribution of PA-related programming and facilities across schools located in different neighbourhoods, and to understand if school location indeed moderates the relationship between student PA and factors of the school environment. Investigating differences in the environment-PA relationship across schools located in varying neighbourhoods may have implications for targeting modifications and addressing existing disparities in student PA.

Overall, what is apparent from the review findings is that while the volume of literature exploring environment-level factors associated with student PA is expanding, the field offers important opportunities for further study. In particular, this review of literature reveals the general lack of school-based multilevel studies examining the association between student PA and features of the built environment of secondary schools and the neighbourhood surrounding these schools. Furthermore, few of the available studies investigating associations between student PA and the school environment have been conducted in Canada, which may be important as the characteristics of secondary students and schools likely vary between countries due to differences in qualities such as cultural norms (e.g., students interest in soccer in European countries) and structure of the school system (e.g. semester system often used in Canada and the US). Finally, findings purport that the contribution of the school built environment to student PA may differ by gender and school location but more research is needed to substantiate these relationships as well as explore the environment-level mechanisms reinforcing these variations. A better understanding of the relationship between factors of the school environment and student PA will assist in improving the development, tailoring, and targeting of effective school-based policies, programs, and interventions to increase PA.

CHAPTER 2: STUDY METHODOLOGY AND SAMPLE

2.1 Study Design

The current research project describes three multilevel cross-sectional studies based on the secondary data analysis of a sample of student- and environment-level data collected using the School Health Action, Planning and Evaluation System (SHAPES) student PA questionnaire and the School Capacity Survey as part of the SHAPES Ontario (SHAPES-ON) project (2005/2006). To supplement the school survey data, measures of the built environment within 1-km circular buffers of the schools in 2005/2006 have been calculated using geographic information systems (GIS) for each of the 76 participating schools. The GIS data was linked with the school and student survey data to provide a more comprehensive representation of the schools' built environment. The GIS data were included at the environment-level (level-2) instead of creating an additional level (level-3) because the size of school clusters within each 1-km buffer (i.e., one to two schools) is insufficient to create enough variability to warrant a third level in the analysis.

2.2 Data Sources

2.2.1 The School Health Action, Planning and Evaluation System

The School Health Action, Planning and Evaluation System (SHAPES) is an information technology platform and data collection system designed to provide practitioners with local data and feedback to support population health intervention planning, evaluation, and field research related to youth (Cameron et al., 2006; Leatherdale et al., 2009; Weiler et al., 2009). Each SHAPES module consists of: 1) a low-cost, machine-readable survey validated for students in grades 6 - 12; 2) a school administrator survey on school environment factors (i.e., policy, program, and resources) for PA and tobacco; and, 3) computer-generated, school-specific feedback reports of student- and school-level results (Cameron et al., 2006). There are currently four SHAPES modules: tobacco, PA, healthy eating, and mental fitness. The impetus for SHAPES stemmed from the mutual need of policy makers, practitioners and researchers to develop a system for economically collecting and using quality school-level data. These data could enable local health and education systems to plan, tailor, and evaluate local population health initiatives based on evidence. Since its inception in 2000, SHAPES-based projects have engaged all 10 provinces, and the surveys have been completed in more than 1500 schools by more than 350,000 students from across Canada.

2.2.2 The SHAPES-Ontario Project

The School Health Action, Planning and Evaluation System Ontario Project (SHAPES-ON) used SHAPES to collect data from Ontario secondary schools. The co-principal investigators were Dr. Steve Manske (Propel Centre for Population Health Impact formerly known as Centre for Behavioural Research and Evaluation at the University of Waterloo) and Dr. Scott Leatherdale (School of Public Health and Healthy Systems, University of Waterloo and formerly of Cancer Care Ontario).

Funding for SHAPES-ON was granted as part of the Smoke-Free Ontario Strategy through the Ontario Ministries of Health and Long-term Care and of Health Promotion. The primary purpose of SHAPES-ON was to collect data on tobacco-related behaviours, programs, and policies. However, the design was modified to enable the collection of PA data to increase potential value to stakeholders, including school boards and schools. The University of Waterloo collaborated with the Canadian Fitness and Lifestyles Research Institute (CLFRI) to use their School Capacity Survey as the administrator level PA questionnaire for SHAPES-ON. Since CLFRI was planning to collect data using the School Capacity Survey at the same time as data collection for SHAPES-ON, this collaboration enabled researchers to reduce the response burden on schools and school boards.

SHAPES PA Module Student Questionnaire

The SHAPES PA module student questionnaire consists of 45 multiple choice questions in a four-page machine-readable SHAPES booklet (Appendix I)(Leatherdale et al., 2009). The survey takes students approximately 15 to 20 minutes to complete. Two core PA items requested 7-day recall of vigorous PA and moderate PA, respectively. Vigorous PA was defined as "jogging, team sports, fast dancing, jump-rope, and any other physical activities that increase your heart rate and make you breathe hard and sweat." Moderate PA was defined as "lower intensity physical activities such as walking, biking to school, and recreational swimming." Responses are provided by indicating the number of hours (0-4 h) and 15-min increments (0-45 min) that each type of PA was performed for each day of the previous week. Thus, intensity, duration, and frequency data are collected. Additional items asked about participation in school PE and physical activities, sedentary activities, social influences, school environment, self-perceptions, height, weight, smoking behaviour and demographics.

The questionnaire has demonstrated satisfactory readability, comprehension, reliability and validity (Wong et al., 2006). Pilot testing with students in grades 6 and 7 indicated adequate readability and comprehension of the questionnaire. Further, the questionnaire demonstrated satisfactory one-week test-retest reliability with students in grades 9 - 12. The overall kappa/weighted kappa coefficient for the one-week test-retest reliability of the questionnaire items indicated moderate agreement (mean 0.57±0.24). The questionnaire also demonstrated satisfactory validity of the core PA, height and weight items with students in grades 6 - 12. Students wore an accelerometer for seven consecutive days to objectively measure PA, and then completed the questionnaire and had their height and weight measured. Prior to data collection, students were informed that their height and weight would be measured after completing the questionnaire. The correlation between self-reported and accelerometer-measured daily time spent performing MVPA were modest (Spearman $r = 0.44$) but significant ($p<0.01$). The strength of the correlation between MVPA assessed using the SHAPES PA module student questionnaire and an accelerometer are as robust as other youth 7-day PA recalls (Kowalski et al., 1997; Crocker et al., 1997).

Height and weight were not consistently over- or under-reported. Correlations between self-reported body mass index (BMI) and measured height and weight were high (Spearman r = 0.90) and significant ($p<0.001$). Classification of weight status by BMI was similar using self-reported values compared to measured values (Wong et al., 2006).

School Capacity Survey – School Questionnaire

The School Capacity Survey was developed by CFLRI in collaboration with Physical and Health Education (PHE) Canada (formerly known as the Canadian Association for Physical Health Education, Recreation and Dance (CAPHERD)). The instrument is administered to an administrator or school staff member to document individual schools' PA programs, policies and resources (Appendix J). Several items on the School Capacity Survey were based on the secondary school version of the School Health Index developed by the Centers for Disease Control and Prevention in the US. Implementation and use of the School Health Index has been evaluated in several scientific journals (Austin et al., 2006; Brener et al., 2006; Pearlman et al., 2005; Staten et al. 2005). Although the School Health Index was field tested for readability and user-friendliness (Centers for Disease Control and Prevention, 2008), researchers from CFLRI collaborated with PHE Canada representatives to further test the School Capacity Survey in the Canadian school context (C. Craig, personal communication, October 18, 2010). Validity and reliability testing has not been completed on the School Capacity Survey; however responses to items on the School Capacity Survey, collected as part of the SHAPES-ON project and being used for this study, that appeared unrealistic or inconsistent with other responses were followed up for clarification with respondents by telephone.

2.2.3 Geographic Information Systems

A geographic information system (GIS) is a tool that facilitates the development of dynamic maps within data integration and analysis techniques focused on public health issues such as environmental support for

PA (Porter et al., 2004). Using seed funds from an ancillary project grant of which the author is the principal investigator, a geographer from the School of Geography and Earth Sciences at McMaster University was hired to manipulate, analyze, and present spatially related data for each school environment using data for GIS.

Data for GIS measuring features of the built environment of the schools were provided by the CanMap RouteLogistics (CANMAP ROUTELOGISTICS) spatial information database as well as the Enhanced Points of Interest (EPOI) data resource from the Desktop Mapping Technologies Inc. (DMTI) (Desktop Mapping Technologies Inc, 2009). The existing CANMAP ROUTELOGISTICS databases provided by the DMTI maintains a current street address database as well as many other data layers (e.g., boundary files, street networks, and land-use information) from which the characteristics (e.g., type, location) of the built environment relevant to this study can be derived. The EPOI file is a national database of over 1.6 million Canadian business and recreational points of interest. Engineered to be compatible with CANMAP ROUTELOGISTICS, EPOI are assigned highly accurate latitude and longitude coordinates, represent a high level of completeness and have detailed standard industrial classification code assignments. Students and scientists conducting research with Dr. Susan Elliott, Dean of the Faculty of Applied Health Sciences, University of Waterloo, have been granted free access to these databases. The GIS measured features of the built environment used in this thesis were assessed by Dr. Theodora Pouliou, Research Associate at the UCL Institute of Child Health.

2.2.4 Canadian Census Tract Profiles

Canadian Census Tract Profiles is a Statistics Canada web-based interactive teaching and learning tool that the public can access through the Statistics Canada website (Statistics Canada, 2006). A census tract is a small area with a population of 2,500 to 8,000 located in census agglomerations with an urban core population of 50,000 or more in the previous census. By entering the postal code of the school, census tract information to be used as proxy measures for school-level SES (i.e., low income cut-off value (LICO, based on the 2006 Canadian Population Census) and residential density (i.e., total number of private dwellings, land area in square kilometers) was retrieved and displayed in a table.

2.3 Data Collection and Student Response Rate

School board and school recruitment for the SHAPES-ON study began in February 2005. All 22 school boards within seven select public health jurisdictions across Ontario were approached to participate, of which 19 (86% agreed). School boards (N=18) from seven of the public health units approved active information with passive consent procedures, whereas the school board (N=1) from one public health unit required active consent procedures. Due to the differences in consent procedures and their subsequent impact on participation rates and data collection, schools using active consent procedures were not included in this study.

A total of 118 schools from the 18 school boards approving passive consent were approached to participate, of which 76 (64%) agreed. Data were not available for schools that declined to participate, so it is unclear if or how schools that agreed to participate differed from schools that declined to participate. All participating secondary schools consisted of students in grades 9-12. All students in participating secondary schools were eligible to participate.

Data collection was conducted in partnership with public health staff over two waves; Wave 1 (April to May 2005 (6 schools)) and Wave 2 (September 2005 to May 2006 (70 schools)). All surveys were completed in class time and participants were not provided compensation. GIS data were collected in April 2010 retrospectively to correspond with the 2005/2006 data collection period of the SHAPES-ON study.

2.3.1 Environment-level Data

School Capacity Survey

Researchers from the University of Waterloo mailed school administrators a standardized package including the School Capacity Survey and active consent forms. Online completion of the school survey was also possible. If a school did not return a completed survey within four weeks, researchers emailed a standardized reminder to the school administrator. Within three months, school administrators from all 76 schools completed and returned the School Capacity Survey.

GIS Data

Spatial data from the DMTI-EPOI databases were obtained for all 76 secondary schools using the longitudinal and latitudinal points associated with the schools' street addresses. Consistent with previous research (Pouliou and Elliott, 2010; Leatherdale et al., 2011), the process of identifying and linking the built environment from the DMTI-EPOI databases to the SHAPES-ON survey data involved three steps: (1) geocoding the street address for each SHAPES-ON school; (2) creating 1-km circular buffers (i.e., bounded areas surrounding each school in which the different features of the built environment were quantified); and (3) linking the quantified built environment data for each school to the student- and environment-level data from each school. Arcview 3.3 (ESRI, 2002) software was used to geocode the school addresses and to create the 1-km buffers.

2.3.2 Student-Level Data

SHAPES PA Module Student Questionnaire

All students in a school were invited to participate in the SHAPES-ON study. Within each school, researchers randomly assigned classes to complete either the SHAPES Tobacco Module student questionnaire or the SHAPES PA Module student questionnaire. Students completed surveys during class time without compensation. Active information with passive consent for parents was used to reduce demands on schools and to increase student participation rates. The process involved researchers informing the parents of the students about the study via a mailed letter (Appendix K), and asking them to call a toll-free number (accessible 24 hours a day) if they refused their child's participation. Students who did not wish to participate in the survey on the day of the data collection did not complete a survey. Students received assurances that their data would be kept confidential. The University of Waterloo Office of Research Ethics and appropriate school board and public health ethics committees approved all procedures, including active information-passive consent.

On the data collection date, teachers administered the questionnaires according to detailed instructions during a designated class period. Completed questionnaires were placed in individual student envelopes to protect confidentiality, and then into a classroom envelope. A project staff member (or data collector from the public health unit) was present on the day of the survey to provide assistance and supplies, answer any questions, and to receive classroom envelopes at the end of the data collection period. Completed questionnaires were couriered to the Propel Centre for Population Health Impact (formerly known as Population Health Research) at the University of Waterloo for processing. The questionnaires were visually scanned, then read by a machine, and an electronic data file was generated. Measures taken to reduce non-sampling errors at the questionnaire processing stage included extensive training of project staff with respect to the survey procedures, procedures to ensure that data capture errors were minimized, and coding and edit quality checks to verify the processing logic. A detailed description of the quality control procedures is provided in Appendix L. Following electronic generation of the data file, feedback reports with survey results were sent to schools and school boards, and with permission, to their corresponding public health units. Feedback reports were provided to schools within six to eight weights of their data of data collection.

2.3.3 Student Response Rate

Of the 34,578 students invited to participate in the SHAPES PA module student questionnaire, a total of 25,416 students (73.0%) completed it. The distribution of students completing questionnaires was consistent with previous SHAPES data collections (Murnaghan et al., 2007; Leatherdale et al., 2005). Non-response at the student level can be attributed to several factors: parents/ guardians refusal to allow their child to take part in the survey, student refusal to participate, absenteeism on the day of the survey, not enrolled in a class that was administering the survey (e.g., spare/study period, co-operative education work placement outside the school, peer tutoring), or enrolled in a class that elected not to complete the survey (e.g., field trip, special needs students, other activities scheduled, etc.). In each of the three manuscripts included in this thesis, students were further removed from the sample due to missing data, biologically implausible values, or if the students reported not being in grades 9-12. As such, data from 22,117 students (64.0%) were used in Study #1 and data from 21,754 students (62.9%) were used in Study #2 and Study #3.

2.4 Measures

2.4.1 Response Variable

To be consistent with Canada's Physical Activity Guidelines for youth aged 12-17 years, this study defines student PA as an individual's average daily minutes spent performing MVPA (Tremblay et al., 2011). To calculate MVPA, each student's responses to the items "Mark how many minutes of moderate physical activity you did on each of the last 7-days" and "Mark how many minutes of hard physical activity you did on each of the last 7-days" were summed and divided by 7-days. Responses of students who reported four or more days of PA for both items were included in the analysis and students who reported less than four days of PA for either item were excluded. Going forward in this thesis, the response variable is referred to as a student's time spent in PA.

2.4.2 Explanatory Variables

Based on the literature review conducted, multiple explanatory variables were used to account for characteristics of students and school environments. The potential correlates of students' time spent in PA included in the analyses were divided into student- and environment-level factors. Using definitions from Ontario's Foundations for a Healthy School framework, the environment-level factors relate to a school's instruction and programs, social environment, and built environment. Potential environment-level confounders were also included in the analysis.

Student-level Explanatory Variables

Student-level explanatory variables were taken from the SHAPES PA module student questionnaire and included students' age, grade, gender, and height and weight. Gender was derived from the item "Are you male or female?" (male / female). Grade was derived from the item "What grade are you in?" (response options listed each grade from 5 to 12). Students' BMI was derived from previously validated self-reported height and weight items (see Appendix I, questions 12 and 13; Wong et al., 2006). Age and gender-adjusted BMI cut-points derived from the World Health Organization (WHO) growth charts were used to classify students' weight status (Onis et al., 2007). Students within the lowest 5th percentiles for BMI adjusted for age and sex were classified as underweight, students within the 6th to 84th percentile for BMI adjusted for age and sex were classified as normal weight, students within the 85th to 94th percentile for BMI adjusted for age and sex were classified as overweight, and students within the highest 5th percentiles for BMI adjusted for age and sex were classified as obese. Dummy variables were created to compare normal weight students (referent) to underweight, overweight, and obese.

To assess students' mode of transportation to school, students responded to the single item: "In the last 7-days, how did you usually get to and from school" with response options of "actively" (e.g., walk, bike), "mixed", or "inactively" (e.g., car, bus; referent).

Consistent with previous research (Hobin et al., 2010), enrollment in PE was measured by asking students, "In a typical PE class, how much time are you actually active?" The response options were: "Less than 15 minutes", "15 to 30 minutes", "31 to 45 minutes", "46 to 60 minutes", "More than 1 hour", and "I am not taking a physical education class". If a student responded "I am not taking a physical education class", they were considered to not be enrolled in PE. If a student responded to spending any amount of time being active in PE class, they were considered to be enrolled in PE. Students were also asked to report if they participated in school intramural activities or varsity sports teams (Yes/No (referent)). Generally, intramural activities are competitive and non-competitive activities that are open to anyone wishing to participate, and competition occurs within a school. Interschool sports, otherwise known as varsity sports, are those that compete with other schools and often require tryouts.

Finally, students were asked to report on their participation in activities for flexibility and strength. To assess their participation in flexibility-related activities, students responded to the single item: "In the last 7-days, how many days did you do exercises for flexibility, such as stretching or yoga" with response options from 0 to 7-days. Similarly, to assess their participation in strength-related activities, students responded to the single item: "In the last 7-days, how many days did you do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, yoga, or weight lifting" with response options from 0 to 7-days. Consistent with Canada's PA Guidelines for youth, responses for participation in activities for flexibility and strength were classified as “3 or more days per week” or “less than 3 days per week” (Tremblay et al., 2011; PHAC, 2002).

Additional student-level explanatory variables were not examined since accounting for student-level variability was not the focus of this thesis. In addition, little is known about which environment-level variables are associated with PA, much less the mechanisms by which these environment-level variables may be associated with PA. Including too many student-level variables in the model may result in controlling for a student-level variable that was the mechanism by which an environment-level variable influences PA (Aveyard et al., 2004).

Environment-level Explanatory Variables

Using definitions from Ontario’s Foundations for a Healthy School framework, three environment-level variables examined in this study were taken from the School Capacity Survey and relate to both the school’s instruction and programs as well as the school’s social environment. First, given international and national health experts recommend school PE be provided daily to students (WHO, 2007; Physical and Health Education Canada, 2010), and previous research indicates a positive relationship between secondary school student enrolment in PE and schools offering daily PE (Hobin et al., 2010), administrators were asked to report in a typical week, how many times does a typical junior student and a typical senior student in your school take part in a PE class. The responses for junior (grades 9 and 10) and senior (grades 11 and 12) secondary students were averaged. Schools that reported 5 days of PE classes per week (daily PE) were compared to schools that reported less than 5 days of PE classes per week (referent).

Two questions from the School Capacity Survey determined whether intramural and interschool activities were offered at each school. Offering intramural PA programs was measured by asking administrators, “Does your school offer intramural activities?” (Yes/No). Offering interschool PA or varsity sports programs was measured by asking administrators, “Does your school offer inter-school activities? (Yes/No). The number of intramural and varsity sports programs were not included as this information is not assessed on the School Capacity Survey.

Explanatory variables relating to the schools’ built environment were also examined in this study. Features of the schools’ built environment were measured on school grounds and within a 1-km circular buffer of each school. Fourteen questions from the School Capacity Survey determined the availability of 14 indoor and outdoor PA facilities on school grounds including a gymnasium, another room used for PA, dance studio, swimming pool, weight equipment, playing fields, baseball diamond, outdoor basketball hoops, running track, tennis court, area with playground equipment, paved area for active games such as hopscotch, bicycle racks, and skating rinks. The availability of school PA facilities was measured by asking administrators, “Does your school have access to any of the following for students on or off school grounds for use during school hours?” Response options included: “Yes, on grounds”, “Yes, off grounds”, “No”, and “Don’t know”. Those who reported having the PA facility on school grounds (Yes, on grounds) were compared to those who reported not having the PA facility on school grounds (Yes, off grounds; No; Don’t know (referent)). Since a gymnasium, playing fields, and weight equipment were reported to be available at all 76 secondary schools, these factors were excluded from the analysis. One further variable, area with playground equipment, was also excluded from analysis as this type of PA facility is not believed to be of interest to secondary students. Therefore, the availability of the remaining ten school PA facilities was considered. Following previous research, a school PA facilities index was also created representing the number of PA facilities available on school grounds on a continuum of 1 to 10 (Haug et al., 2008).

Objective measures of built environment variables believed to be destinations of interest to youth and located within a 1-km circular buffer of each school were recorded using GIS. These built environment variables included the density of recreation facilities (includes dance studios, fitness/gym facilities, sport and recreation clubs, and golf courses), parks, fast-food outlets, and shopping malls. Three measures of neighbourhood design features were also considered, land mix use, residential density, and street connectivity, independently as well as part of a walkability index (Frank et al., 2005). The walkability index was created to control for potential issues of multicollinearity between measures of land-use mix diversity, street connectivity, and residential density. That is, areas of higher residential density are often characterized by mixed land-uses and an interconnected street network (Frank et al., 2005). For comparison purposes, the analyses were conducted with the environmental variables separately as well as combined (using the walkability index). Brief operational definitions of each of the built environment measures are presented in Table 5 (Appendix M).

Potential Environment-level Effect Modifiers

Three potential environment-level confounding variables were considered in this thesis. The first potential environment-level confounding variable, school location (i.e., urban, suburban, rural) was created based on information collected from the schools during recruitment. For school location, urban and suburban were compared to rural schools (referent).

Next, schools were classified according to the season in which data were collected based on the data of data collection. As in other studies, common seasons (winter: December 21 – March 20, spring: March 21 – June 20, fall: September 21 – December 20) were used (Merriam et al., 1999; Robertson-Wilson et al., 2008). Data collected from schools in the winter (referent) were compared to data collected from schools in the spring and fall seasons.

Finally, using data from the 2006 Canadian Census Tract Profiles, the area-level SES measure for each school was based on the proportion of households in the census tract living below the Statistics Canada low-income cutoff (LICO). The LICO values identify those who are substantially worse off than the average population as it represents the proportion of households in the census tract that attribute 20% more than the average Canadian family to food, shelter, and clothing. There are different cutoffs according to the number of people in a household and whether the household is located in a rural are or a small or large urban area (Giles, 2004). These values are based on after-tax income for two reasons. First, income taxes and transfers are essentially two methods of income redistribution. The before-tax rates only partly reflect the entire redistributive impact of Canada's tax/transfer system because they include the effect of transfers but not the effect of income taxes. Second, since the purchase of necessities is made with after-tax dollars, it is logical to use people's after-tax income to draw conclusions about their overall economic well-being (Giles, 2004). The LICO function at the census tract level was available for postal codes of 56 schools (74%) of schools. School postal codes that did not have a LICOs value at the census tract level were taken from the census agglomeration.

2.5 Statistics

2.5.1 Descriptive Statistics

Descriptive statistics were calculated for the students included in the study overall and by gender, as well as for schools included in the study overall and by school location.

2.5.2 General Hierarchical Modeling Approach

Due to the hierarchical nature of the data (students nested within schools), a hierarchical linear regression modeling approach was used to evaluate the degree to which environment-level variables associate with students' time spent in PA while controlling for student-level variables and potential environment-level confounders. Consistent with previous research (Elliott et al., 1993; Loucaides et al., 2007), a three-step modeling procedure was used to examine student's time spent in PA in each of the three studies in the current thesis. Step 1 used an empty model to determine the variability in students' time spent in PA across the 76 schools. The empty model did not contain any student-level or environment-level explanatory variables. Empty models were examined overall, by gender, and by school location. The school- or environment-level variance term from the empty model (σ^2_{u0}) was used to calculate the intraclass correlation (ICC) for continuous outcomes $\frac{\sigma^2_{u0}}{\sigma^2_{u0}+\sigma^2_{e}}$, where the ICC represents the proportion of the total variance in student's time spent in PA that is due to differences across schools.

Step 2 included a series of univariate analyses examining if each of the environment–level variables were associated with students' time spent in PA. School PA facility and walkability index variables were also examined. To be reasonable but yet not too restrictive at the initial screening stage, explanatory variables that were not statistically significant (p>0.2) were removed from the analysis.

In step 3, multivariate models were developed following a blockwise modeling approach. Order of entry into the regression model was based on ecological frameworks positing that multilevel factors influence PA behaviour, from the proximal factors (e.g., student characteristics) to the more distal factors (e.g., school social environment, school and neighbourhood built environment variables). However, only the factors identified as significant in Step 2 and were significant at the p<0.2 level within the block, were retained in the multivariate analysis. Therefore, to create a more parsimonious model, factors not significant at the p<0.2 level within the block were backward removed from the model, starting with the least significant factor. If all of the variables within a block proved not to be significant the entire block was removed from the analysis. Due to the model building process applied, where each model builds on the previous model, the contribution of adding each block of variables to the model fit was tested using the -2 log likelihood procedure. To a good approximation in large samples, the change in deviance between the -2 log likelihood of nested models is distributed as X^2 degrees of freedom given by the parameters that have been eliminated (Leyland and Goldstein, 2001). Cross-level interactions between student- and environment-level variables found to be significant in the univariate analyses were also tested. Due to their a priori importance, the student-level variables gender, grade, and weight status as well as all three potential environment-level confounders were forced into every model regardless of their contribution.

Slight modifications to the general 3-step hierarchical regression modelling procedure were made in Study #2 and Study #3. Study #2 applied gender-specific regression models to evaluate the degree to which environment-level characteristics were associated with male and female students' time spent in PA while controlling for student characteristics and- and environment-level confounding variables. In Study #3, the 3-step modeling approach was first conducted with the full data set testing for interactions between environment-level factors significant in the univariate analysis and school location. Then, school-location specific regression models were run separately for urban, suburban, and rural schools in order to investigate the specific environment-level factors associated with student PA for each school-location.

All statistical analyses were performed using SAS (version 9.2; SAS Institute Inc., Cary, NC) and the Proc Mixed procedure was used for the multilevel analyses. Satterwaite degrees of freedom were used in all multilevel models as Hox (2010) suggests this approximation is the better choice for degrees of freedom in multilevel models as it estimates the number of degrees of freedom using the values of the residual variance.

CHAPTER 3: A multilevel examination of factors of the school environment and time spent in moderate to vigorous physical activity among a sample of secondary school students in grades 9 to 12 in Ontario, Canada.

3.1 Overview

OBJECTIVE: To examine associations between students' time spent in moderate to vigorous physical activity (MVPA) and the school built environment when also considering features of the schools' social environment and student-level characteristics.

METHODS: Using surveys and GIS measures, multi-level linear regression analysis were applied to examine the environment- and student-level characteristics associated with time spent in MVPA among grade 9 - 12 students (n=22,117) attending 76 secondary schools in Ontario, Canada as part of the SHAPES-Ontario study.

RESULTS: Significant between-school random variation in student MVPA was identified [$\sigma^2_{\mu 0}$=9065.22 (250.64)]; school-level differences accounted for 3.0% of the variability in student MVPA. Students attending a school that offered daily physical education or provided an alternate room for physical activity spent more time in MVPA than students attending a school without these resources. Moreover, as land use mix diversity and walkability of the school neighbourhood increased, students' time spent in MVPA decreased.

CONCLUSIONS: Developing a better understanding of the school- and student-level characteristics associated with students' time spent in MVPA is critical for informing school-based physical activity intervention programs and policies.

Keywords: physical activity; built environment; prevention; youth; school.

3.2 Introduction

A lack of regular physical activity (PA) is associated with an increased risk for 25 chronic illnesses [Booth, 2007]. Despite these health risks, only 7% of youth in Canada accumulate the recommended 60 minutes of moderate to vigorous PA (MVPA) per day required for optimal health, with almost twice as many 6-10 year olds meeting this criterion as 15-19 year olds [Colley et al., 2011]. The decline in MVPA during adolescence is concerning as regular PA in adolescence protects against obesity and reduces risk of several chronic diseases, and improves quality of life during adulthood [Bouchard et al., 1994; Herman et al., 2009]. As low levels of MVPA become more normative among adolescents, population-level interventions will be required to shift the risk profile of this population with respect to PA.

The use of ecological frameworks in population-level PA promotion interventions is receiving increased attention [Ontario Ministry of Health Promotion, 2007]. An ecological perspective addresses multiple influences on individuals' PA behaviour [McLeroy et al., 1988]. Several ecological models have been proposed for health generally [Bronfenbrenner, 1977; Stokols, 1992], and PA, or PA–related health outcomes (e.g., obesity) more specifically [Spence and Lee, 2003; Kremers et al., 2006]. Each of these models uses different typologies, but all include both the social and built environments and posit multiple levels of environmental influences.

International and national policy documents have identified the school as a key environment for promoting PA among young people [Stewart-Brown, 2006; Public Health Agency of Canada, 2010]. As such, ecological approaches to school-based PA promotion involve moving beyond individual factors that rely on traditional knowledge-based classroom models, to a more holistic approach that reinforces PA at the individual- and environmental-levels [Stewart-Brown, 2006]. Recently, researchers have applied a multilevel analytic approach to simultaneously examine the effects of individual- and environment-level influences on student PA in school-based studies, and have successfully detected significant between-school variability [Hobin et al., 2010; Veugelers et al., 2005; Robertson-Wilson et al., 2007; Haug et al., 2010; Nichol et al., 2009, 2010; Loucaides et al., 2007; Cradock et al., 2009]. Despite the growing number of these multilevel studies, it remains unclear as to which school policy and practice-level initiatives are important for explaining school-level variance in student PA. A relatively consistent finding however, is the cumulative effect of school PA programming and facilities on student PA. For example, results of one Norwegian study examining the PA of students in grades 8 - 10 and the availability of eight school PA outdoor facilities found students had more than 2.5 times higher odds of being more active if they attended a school with all eight PA facilities compared to no PA facilities [Haug et al., 2010]. A study of Canadian students in grades 9 and 10 also found the cumulative effect of five to six school PA-related opportunities and facilities to be positively associated with higher levels of PA at school compared to having one or fewer, even after adjusting for potential confounders. These studies, however, examine school PA programming and facilities associated with the variance in PA among students attending middle and secondary schools and do not involve older students in grades 11 and 12. Given the excessively low levels of PA among adolescents aged 15 to 19 years, focusing on the secondary school environment in school-based examinations of PA would be helpful for informing PA promotion interventions.

As research suggests secondary students accumulate a substantial portion of their PA in the neighbourhoods surrounding schools [Asanin-Dean et al., 2010; Trilk et al., 2011], the built environment features within this area may also help to explain the variability in student PA across schools. Results of three multilevel studies investigating built environment features within the school neighbourhood reveal few associations with student PA [Cradock et al., 2009; Deforche et al., 2010; Nichol et al., 2010] with some exceptions including destinations of interest to youth (e.g., shopping malls, fast-food outlets)

[Cradock et al., 2009]. The limited associations between the built environment of the school neighbourhood and student PA may be due to methodological limitations inherent in these studies. For example, all three studies used the area surrounding the school as a proxy for the students' residential neighbourhoods and two of the three studies assessed students' PA outside school time (e.g., PA on weekends). It is possible that students do not live within close proximity to the schools they attend and thus the school neighbourhood characteristics examined in these studies may have been ascribed to students who do not reside within this area. In addition, two of the three studies constructed buffers surrounding schools to capture factors of the built environment believed to associate with student PA [Cradock et al., 2009; Nichol et al., 2010]. Since no standard method exists for assessing school neighbourhood environments in PA research, it is unclear what buffer distance around schools would be appropriate for modeling student PA. Nichol and colleagues (2010) applied a five kilometer circular buffer around the school when measuring the availability of PA facilities. Five kilometers may be too large a distance to expect students to travel to access neighbourhood PA resources. Indeed, recent PA research suggests a buffer of 1-km is considered to be an easy walking distance for adolescents [Colabianchi et al., 2007, Trilk et al., 2011]. Learning more about the associations between student PA and features of the built environment within 1-km of schools may provide important insight for school-based PA interventions targeting adolescents.

With the overall goal of creating healthy school environments for PA promotion among adolescents, this research aims to determine whether factors of the built environment on school grounds and within the neighbourhood surrounding secondary schools are associated with students' time spent in PA when also considering school PA programming initiatives, and controlling for student-level differences.

3.3 Methods

3.3.1 Design

This cross-sectional secondary analysis used self-report data collected from students in grades 9 – 12 and administrators at 76 secondary schools in Ontario as part of the SHAPES-Ontario study (2005-2006). Objective measures of the built environment surrounding each of the 76 schools were also collected. The University of Waterloo Office of Research Ethics and appropriate School Board Ethics committees approved this study and data collection procedures.

3.3.2 Data sources and procedures

Student-level data

Student-level data were collected using the SHAPES PA survey. The survey asks students about their demographic information and PA-related behaviours. Validity testing has previously demonstrated significant criterion validity based on Spearman correlations for the SHAPES self-reported measures of height ($r = 0.97$, $p<0.001$), weight ($r = 0.98$, $p<0.001$), and MVPA ($r = 0.44$, $p<0.01$) [Wong et al., 2006]. Additional details about SHAPES, SHAPES-Ontario, and the survey measures are available in print [Wong et al., 2006; Leatherdale et al., 2009] and online (www.shapes.uwaterloo.ca).

Of the 34,578 students invited to participate in the SHAPES-Ontario project, a total of 25,416 students (73.5%) completed the survey. This distribution is consistent with previous SHAPES data collections. Students were further removed from the sample due to missing data (12.6%, n=3192), biologically implausible values (0.01%, n=65), or if they reported not being in grades 9-12 (0.01%, n=42). As such, data from 22,117 students (64.0%) were used in the present study.

Environment-level data

As part of the SHAPES-Ontario project, all 76 school administrators completed and returned the Canadian Lifestyle and Fitness Research Institute's School Capacity Survey. Administrators indicated the availability of 14 PA facilities at the school as well as the geographical location of the school (i.e., urban, suburban, rural). Researchers mailed administrators a standardized package including a consent form and the School Capacity Survey.

Built environment features in the neighbourhood surrounding the 76 schools were assessed using geographic information systems (GIS) data from the Desktop Mapping Technologies Inc. (DMTI) data resource. Built environment features within 1-km circular buffers surrounding each of the 76 school were identified using data provided by the CanMap RouteLogistics (CMRL) spatial information database as well as the Enhanced Points of Interest (EPOI) data resource from DMTI. Consistent with previous research [Pouliou and Elliott, 2010; Leatherdale et al., 2011], the process of identifying and linking the DMTI-EPOI data to the SHAPES-Ontario student and school survey data involved three steps: 1) geocoding the address for each SHAPES-Ontario school; 2) creating 1-km circular buffers; and, 3) linking quantified built environment data for each school to the student and school survey data. Arcview 3.3 (ESRI, 2002) software was used to geocode the school addresses and to create the 1-km buffers.

School neighbourhood SES information was collected from the 2006 Canadian Census Tract Profiles [Statistics Canada, 2006] by entering the postal codes of the schools.

3.3.3 Measures

Outcome measure

The outcome measure was a student's average daily minutes spent performing MVPA. To calculate MVPA, each student's responses to the items "Mark how many minutes of moderate physical activity you did on each of the last 7-days" and "Mark how many minutes of hard physical activity you did on each of the last 7-days" were summed and divided by 7-days.

Student characteristics

Students were asked to report their age, grade, gender, and height and weight. Age- and sex-adjusted body mass index (BMI) cut-points derived from the WHO growth charts were used to classify students' weight status [Onis et al., 2007]. Students within the lowest 5 percentiles for BMI adjusted for age and sex were classified as underweight, students within the 6^{th} to 84^{th} percentile for BMI adjusted for age and sex were classified as normal weight, students within the 85^{th} to 94^{th} percentile for BMI for age and sex were classified as overweight, and students within the highest 5 percentiles for BMI adjusted for age and sex were classified as obese. Dummy variables were created to compare normal weight students (referent) to underweight, overweight, and obese.

To assess students' mode of transportation to school, students responded to the single item: "In the last 7-days, how did you usually get to and from school" with response options of "actively" (e.g., walk, bike), "mixed", or "inactively" (e.g., car, bus; referent).

Finally, enrolment in school physical education (PE) was measured by asking students, "In a typical PE class, how much time are you actually active?" If adolescent student responded "I am not taking a PE class”, they were considered to not be enrolled in PE (referent). If a student responded to spending any amount of time being active in PE class, they were considered to be enrolled in PE.

School social environment variables

Given international and national health experts recommend school PE be provided daily to students [WHO, 2007; Public Health Agency of Canada, 2010], and previous research indicates a positive relationship between secondary school student enrollment in PE and schools offering daily PE [Hobin et al., 2010], administrators were asked to report in a typical week, how many times does a typical junior student and a typical senior student in your school take part in a PE class. The responses for junior and senior were averaged. Schools that reported 5 days of PE classes per week (daily PE) were compared with schools that reported <5 days of PE classes per week (referent).

Previous research suggests offering school intramural and interschool PA programs to positively associate with student PA [Nichol et al., 2009]. Generally, intramural activities are competitive and non-competitive activities that are open to anyone wishing to participate, and competition occurs within a school. Interschool sports are those that compete with other schools and often require tryouts. Offering intramural PA programs was measured by asking administrators, “Does your school offer intramural programs/club activities that involve PA?” [Yes/No (referent)]. Offering interschool PA programs was measured by asking administrators, “Does your school offer interschool programs that involve PA? [Yes/No (referent)].

School and neighbourhood built environment variables

For this study, measures of the built environment included 14 indoor and outdoor PA facilities on school grounds. Administrators were asked to report if their school has access to the following PA facilities during school hours. Those who reported having the PA facility on school grounds [Yes, on grounds] were compared to those who reported not having the PA facility on school grounds [Yes, off grounds; No; Don't know (referent)]. Since "gymnasium", "room with cardio and weight equipment", and "playing fields" were available at all 76 schools and "playground equipment" was not available at any of the 76 schools, these factors were excluded from the analysis. A school facilities index was also created representing the cumulative number of PA facilities available on school grounds on a continuum of 1 to 10.

The density of built environment variables located within a 1-km circular buffer of each school including recreation facilities (includes dance studios, fitness/gym facilities, sport and recreation clubs, and golf courses), parks, fast-food outlets, and shopping malls were recorded. Three measures of neighbourhood design features were also considered, land mix use, residential density, and street connectivity, independently as well as part of a walkability index [Frank et al., 2005]. Brief operational definitions of each of the built environment measures are presented in Table 5.

School characteristics

An administrator at each school reported the location of the school. For school location, urban and suburban were compared to rural schools (referent). Based on the date of data collection, schools were classified according to the season in which data were collected. As in other studies [Merriam et al., 1999; Robertson-Wilson et al., 2007], common seasons (winter: December 21–March 20, spring: March 21–June 20, summer: June 21–September 20, fall: September 21–December 20) were used. Data collected from schools in the winter (referent) were compared to data collected from schools in the spring and fall seasons.

Using data from the 2006 Canadian Census Tract Profiles, the area-level SES measure for each school was based on the proportion of households in the census tract living below the Statistics Canada low-income cut-off (LICO) level. The LICO values identify those who are substantially worse off than the average population as it represents the proportion of households in the census tract that attribute 20% more than the average Canadian family to food, shelter, and clothing [Giles, 2004]. There are different cut-offs according to the number of people in the household and whether the household is located in a rural, suburban, or large urban areas. These values are based on after-tax income. The LICO function at the census tract level was available for postal codes of 56 schools (74%) of schools. School postal codes that did not have a LICO value at the census tract level were taken at the level of the census agglomeration.

3.3.4 Analysis

Due to the hierarchical nature of these data (students nested within schools), a hierarchical linear regression modeling approach was used to evaluate the degree to which school social and built environment variables associate with students' time spent in MVPA while controlling for student-level variables. Consistent with previous research [Elliott et al., 1993; Loucaides et al., 2007], a three-step modeling procedure was used to examine student MVPA. Step 1 used an empty model to determine the variability in students' time spent in MVPA across schools.

Step 2 included a series of univariate analyses examining if each of the school social environment variables and school and neighbourhood built environment variables were associated with students' time spent in MVPA. School PA facility and walkability index variables were also examined. To be reasonable but yet not too restrictive at the initial screening stage, explanatory variables that were not statistically significant (p>0.2) were removed from the analysis.

In step 3, multivariate models were developed following a blockwise modeling approach. Order of entry into the regression model was based on ecological frameworks positing that multilevel factors influence PA behaviour, from the proximal factors (e.g., student characteristics) to the more distal factors (e.g., school and neighbourhood built environment variables). However, only the factors identified as significant in Step 2 and were significant at the p<0.2 level within the block, were retained in the multivariate analysis. Therefore, to create a more parsimonious model, factors not significant at the p<0.2 level within the block were backward removed from the model, starting with the least significant factor. If all of the variables within a block proved not to be significant the entire block was removed from the analysis. Due to the model building process applied, where each model builds on the previous model, the contribution of adding each block of variables to the model fit was tested using the -2 log likelihood procedure. Cross-level interactions between student- and environment-level variables found to be significant in the univariate analyses were also tested while controlling for confounders. Due to their a priori importance, gender, grade, weight status, school location, and season of data collection were forced into every model regardless of their contribution. Analyses were conducted using PROC MIXED in SAS version 9.2 (Cary, NC).

3.4 Results

3.4.1 Student characteristics

As shown in Table 6, the sample was 49.4% (n=10,925) female and 50.6% (n=11,192) male (X^2=1.9, p=0.59). Although the majority of males [70.2%, n=7862; mean BMI=22.0 (SD=±3.5)] and females [80.6%, n=8810; mean BMI= 21.3 (SD±3.4)] were classified as a healthy weight, 28.1% (n=3,145) and18.0% (n=1,968) of males and females were classified as overweight and obese, respectively (X^2= 330.4, p<0.0001). Most students (57.4%, n=12,684) reported using an inactive mode of transportation to school. Only 34.9% (n=7,685) of students were enrolled in PE and of those enrolled in PE more were male than female (X^2=98.4, p<0.0001). Males (mean PA=166.9 minutes/d, SD=±101.4) also reported more time spent in MVPA than females (mean PA=134.8 minutes/d, SD=±88.1; t=25.1, p<0.0001).

3.4.2 Environment characteristics

As presented in Table 7, the majority of schools offered intramural (76.3%) and interschool sports (86.8%) to students. Of the 10 PA facilities on school grounds included in the analyses, the most frequently reported included an alternate room for PA (80.3%), bicycle racks (82.9%), and running/walking tracks (86.8%). The average area-level SES of neighbourhoods where schools were located was 13.0% (SD=±8.8), slightly above the provincial average SES in Ontario (11.1%) indicating on average schools in this study were located in slightly lower SES neighbourhoods in Ontario.

3.4.3 Student and environment characteristics associated with time spent in physical activity

Significant between-school variation was identified for time spent in MVPA [$\sigma^2_{\mu0}$= 9065.22 (250.64)]. Using the null models, we found school-level differences accounted for 3.0% of the variability in student MVPA when controlling for student-level variance.

Building on the results of the univariate analyses (Table 8) and using a blockwise modeling approach, findings from the final model (Table 9) indicate students who were male (β=28.20 (1.25), p<0.0001), used an active (β=14.92 (1.67), p<0.0001) or mixed (β=7.49 (1.56), p<0.0001) mode of transportation, and enrolled in PE (β=39.16 (1.35), p<0.0001), spent more time in PA than their counterparts. Students attending a school that offers daily PE (β= 7.45 (3.75), p=0.0498) spent more time in MVPA than students attending schools that did not offer daily PE. As well, students attending a school with an alternate room for PA (β= 11.49(4.23), p=0.012) were also found to spend more time in MVPA than students attending a school without this PA resource. Furthermore, results demonstrate students who were in grades 10 (β=-4.17 (1.70), p=0.013), 11 (β=-12.38 (1.77), p<0.0001) and 12 (β=-21.19 (1.81), p<0.0001) (referent=grade 9), and were obese (β=-7.95 (2.52), p=0.01; referent=healthy weight status) spent less time in MVPA. Moreover, a negative relationship between land-use mix diversity (β=-20.82 (10.66), p=0.043) and attending a school in a suburban area (β=-9.63 (4.22), p=0.025; referent=rural) were also detected. The log likelihood tests demonstrated adding each block of variables significantly contributed to the prediction of students' time spent in PA (e.g., deviance between adding built environment block and potential confounders to model: 262498 – 262461 = 37, df=2, p<0.05, two-tailed test). No significant contextual interactions were identified.

As shown in Table 10, a separate model including the walkability index, student- and environment-level variables, and potential environment-level confounders was also examined. The association between the walkability index (β=-2.79 (1.00), p=0.013, 95CI: -4.8019, -0.7864) and student MVPA remained significant after adjusting for other variables in the final model.

3.5 Discussion

The school environment appears to be associated with students' time spent in MVPA. Consistent with previous research also investigating students' time spent in MVPA [Loucaides et al., 2007; Cradock et al., 2007, 2009], we identified significant variation in student MVPA across schools. Although the amount of school-level variability identified was modest in the present study (3.0%), from a population perspective it is meaningful as even small shifts in students' time spent in MVPA at the school-level could result in a substantial population level impact when applied across a large number of schools [Leatherdale and Papadakis, 2011].

As anticipated, students reported high levels of MVPA with an overall daily average of 151.0 (SD=±96.4) minutes. Using direct measures of MVPA, recent results of the Canadian Health Measures Survey indicate youth aged 6 to19 years accumulate approximately 54 minutes of MVPA per day [Colley et al., 2011]. Over-reporting in self-report measures of MVPA among youth is common [Wong et al., 2006; McMurray et al., 2004]; nevertheless, the SHAPES PA survey used in this study has been validated for comparing youth who report more compared to less MVPA [Wong et al., 2006] and therefore is appropriate for the purposes of this study. The MVPA results should not be used, however, to group youth as active or inactive according to PA time standards.

Consistent with previous research, time spent in MVPA was associated with both students being enrolled in PE [Veugelers et al., 2005; Hobin et al., 2010; Cradock et al., 2007] and schools offering daily PE. This is positive considering that there is an emergence of education policies designed to increase the frequency of PE classes or extend the number of PE credits required for graduation (e.g., the policy recently implemented in Manitoba, Canada) for the purposes of increasing student PA. These findings are also consistent with the advice of stakeholders who have been advocating for schools to provide daily PE classes to students [WHO, 2007].

The factors associated with students' time spent in MVPA also included school built environment features. Having an alternate room for PA within schools was found to positively associate with student MVPA. One explanation for the positive association between student MVPA and an alternate room for PA in schools is that secondary school students in Canada spend the majority of time indoors when at school. However, a common complaint from school staff is indoor space for PA in schools in limited [Dwyer et al., 2006; Jenkinson et al., 2010]. Adapting a room within a school to be used for PA may be a promising solution for increasing the amount of indoor space in schools for student PA; however, this approach requires evaluation.

Finally, land-use mix diversity in the final model (Table 9) and the walkability index in the additional model (Table 10) were found to negatively associate with students' time spent in MVPA. These negative findings are opposite to the results found for adults in international and US studies, showing consistently that adults living in areas with higher land-use mix diversity or in high-walkable neighbourhoods are more physically active [Duncan et al., 2010; Sallis and Owen, 2002; De Bourdeaudhuij et al., 2003]. According to Van Dyck and colleagues (2009), who also found a negative relationship between PA and walkability among a sample of Belgian adolescents, this suggests that the associations between neighbourhood walkability and PA may be different for adolescents than for adults, which is important for the development of future environmental interventions. However, one potential explanation for the negative associations with land-use mix diversity and walkability specific to this study may be the nature of items used to assess PA on the SHAPES survey. Although the SHAPES PA survey has been validated for measuring overall MVPA, it is possible that students may focus more on PA occurring at school since the survey is completed at school, and not including behaviours such as walking which would be more likely to relate to land-use mix diversity and walkability.

Limitations

Some limitations also must be considered. The cross-sectional nature of the data prevents causal inferences to be made. Because no data on ethnicity were available, it was not possible to examine whether student MVPA vary by ethnic groups. Moreover, individual-level measures of SES (e.g., household SES) were not available and area-level SES measures have been found to be weaker predictors of adolescent MVPA by comparison to individual SES measures [Janssen et al., 2006].

Although validity of data based on self-report may be questioned, measures in the PA module have been previously demonstrated to be reliable and valid [Wong et al., 2006] and honest reporting was encouraged by ensuring confidentiality during data collection. Yet, collecting more direct measures of MVPA using pedometers or accelerometers could better profile student PA behaviours and provide more accurate data for testing the associations between students and features of the school built environments. Future studies may also consider incorporating geographic positioning systems (GPS) to provide insight into the appropriate buffer size for investigating features of the school built environment associated with student PA. Finally, additional components of the school environment such as school-community partnerships were not included in the analyses and could provide additional information to inform PA promotion strategies.

Conclusions

After considering the schools' social environment and controlling for student-level differences, results of this study indicate three associations between features of the schools' built environment and students' time spent in MVPA. First, attending a school providing another room for PA was found to promote more time spent in MVPA among students. Moreover, higher walkability and land-use mix diversity in the school neighbourhood were associated with students spending less time in MVPA; however, more research is needed to better understand these negative relationships with student MVPA. To combat the low levels of MVPA among adolescents, these results further strengthen the argument for ecological approaches that consider both student- and environment-level factors as a means to improve school-based PA promotion interventions in secondary schools.

Acknowledgements

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CHAPTER 4: A multilevel examination of gender differences in the association between features of the school environment and time spent in physical activity among a sample of grades 9 to 12 students in Ontario, Canada.

4.1 Overview

BACKGROUND**:** Creating school environments that support student physical activity (PA) is a key recommendation of policy-makers to increase youth PA. Given males are more active than females at all ages, it has been suggested that investigating gender differences in the features of the environment that associate with PA may help to inform gender-focused PA interventions and reduce the gender disparity in PA.

METHODS**:** This cross-sectional study explored gender differences in the association between factors of the school environment and the time spent in PA among a sample of 10,781 female and 10,931 male students in grades 9 - 12 from 76 secondary schools in Ontario, Canada.

RESULTS**:** Results of the gender-specific multilevel analyses indicate schools should consider providing another room for PA, especially for providing flexibility activities directed at female students. Schools should also consider offering daily PE programming to male students in senior grades and providing PA promotion initiatives targeting obese male students. Finally, results show using active modes of transport to school is associated with both males' and females' time spent in PA, particularly among females who tend to participate in less PA than males.

CONCUSIONS**:** More research investigating gender differences in school environment factors associated with youth PA are warranted.

4.2 Background

Adolescence is a particularly important developmental stage as not only can lifestyle choices impact health and sense of well-being in the short-term, but they also can affect adult onset of chronic diseases including obesity, type 2 diabetes, and some cancers (Janssen and LeBlanc, 2010; Herman et al., 2009). Unfortunately, direct measures of PA recently collected in both the US and Canada suggest the vast majority of young people do not meet the recommended 60-minute dose of PA required for adequate growth and health (Colley et al., 2011; CDC, 2010). For example, among Canadians aged 6 to 19 years, results indicate only 9% of males and 4% of females meet the 60-minute per day recommendation for PA, with twice as many 6 to 10 year olds meeting this criterion as 15 to 19 year olds (Colley et al., 2011).

Given there is a well-established tendency for males to be more active than females at all ages, recent discussions suggest that gender differences should be considered within population-level interventions designed to increase PA (Brown and Summerbell, 2009; Simon-Kapeu et al., 2010). Population-level interventions that modify environment level factors are believed to be important for creating more supportive environments for PA and benefiting the PA levels of everyone exposed to this environment to some degree (Committee on Environmental Health for the American Academy of Pediatrics, 2009). By affecting large numbers of people, not just individuals enrolled in a particular intervention, these environment-level changes can potentially have broad-based and long-lasting impact on PA (Stokols, 1988; Ross et al., 2004). Consequently, identifying the unique role environments can play in male and female adolescent PA promotion may serve as a critical component to increase PA among this population, decrease the discrepancy between male and female adolescent PA at the population level, and inform PA gender-focused intervention planning (Simon-Kapeu et al., 2010; Kavangh and Bentley, 2008).

Since students in Canada spend almost 200 days per year in school, schools are a key environment for large-scale population-level PA initiatives among adolescents. The creation of a supportive school environment is believed to have enormous potential to encourage more PA by providing opportunities and cues that can facilitate PA (Story et al., 2006). Indeed, the Canadian Federal/ Provincial/ Territorial Framework for Action to Promote Healthy Weights recommended making schools' social and built environments more supportive of PA by providing students with school physical education (PE), PA programming, and PA-related facilities whenever possible (PHAC, 2010). Many school-based studies examining student- and environment-level characteristics associated with student PA have found positive relationships with schools offering school PE and PA programming (Nichol et al., 2009; Haug et al., 2009) and with students participating in school PE and PA programming (Hobin et al., 2010; Veugelers and Fitzgerald, 2005).

Results from recent research investigating factors of the school built environment also suggest gender-discrepancies in the influence of school PA-related facilities on adolescent PA. For example, results of a study investigating the number of PA facilities within walking distance of school and after-school PA behaviour among 1,394 12th grade females attending 22 secondary schools in the US found females attending schools with ≥5 facilities within a 1-km buffer reported more PA than females in schools with <5 facilities (Trilke et al., 2011). Similar results were noted in a sample of 16,471 students in grades 8 - 10 attending 68 schools in Norway. According to Haug and colleagues (2010), students attending a school with eight PA facilities on school grounds engaged in almost three times more PA during school recess compared with students attending a school with the lowest number of facilities (Haug et al. 2010); however, gender differences were detected in the particular types of school PA-related facilities associated with student PA in this study. The PA levels of male students were higher among those attending schools with a soccer field, playground equipment, sledding hill, or an area for hopscotch or skipping compared to males attending schools without these facilities (Haug et al., 2010). Access to a sledding hill at school was the only school PA facility to influence the PA of females (Haug et al., 2010). Other than areas for hopscotch and skipping, however, this study did not examine school PA facilities that may be more attractive to female students, such as aerobic or dance studios. Indeed, observational research suggests more traditional school PA facilities, such as soccer fields and playground equipment, are predominantly used by males for sports and other physical activities, with females remaining passive and not participating (Beighle et al., 2006).

Consideration of gender-specific needs in school PE and PA program planning as well as the design of school PA facilities may help alleviate the gender discrepancies in PA evident among adolescents. With the scarcity of gender studies focused on environmental factors associated with adolescent PA, the present study aims to extend previous research by determining gender differences in the association between factors of the school environment and students' time spent in PA among a sample of secondary school students (grades 9 – 12) in Ontario, Canada.

4.3 Methods

4.3.1 Design

This cross-sectional secondary analysis used self-report data collected from students in grades 9 – 12 and administrators at 76 high schools in Ontario as part of the SHAPES-Ontario (SHAPES-ON) study (2005-2006). Objective measures of the built environment surrounding each of the 76 schools were also collected. The University of Waterloo Office of Research Ethics and appropriate School Board Ethics committees approved this study and data collection procedures.

4.3.2 Data Sources and Procedures

Student-level Data

Student-level data were collected from consenting students by using the previously validated SHAPES PA module questionnaire (Wong et al., 2006). The survey asks students about their demographic information and PA-related behaviours. Additional details about SHAPES, SHAPES-ON, and the survey measures and their psychometric properties are available in print (Wong et al., 2006; Leatherdale et al., 2009) and online (www.shapes.uwaterloo.ca). All student-level surveys were completed in class time and participants were not provided compensation. Actively providing information to parents with passive permission was used to reduce demands on schools and to increase student participation rates.

Environment-level Data

As part of the SHAPES-ON project, all 76 school administrators completed the Canadian Lifestyle and Fitness Research Institute's School Capacity Survey. Administrators indicated the availability of 14 different PA-related facilities at the school as well as the geographical location of the school (i.e., urban, suburban, rural). Researchers mailed administrators a standardized package including a consent form and the School Capacity Survey. If a school did not return a completed survey within four weeks, researchers emailed a standardized reminder to the school administrator.

Built environment features in the neighbourhood surrounding the 76 schools were assessed using geographic information systems (GIS) data from the Desktop Mapping Technologies Inc (DMTI) data resource. Neighbourhood built environment data within 1-km circular buffers surrounding each of the 76 schools were provided by two DMTI Spatial resources; the CanMap RouteLogistics (CMRL) spatial information database, and the Enhanced Points of Interest (EPOI) database. Consistent with previous research (Pouliou and Elliott, 2010; Leatherdale et al., 2011), the process of identifying and linking the

DMTI-EPOI data to the SHAPES-ON student and school survey data involved three steps: 1) geocoding the address for each SHAPES-ON school; 2) creating 1-km circular buffers (i.e., bounded areas surrounding each school in which the built environment structures were quantified); and, 3) linking quantified built environment data for each school to the student and school survey data. Arcview 3.3 (ESRI, 2002) software was used to geocode the school addresses and to create the 1-km buffers.

School neighbourhood SES information was collected from the 2006 Canadian Census Tract Profiles (Statistics Canada, 2006) by entering the postal codes of the schools.

4.3.3 Measures

Students' Time spent in Physical Activity

To be consistent with Canada's Physical Activity Guidelines for youth aged 12-17 years, this study defines student PA as an individual's average daily minutes spent performing moderate to vigorous PA (MVPA; Tremblay et al., 2011). To calculate MVPA, each student's responses to the questions "Mark how many minutes of moderate physical activity you did on each of the last 7-days" and "Mark how many minutes of hard physical activity you did on each of the last 7-days" were summed and divided by 7-days. Students who reported four or more days of both moderate PA and vigorous PA were included in the analysis and students who reported less than four days of either moderate PA or vigorous PA were excluded.

Student-Level Factors

Students were asked to report their age, grade, gender, and height and weight. Age- and sex-adjusted body mass index (BMI) cut-points derived from the WHO growth charts were used to classify students' weight status (Onis et al., 2007).

Student-level predictors were consistent with previous research (Robertson-Wilson et al., 2007; Hobin et al., 2010; Hobin et al., 2010). Student respondents reported how they usually got to and from school in the last 7-days (active, mixed, inactive (referent)), if they were enrolled in PE (Participated in 1-5 days of PE in past 7-days / Participated in 0 days of PE in past 7-days), and if they participated in school intramural activities or varsity sports teams (Yes/No (referent)).

Finally, students were asked to report on their participation in activities for flexibility and strength. To assess their participation in flexibility-related activities, students responded to the single item: "In the last 7-days, how many days did you do exercises for flexibility, such as stretching or yoga" with response options from 0 to 7-days. Similarly, to assess their participation in strength-related activities, students responded to the single item: "In the last 7-days, how many days did you do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, yoga, or weight lifting" with response options from 0 to 7-days. Consistent with Canada's PA Guidelines for youth, responses for participation in activities for strength were classified as "3 or more days per week" or "less than 3 days per week" (Tremblay et al., 2011). Similarly, responses for participation in activities for flexibility were also classified as "3 or more days per week" or "less than 3 days per week" to parallel recommendations outlined in Canada's previous PA Guidelines for youth (PHAC, 2002).

Environment-Level Factors

School Social Environment Variables

School-level predictors were also consistent with previous research (Hobin et al., 2010; Hobin et al., 2011). Administrators reported if their school offers daily PE class (5 days of PE class per week/<5 days of PE class per week (referent)), intramural PA programs (Yes/No (referent)), and varsity sports teams (Yes/No (referent)).

School and Neighbourhood Built Environment Variables

For this study, measures of the built environment included 14 different indoor and outdoor PA-related facilities on school grounds. Administrators were asked to report if their “school has access to any of the following PA-related facilities during school hours”. Those who reported having the PA-related facility on school grounds (Yes, on grounds) were compared to those who reported not having the PA-related facility on school grounds (Yes, off grounds; No; Don’t know (referent)). Since “gymnasium”, “room with cardio and weight equipment”, and “playing fields” were reported to be available at all 76 schools and “playground equipment” was not available to high school students at any of the 76 schools, these factors were excluded from the analysis. A school facilities index was also created representing the cumulative number of PA-related facilities available on school grounds on a continuum of 1 to 10.

The density of built environment variables located within a 1-km circular buffer of each school including recreation facilities (includes dance studios, fitness/gym facilities, sport and recreation clubs, and golf courses), parks, fast-food outlets, and shopping malls were recorded. Three continuous measures of neighbourhood design features were also considered, land mix use, residential density, and street connectivity, independently as well as part of a walkability index[1] (Frank et al., 2005).

Potential Environment-Level Confounders

An administrator at each school reported the location of the school (rural, urban, suburban) at time of recruitment. Based on the date of data collection, schools were classified according to the season in which data were collected. As in other studies (Merriam et al., 1999; Robertson-Wilson et al., 2007), common seasons (winter: December 21–March 20, spring: March 21–June 20, fall: September 21–December 20) were used. Data collected from schools in the winter (referent) were compared to data

[1]Walkability index= (6 x z-score land-use mix diversity) + (z-score street connectivity) + (z-score residential density)

collected from schools in the spring and fall seasons.

Using data from the 2006 Canadian Census Tract Profiles, the area-level SES measure for each school was based on the proportion of households in the census tract living below the Statistics Canada low-income cut-off (LICO). The LICO values identify those who are substantially worse off than the average population as it represents the proportion of households in the census tract that attribute 20% more than the average Canadian family to food, shelter, and clothing (Giles, 2004). There are different cut-offs according to the number of people in the household and whether the household is located in a rural, suburban, or large urban area. These values are based on after-tax income. The LICO function at the census tract level was available for postal codes of 56 schools (74%) of schools. School postal codes that did not have a LICO value at the census tract level were taken at the level of the census agglomeration (i.e., one level less specific, typically for rural areas).

4.3.4 Analysis

Due to the hierarchical nature of these data (students nested within schools), a gender-specific hierarchical linear regression modeling approach was used to evaluate the degree to which school characteristics were associated with male and female students' average daily time spent performing MVPA, herein referred to as "students' time spent in PA", when considering student characteristics and school PE and PA programming, and while controlling for environment-level confounding variables. Consistent with previous research (Elliott et al., 1993; Dunn et al., 1994; Loucaides et al., 2004), a three-step modeling procedure was used to examine student PA. Step 1 determined the across school variability in students' time spent in PA.

Step 2 included a series of univariate analyses examining if each of the environment-level fators was associated with male and female students' time spent in PA. School PA facility and walkability index variables were also examined. In order to not be too restrictive at the initial screening stage, explanatory variables that were not statistically significant (*p*>0.2) were removed from the analysis.

In Step 3, multivariate models were developed following a blockwise modeling approach. Order of entry into the regression model was based on ecological frameworks positing that multilevel factors influence PA behaviour, from the proximal factors (e.g., student characteristics) to the more distal factors (e.g., school social environment, school and neighbourhood built environment variables). However, only the factors identified as significant in Step 2, were significant at the p<0.2 level within the block, and contributed to the models were retained in their blocks in the multivariate analysis. Therefore, if all of the variables within a block proved not to significantly contribute to the models the entire block was removed from the analysis. As part of an exploratory analysis, cross-level interactions with student-level factors and environment-level factors found to be significant in the univariate models were also tested while controlling for potential confounders. Due to their a priori importance grade and weight status were forced into every model regardless of their contribution as well as area-level SES, school location, and season of data collection. Analyses were conducted using PROC MIXED in SAS version 9.2 (Cary, NC).

4.4 Results

4.4.1 Student-Level Factors

This study included both males (50.4%, n=10,973) and females (49.6%, n=10,781) across grades 9 - 12 (Table 11, Appendix S). As shown in Table 11 (Appendix S), males (mean PA= 166.8min/day, SD: ±101.2) reported spending significantly more minutes per day in MVPA than females (mean PA= 134.7min/day, SD: ±88.1; t=24.9, p<0.0001). Yet, the prevalence of overweight and obesity was significantly higher among males (28.0%, mean BMI=22.05, SD: ±3.52) than females (18.1%, mean BMI=21.34, SD: ±3.41).

More males than females also used active and mixed modes of transportation to school (X^2= 178.87, p<0.0001), enrolled in PE (X^2= 100.73, p<0.0001), participated in school intramurals (X^2= 279.63, p<0.0001) and varsity sports teams (X^2= 124.86, p<0.0001), and engaged in strength training activities 3 or more days per week (X^2= 191.68, p<0.0001). More females than males, however, engaged in flexibility activities 3 or more days per week (X^2= 148.18, p<0.0001).

4.4.2 Student- and Environment-Level Characteristics associated with Female Students' Time Spent in PA

Significant between-school variation was identified for female students' time spent in PA ($\sigma^2_{\mu 0}$= 7600.26 (163.00)), where school-level differences accounted for 2.1% of the variability in female students' time spent in PA. As shown in Table 13 (Appendix U), the environment-level variable found to positively associate with female students' time spent in PA was attending a school with another room for PA (β=12.51 (3.96), p=0.002). Land-use mix diversity (β=-26.14 (10.19), p=0.01) was the environment-level variable found to negatively associate with female students' time spent in PA. Student-level variables positively associated with female students' time spent in PA included using an active mode of transportation (β=18.28 (2.23), p<0.0001), using a mixed mode of transportation (β=4.00 (1.90), p=0.04), enrolling in PE (β=24.10 (1.86), p<0.0001), participating in school intramurals (β=18.32 (2.19), p<0.0001), participating on school varsity teams (β=9.36 (2.03), p<0.0001), engaging in flexibility activities 3 or more days per week (β=26.96 (1.90), p<0.0001), and engaging in strength activities 3 or more days per week (β=22.91 (1.96), p<0.0001). Being in grades 11 (β=-7.77 (2.28), p<0.0001) and 12 (β=-12.77 (2.34), p<0.0001; referent=grade 9) were negatively associated with female students' time spent in PA. The log likelihood tests demonstrated adding each block of variables significantly contributed to the prediction of females students' time spent in PA (e.g., deviance between adding built environment block and potential confounders to model: 125210 – 125181 = 29, df=2, p<0.05, two-tailed test). As shown in Table 14 (Appendix V), the association between female students' time spent in PA and the walkability index (β=-1.89 (0.95), p=0.25) did not remain significant after adjusting for all other variables in the full model.

As part of the exploratory analysis, a significant contextual interaction was identified between participating in flexibility activities and attending a school with another room for PA (F=6.13, p=0.01). Female students who participated in 3 or more days per week of flexibility activities engaged in more minutes of PA but the increase was significantly higher among females attending schools with another room for PA compared to females attending schools without this facility (Figure 5, Appendix Y). Using conservative energy expenditure estimates (CDC, 1999), our finding suggests that a female student who participated in 3 or more days per week of flexibility activities and attended a school with another room for PA would expend roughly 3840 kcal/school year more than a female student who participated in 3 or more days per week of flexibility activities and did not attend a school with another room for PA, about equivalent to the caloric value in one pound (0.45kg) of fat.

4.4.3 Student- and Environment-Level Characteristics associated with Male Students' Time Spent in PA

Significant between-school variation was identified for male students' time spent in PA ($\sigma^2_{\mu 0}$= 9993.02 (287.74). Using the null models, we found school-level differences accounted for 2.8% of the variability in male students' time spent in PA when controlling for individual-level variance.

Building on the results of the univariate analyses (Table 12, Appendix T) and using a blockwise modeling approach, findings from the full model shown in Table 15 (Appendix W) indicate environment-level variables found to positively associate with male students' time spent in PA included attending a school with another room for PA (β=13.32 (5.21), p= 0.01). Student-level variables positively associated with males' time spent in PA included using an active mode of transportation (β=11.69 (2.37), p<0.0001), using a mixed mode of transportation (β=6.41 (2.36), p=0.01), enrolling in PE (β=19.83 (1.97), p<0.0001), participating in school intramurals (β=23.78 (2.28), p<0.0001), participating in school varsity teams (β=12.36 (2.23), p<0.0001), engaging in flexibility-related activities on 3 or more days per week (β=23.18 (1.99), p<0.0001), and engaging in strength activities on 3 or more days per week (β=33.83 (2.21), p<0.0001). Student-level variables found to negatively associate with male students' time spent in PA included being in grades 11 (β=-10.59 (2.54), p<0.0001) or 12 (β=-19.86 (2.59), p<0.0001; referent=grade 9), and being obese (β=-8.63 (3.47), p<0.0001; referent=healthy weight). The log likelihood tests demonstrated adding each block of variables significantly contributed to the prediction of male students' time spent in PA (e.g., deviance between adding built environment block and potential confounders to model: 130615 – 130581 = 34, df=2, p=0.01, two-tailed test). As presented in Table 16 (Appendix X), a separate model including the walkability index, student- and environment-level factors, and potential environment-level confounding variables was also examined. The negative association between male students' time spent in PA and the walkability index (β=-3.11 (1.18), p=0.02) remained significant even after adjusting for all other variables in the full model.

During the additional exploratory analyses, a significant interaction was detected for male students' PA between grade and attending school that offers daily PE (F=2.63, p=0.0484). This interaction indicates the relationship between male students' PA and grade level is significantly different for males attending schools that do and do not offer daily PE (Figure 6, Appendix Z). Figure 6 (Appendix Z) illustrates males who are in grades 11 and 12 engaged in less minutes of PA than their grade 9 counterparts but the difference was significantly lower among males attending schools that offer daily PE compared to schools that do not offer daily PE. Using conservative estimates (CDC, 1999), our finding suggests that males in grades 11 and 12 who attended a school that offers daily PE expend roughly 3155.6 kcal/school year and 3218.3 kcal/school year more than males in grades 11 and 12 who did not attend a school that offers daily PE, about equivalent to the caloric value in one pound of fat (0.45kg).

4.5 Discussion

Gender-specific investigations in PA research are critical due to the well-established gender discrepancies in PA among youth and the need to inform gender-focused interventions for PA (Simon-Kapeu et al., 2010; Colley et al., 2011; CLFRI-CanPlay 2010). Findings from the present study revealed significant differences in the time male and female students spend in PA as well as in some of the environment- and student-level factors associated with PA. Few studies have used multilevel modeling to examine gender differences in the association between factors of the school environment, especially the features of the school built environment, and the PA levels of students attending secondary schools. Identifying and addressing the gender-specific environment-level factors in school-based PA promotion may be key for improving intervention effectiveness and supporting gender-focused health promotion as a strategy for reducing physical inactivity among youth.

4.5.1 Importance of Environment

Consistent with the tenets of ecological theory (Bronfenbrenner, 1979), we identified that school-level differences accounted for a significant amount of the variability in female students (2.1%) and male students' (2.8%) time spent in PA suggesting that the characteristics of the school environment a student attends are associated with their PA. These findings are consistent with previous empirical research which suggest similar amounts of between school variability in student PA levels (Hobin et al., 2010; Deforche et al., 2010) and that characteristics of the school a student attends can have important impact on their time spent in PA (Loucaides et al., 2007; Cradock et al., 2007, 2009); however, these earlier studies did not explore the between school variability in PA by gender. Identifying significant differences in between school variability in student PA by gender is important as an increasing number of reports suggest that gender specific approaches to PA promotion and obesity prevention may be more effective (Brown and Summerbell, 2009; Simon-Kapeu et al., 2010). Although the amount of and difference between school-level variability in female and male students' time spent in PA in this study appears modest, it is important as even small changes on large numbers of individuals can have appreciable effects (Rose, 1985; Leatherdale and Papadakis, 2011) and may help account for gender differences in the time spent in PA.

The environment-level factor, attending a school with another room for PA, was found to associate with more time spent in PA among both male and female students. To better understand the relationship between attending a school with another room for PA and student PA, the two-way interaction between another room for PA and student-level factors was examined for each gender. An interaction between attending a school with another room for PA and participation in flexibility activities 3 or more days per week was significant among female students. Female students who participated in flexibility activities 3 or more days per week reported spending more time in PA especially if they attended a school with another room for PA. Previous research suggests female secondary school students prefer more individual and cooperative activities such as dance and yoga (Gibbons et al., 1999). The lack of indoor space within schools is often cited as a reason for not offering school PE or school PA programming (Dwyer et al., 2006; Jenkinson et al., 2010); therefore, adapting a room for PA within a school may provide the extra space needed to enable additional school PE classes or school PA programming activities that are known to be particularly attractive to females.

A two-way interaction was also identified between attending a school that offered school PE daily and grade level among males. Consistent with previous research, there was an inverse association between grade level and time spent in PA among students (Hobin et al., 2010; Belcher et al., 2010); however, our findings indicate males in grades 11 and 12 participated in significantly more minutes of PA if they attended a school that offered daily PE. Although earlier research has shown that students are more likely to enrol in PE if they attend a school that offers daily PE (Hobin et al., 2010), this is the first study to our knowledge, to suggest that the decline in male PA with increasing grade level is attenuated when a male attends a school that offers daily PE. While future research might identify the particular mechanism at work among older students PA participation, school initiatives that seek to encourage PA among male secondary school students might consider offering daily school PE in an effort to increase enrolment in PE and participation in PA.

Finally, land-use mix was found to negatively associate with female students' time spent in PA and walkability was found to negatively associate with male students' time spent in PA. These findings are opposite to the results found for adults in international studies, showing consistently that adults living in neighbourhoods with mixed land-use and high-walkability are more physically active (Duncan et al., 2010; De Bourdeaudhuij et al., 2003).According to Van Dyck and colleagues (2009), who also found a negative relationship between PA and walkability among a sample of Belgian adolescents, this suggests that the associations between neighbourhood walkability and PA may be different for adolescents than for adults, which is important for the development of future environmental interventions.

4.5.2 Importance of Student Characteristics

One notable gender discrepancy between the student level factors associated with students' time spent in PA is the negative association with weight status. Being obese had a relatively strong negative association with male students' time spent in PA, whereas there was no discernible pattern in the association between female students' weight status and time spent in PA. Although somewhat atypical, other studies have also found gender differences in the relationship between weight status and PA among youth where overweight and obese males are less active than normal weight males but the pattern is not found among females (Colley et al., 2011; Belcher et al., 2010; Byrd-Williams, 2007). A possible explanation for this result is that male weight status is more related to PA participation than to other obesity-related behaviours such as eating or sedentary (e.g., television or video game) habits (McMurray, 2000; Simon-Kapeu et al., 2010). Alternatively, this finding could reflect the tendency for overweight females to over-report PA compared to normal weight females (McMurray, 2008) or be a function of missing data, as previous research has identified that respondents with missing BMI data were more likely to be female and to have lower daily energy expenditure values than those children with BMI data (Arbour-Nicitopoulos et al., 2010). Given the findings of this study indicate obese males are particularly vulnerable to less time spent in PA, school PA promotion initiatives should consider targeting this population.

Active transport to school receives much attention as a mode to promote PA among youth. The results of this study suggest female and male students' spend 18 and 12 additional minutes per day when using active modes of transportation to school, respectively. In other words, active transport to school is an important source of PA for both genders, but particularly female students who tend to spend less time participating in PA than males, and strategies to encourage active transport to school among secondary students should be considered.

Of the school PE and PA activities examined in this study, enrolment in PE and participation in flexibility activities were the only two that had a stronger positive effect on female students' time spent in PA compared with males. School intramurals and varsity sports teams often include traditional competitive sports-related activities that have been reported to be more attractive to males than females (Sallis et al., 1996; Humbert, 1995; Gibbons et al., 1999). Indeed, research suggests females typically enjoy more individual, cooperative, and recreation activities, such as yoga, dance and aerobics (Fairclough, 2003; Gibbons et al., 1999). Secondary school PE classes in Ontario do offer female-only classes as well as curriculum that can cater to the PA needs and interests of females if implemented by PE teachers appropriately. Designing PE classes to support participation and encourage success among females by incorporating flexibility activities and other female-friendly programming should be considered.

Limitations

This study is subject to some limitations. Causal relationships cannot be inferred from these cross-sectional data; however, the relationship is beneficial for understanding associations. Over-reporting of PA is always possible with self-report instruments; however, the SHAPES student PA survey has been validated against objectively measured PA (Wong et al., 2006). Also, the 1-km school buffer zone may not have provided a complete picture of the PA opportunity structures accessible to secondary students, who may have access to transportation taking them beyond the buffer. Moreover, the availability of churches in the school neighbourhood was not considered as a feature of the school built environment despite recent evidence indicating a positive association with adolescent female PA (Trilk et al., 2011). Finally, the study involved secondary data analysis so data were not available for all of the measures in an ideal study. For example, individual-level measures of SES (e.g., household SES) were not available and area-level SES measures have been found to be weaker predictors of adolescent PA in Canada by comparison to individual SES measures (Janssen et al., 2006).

Conclusions

Because of the significant discrepancy in the time spent in PA among male and female students, and some environment- and student-level variables associated with students' time spent in PA are not consistent across genders, interventions promoting PA should take gender differences into account. Results demonstrate school variation exists for both male and female students indicating the school a student attends influences the students' time spent in PA over and above student characteristics. To increase student PA, schools should consider providing another room for PA, especially for flexibility activity programming among females. Schools should also consider offering daily PE classes to male students in senior grades and providing PA promotion initiatives specifically targeting obese males. Additional studies examining gender differences in the associations between factors of the school environment and student PA are warranted. Experimental studies with random allocation of change and no change to features of the school environment or natural experiments testing male and female students' PA pre- and post-change to features of the school environment would be stronger research designs to test the effect of the school environment on student PA, but less feasible.

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CHAPTER 5: Are environmental influences on physical activity distinct for urban, suburban and rural schools? A multilevel study among secondary school students in Ontario, Canada.

5.1 Overview

INTRODUCTON**:** The purpose of this study was to examine differences in students' time spent in PA across secondary schools in rural, suburban, and urban environments and to identify the environment-level factors associated with these between school differences in student PA when considering student characteristics and school PA programming, and while controlling for potential environment-level confounders.

METHODS**:** Multilevel linear regression analyses were used to examine the environment- and student-level characteristics associated with time spent in PA among grades 9 to 12 students attending 76 secondary schools in Ontario, Canada as part of the SHAPES-Ontario study. This approach was first conducted with the full data set testing for interactions between environment-level factors and school location. Then, school-location specific regression models were run separately for urban, suburban, and rural schools.

RESULTS**:** Statistically significant between-school variation was identified among students attending urban ($\sigma^2_{\mu0}$= 8959.63 (372.46)), suburban ($\sigma^2_{\mu0}$= 8918.75 (186.20)), and rural ($\sigma^2_{\mu0}$= 9403.17 (203.69)) schools, where school-level differences accounted for 4.0%, 2.0%, and 2.1% of the variability in students' time spent in PA, respectively. Students attending an urban or suburban school that provided another room for PA or was located within close proximity to a shopping mall or fast food outlet spent more time in PA.

CONCLUSIONS**:** The key observations of the present study are that students' time spent in PA varies by school location and some features of the school environment have a different impact on students' time spent in PA by school location. Developing a better understanding of the environment-level characteristics associated with students' time spent in PA by school location may help public health, planning, and transportation experts to tailor school programs and policies to the needs of students in different locations.

Keywords: physical activity; built environment; geographic location; adolescents; school.

5.2 Introduction

Physical activity (PA) provides immediate health benefits for youth, including reduced body fat, decreased cardiovascular disease risk, increased bone health, and decreased symptoms of depression and anxiety (Janssen and LeBlanc, 2010). Because of the rising prevalence of youth overweight and obesity across Canada, and the recent findings that less than 7% of youth 6-19 years in Canada obtain enough moderate to vigorous PA (MVPA) to meet recommendations (Colley et al., 2011; Janssen et al., 2011), public health, planning, and transportation researchers have focused on environmental features that may have the potential to influence PA for transportation and recreation among children and adolescents (Public Health Agency of Canada, 2010; Transportation Research Board, Institute of Medicine of the National Academies, 2007).

Evidence shows the prevalence of obesity is higher among youth in rural compared to urban areas in Canada (Bruner et al., 2008; Ismailov and Leatherdale, 2010; Simen-Kapeu and al., 2010); however, establishing PA as a mechanistic link to explain the increased prevalence of obesity in rural youth populations remains elusive. Data produce a reasonable consensus that rural adults are less physically active than their urban counterparts (Patterson et al., 2004; Martin et al., 2005); however, researchers examining the PA levels of youth attending schools in different geographic locations in Canada have found mixed results (Simen-Kapeu et al., 2010; Loucaides et al., 2007). Simen-Kapeu and colleagues (2010) examined grade 5 students attending 148 schools and found students attending schools in towns and rural areas of Alberta reported more PA than their urban counterparts, whereas, earlier research found no significant differences in PA between secondary school students attending eight schools in urban and rural areas in Canada (Loucaides et al., 2007). The small number of school participating in the study conducted by Loucaides and colleagues (2007) and the simple geographic split into urban and rural, however, may be at fault for masking important differences in student PA. Indeed, a recent review of the PA levels of children in different geographic locations recommended that further research divide built environments into urban, suburban, and rural to provide greater insight into differences in youth PA (Sandercock et al., 2010). Authors of the review also suggest future studies to take into account socioeconomic and seasonal effects.

The purpose of this study was to examine differences in students' time spent in PA across secondary schools in rural, suburban, and urban environments and to identify the environment-level factors associated with these between school differences in student PA while controlling for potential confounders such as socioeconomic status and season of data collection.

5.3 Methods

5.3.1 Design

This cross-sectional secondary analysis used self-report data collected from students in grades 9 – 12 and administrators at 76 high schools in Ontario as part of the SHAPES-Ontario (SHAPES-ON) study (2005-2006). Objective measures of the built environment surrounding each of the 76 schools were also collected. The University of Waterloo Office of Research Ethics and appropriate School Board Ethics committees approved this study and data collection procedures.

5.3.2 Data Sources and Procedures

Student-level Data

Student-level data were collected from consenting students by using the previously validated SHAPES PA module student questionnaire (Wong et al., 2006). The survey asks students about their demographic information and PA-related behaviours. Additional details about SHAPES, SHAPES-ON, and the survey measures and their psychometric properties are available in print (Wong et al., 2006; Leatherdale et al.,

2009) and online (www.shapes.uwaterloo.ca). Active information with passive parental permission procedures were used to reduce demands on schools and to increase student participation rates.

Environment-level Data

As part of the SHAPES-ON project, all 76 school administrators completed the Canadian Lifestyle and Fitness Research Institute's School Capacity Survey. Administrators indicated the availability of 14 different PA-related facilities at the school as well as the geographical location of the school (i.e., urban, suburban, rural) at time of recruitment. Researchers mailed administrators a standardized package including a consent form and the School Capacity Survey.

Built environment features in the neighbourhood surrounding the 76 schools were assessed using geographic information systems (GIS) data from the Desktop Mapping Technologies Inc (DMTI) data resource. Neighbourhood built environment data within 1-km circular buffers surrounding each of the 76 schools were provided by two DMTI Spatial resources; the CanMap RouteLogistics (CMRL) spatial information database and the Enhanced Points of Interest (EPOI) database. The process of identifying and linking the DMTI-EPOI data to the SHAPES-Ontario student and school survey data can be found elsewhere (Leatherdale et al., 2011; Hobin et al., submitted).

School neighbourhood SES information was collected from the 2006 Canadian Census Tract Profiles by entering the postal codes of the schools.

5.3.3 Measures

Students' Time spent in Physical Activity

For consistency with Canada's Physical Activity Guidelines for youth aged 12-17 years, this study defines student PA as average daily minutes spent performing MVPA (Tremblay et al., 2011). To calculate MVPA, each student's responses to the items "Mark how many minutes of moderate physical activity you did on each of the last 7-days" and "Mark how many minutes of hard physical activity you did on each of the last 7-days" were summed and divided by seven days. Students who reported four or more days of both moderate PA and vigorous PA were included in the analysis and students who reported less than four days of either moderate PA or vigorous PA were excluded.

Student-Level Factors

Students were asked to report their age, grade, gender, and height and weight. Age- and sex-adjusted body mass index (BMI) cut-points derived from the WHO growth charts were used to classify students' weight status (Onis et al., 2007).

Student-level predictors were consistent with previous research (Robertson-Wilson et al., 2007; Hobin et al., 2010, 2010). Student respondents reported how they usually got to and from school in the last 7-days (active, mixed, inactive (referent)), if they were enrolled in PE (Participated in 1-5 days of PE in past 7-days / Participated in 0 days of PE in past 7-days (referent)), if they participated in school intramural activities or varsity sports teams (Yes/No (referent)), and if they participated in activities for flexibility and strength (Participated in 3 or more days of flexibility and strength activities in past 7-days / Participated in less than 3 days of flexibility and strength activities in past 7-days (referent)).

Environment-Level Factors

School Social Environment Variables

Environment-level predictors were also consistent with previous research (Hobin et al., 2010, 2010). Administrators reported if their school offers daily PE class (5-days of PE class per week/<5-days of PE class per week (referent)), intramural PA programs (Yes/No (referent)), and varsity sports teams (Yes/No (referent)).

School and Neighbourhood Built Environment Variables

An administrator at each school indicated whether their school was situated in an urban, suburban, or rural location at time of recruitment.

Measures of the built environment included 14 indoor or outdoor PA-related facilities on school grounds. Administrators were asked to report if their “school has access to any of the following PA-related facilities during school hours”. Those who reported having the PA-related facility on school grounds (Yes, on grounds) were compared to those who reported not having the PA-related facility on school grounds (Yes, off grounds; No; Don’t know (referent)). Since “gymnasium”, “room with cardio and weight equipment”, and “playing fields” were reported to be available at all 76 schools and “playground equipment” was not available to high school students at any of the 76 schools, these factors were excluded from the analysis. A school facilities index was also created representing the cumulative number of PA-related facilities available on school grounds on a continuum of 1 to 10.

Built environment variables located within a 1-km circular buffer of each school including the density of recreation facilities (includes dance studios, fitness/gym facilities, sport and recreation clubs, and golf courses), parks, fast-food outlets, and shopping malls were recorded. Three continuous measures of neighbourhood design features were also considered, land mix use, residential density, and street connectivity, independently as well as part of a walkability index[1] (Frank et al., 2005).

[1]Walkability index= (6 x z-score land-use mix diversity) + (z-score street connectivity) + (z-score residential density)

Potential Environment-Level Confounders

Based on the date of data collection, schools were classified according to the season in which data were collected. As in other studies (Robertson-Wilson et al., 2007; Merriam et al., 1999), data collected from schools in the winter (December 21–March 20; referent) were compared to data collected from schools in the spring and fall seasons (spring: March 21–June 20, fall: September 21–December 20).

Using data from the 2006 Canadian Census Tract Profiles, the area-level SES measure for each school was based on the proportion of households in the census tract living below the Statistics Canada low-income cut-off (LICO). A definition of the LICO values and how they are calculated is provided by Statistics Canada (Giles, 2004). The LICO function at the census tract level was available for postal codes of 56 schools (74%) of schools. School postal codes that did not have a LICO value at the census tract level were taken at the level of the census agglomeration (i.e., one level less specific, typically for rural areas).

5.3.4 Analysis

Due to the hierarchical nature of these data, a hierarchical linear regression modeling approach was used to evaluate the degree to which environment-level factors were associated with an individual's average daily time spent performing MVPA, herein referred to as students' time spent in PA, when considering school PE and PA programming, and while controlling for potential environment-level confounders. Consistent with previous research (Elliott et al., 1993; Loucaides et al., 2007), a three-step modeling procedure was used to examine student PA. This 3-step modeling approach was first conducted with the full data set testing for interactions between environment-level factors significant in the univariate analysis and school location. Then, school-location specific regression models were run separately for urban, suburban, and rural schools to explore if indeed unique associations between school location and student PA could be identified. Analyses were conducted using PROC MIXED in SAS version 9.2 (Cary, NC).

5.4 Results

As shown in Table 17 (Appendix AA), significant differences were found across school locations for students' time spent in PA ($F=16.47$, $p<0.0001$). Students attending rural schools (mean PA=155.6, SD=97.7) reported more time spent in PA than students attending urban schools (mean PA = 148.0, SD=96.3) or suburban schools (mean PA=150.9, SD=95.4). Results also indicated, however, a higher percentage of students attending urban schools used active or mixed modes of transportation to school than students attending rural schools ($X^2=164.15$, $p<0.0001$). Across school locations (Table 18, Appendix BB), a significantly higher percentage of urban schools compared to rural schools do not offer daily PE to students ($X^2=6.85$, $p=0.03$) and do not have access to a running track on school grounds ($X^2=6.58$, $p=0.04$).

5.4.1 Environment-Level Factors associated with Students' Time Spent in Physical Activity

Building on the univariate analysis (Table 19, Appendix CC), results of the multilevel models for students' time spent in PA for the full data set and stratified by school location are presented in Tables 20-22 (Appendices EE-GG). Results from the multilevel analysis using the full data set did not indicate any significant interactions between environment-level variables found to be significant in the univariate analysis and school location (Table 20, Appendix DD). In the models stratified by school location, statistically significant between-school variation was identified among students attending urban ($\sigma^2_{\mu 0}$= 8959.63 (372.46)), suburban ($\sigma^2_{\mu 0}$= 8918.75 (186.20)), and rural ($\sigma^2_{\mu 0}$= 9403.17 (203.69)) schools, where school-level differences accounted for 4.0%, 2.0%, and 2.1% of the variability in students' time spent in

PA, respectively. Table 21 (Appendix EE) presents results of school-location specific models including the walkability and student- and environment-level variables.

In the models stratified by school location (Table 21, Appendix EE), environment-level factors found to associate with increased time spent in PA for students' attending urban schools included having another room for PA in schools (β=17.35, SD=7.29, p= 0.03) and having one shopping mall within a 1-km radius of the school (β=23.15, SD=7.89, p=0.01). Environment-level factors shown to associate with increased time spent in PA for students attending suburban schools included offering daily school PE (β=12.23, SD=5.27, p=0.03), having another room for PA on school grounds (β=19.34, SD=7.46, p=0.02), and being located within a 1-km radius of one fast food outlet (β=18.80, SD=6.07, p=0.01). None of the environment-level factors were associated with students' time spent in PA across rural schools, and no contextual interactions between environment- and school-level variables were detected for urban, suburban, or rural schools. The log likelihood tests demonstrated adding each block of variables significantly contributed to the prediction of students' time spent in PA among urban schools (e.g., deviance between adding built environment block and potential confounders to model: 80163 – 80149 = 14, df=2, p<0.05, two-tailed test) and suburban schools (e.g., deviance between adding built environment block and potential confounders to model: 122471 – 122449 = 22, df=2, p<0.05, two-tailed test).

As presented in Table 22 (Appendix FF), a separate model including the walkability index, student- and environment-level factors, and potential school-level confounding variables was also examined by school location. The association between time spent in PA among students attending suburban schools and the walkability index (β=-4.39 (1.27), p=0.002) remained significant even after adjusting for all other variables in the full model. The walkability index variable was not significantly associated with time spent in PA among students attending urban (β=-5.22 (3.24), p=0.13) or rural (β=0.48 (1.39), p=0.73) schools.

5.4.2 Student-Level Factors associated with Students' Time Spent in Physical Activity

As shown in Table 21 (Appendix EE), student-level factors found to associate with increased time spent in PA among students attending schools in urban areas included being male (β=22.82, SD=2.19, p<0.0001), using active modes(β=17.16, SD=2.74, p<0.0001) and mixed modes (β=10.59, SD=2.61, p<0.0001) of transport to school compared to inactive modes of transport to school, enrolling in school PE (β=23.63, SD=2.41, p<0.0001), participating in school intramurals (β=22.77, SD=2.85, p<0.0001) and varsity teams (β=10.40, SD=2.70, p<0.0001) as well as participating in flexibility activities (β=22.85, SD=2.43, p<0.0001) and strength activities (β=31.71, SD=2.62, p<0.0001) 3 or more days per week compared to less than 3 days per week. Being in grades 10 (β=-9.47, SD=2.91, p<0.0001), 11 (β=-12.19, SD=3.02, p<0.0001), and 12 (β=-14.72, SD=3.04, p<0.0001) compared to grade 9 were found to associate with decreased time spent in PA among students in urban schools. Student-level factors found to associate with increased time spent in PA among students attending suburban schools included being male (β=27.04, SD=1.76, p<0.0001), using active modes of transportation to school (β=11.19, SD=2.31, p<0.0001) compared to inactive modes of transport to school, enrolling in school PE (β=20.21, SD=1.94, p<0.0001), participating in school intramurals (β=22.97, SD=2.23, p<0.0001) and varsity teams (β=10.41, SD=2.14, p<0.0001) as well as participating in flexibility activities (β=27.69, SD=1.97, p<0.0001) and strength activities (β=25.44, SD=2.11, p<0.0001) 3 or more days per week compared to less than 3 days per week. Being in grades 11 (β=-8.78, SD=2.44, p=0.0003) and 12 (β=-17.53, SD=2.54, p<0.0001) compared to grade 9 were found to associate with decreased time spent in PA among suburban students. Lastly, the student-level factors found to associate with increased time spent in PA among students attending rural schools were being male (β=24.97, SD=2.79, p<0.0001), using active modes of transport to school (β=19.11, SD=3.83, $p<0.0001$) compared to inactive modes of transport, enrolling in school PE (β=23.19, SD=3.06, $p<0.0001$), participating in school intramurals (β=15.44, SD=3.66, $p<0.0001$) and varsity teams (β=11.87, SD=3.49, $p<0.0001$), as well as participating in flexibility activities (β=19.05, SD=3.12, $p<.0001$) and strength activities (β=29.95, SD=3.32, $p<0.0001$) 3 or more days per week compared to less than 3 days per week. Being in grade 12 (β=-17.80, SD=3.93, $p<0.0001$) compared to grade 9, and being obese (β=-11.74, SD=5.41, $p=0.0301$) compared to healthy weight were found to associate with decreased time spent in PA among rural students.

5.5 Discussion

In addition to identifying significant differences in students' time spent in PA by location, we also identified that attending urban and suburban schools with another room for PA and located within close proximity to facilities that provide students with opportunities for social interaction encourages students to spend more time in PA. These new insights are important as social interaction with peers is a top priority for adolescents and is consistent with previous research demonstrating adults are more active if they reside in neighbourhoods located near shops and restaurants (Duzenli et al., 2010; Frank et al., 2007). When the full data set was examined no significant interactions between environment-level factors and school location were detected. Despite the lack of interactions between environment-level factors and school location, additional models stratified by school location were analyzed due to the mixed results of previous studies investigating the PA discrepancies among youth across locations and expert requests for more research investigating PA discrepancies among youth in urban, suburban, and rural areas (Sandercock et al., 2010).

From the models stratified by school-location, we identified that school-level differences accounted for a statistically significant amount of the variability in time spent in PA among students attending urban

(4.0%), suburban (2.0%), and rural schools (2.1%) suggesting that the characteristics of the school environment a student attends are associated with their PA. We also identified environment-level factors associated with time spent in PA among students attending urban and suburban schools but not rural schools. Three possible explanations for not finding a significant association between environment-level factors and the PA of students attending rural schools include issues with how variables were defined, sample size, and the possibility that environmental variables relevant for more urban areas do not apply to rural areas. In this thesis the school PA facilities index was created as a continuous variable, however, previous research conducted by Trilk and colleagues (2011) found female students attending rural secondary schools are more apt to be active if they attend a school with the greatest number of PA facilities in the school neighbourhood (75^{th} percentile) compared to the fewest number of PA facilities (25^{th} percentile). Exploratory analyses to test the associations between student PA and alternative methods of creating the school PA facilities index were conducted and still schools with the greatest number of PA facilities did not associate with student PA among rural schools in the current study (Appendix GG). Another potential explanation for not finding significant associations between environment-level factors and students' time spent in PA among rural schools is sample size. There were only 20 rural schools participating in this study. Experts suggest aiming for a minimum sample size of approximately 30 units at each level in multilevel analysis, particularly at the highest level, to avoid a reduction in the accuracy of point estimates for each level of factors (Bell et al., 2008; Mass and Hox, 2005); therefore, the findings suggest there may have been enough power to detect significant associations between student PA and factors of the school environment for the 30 suburban schools and 26 urban schools, but not the 20 rural schools. Nevertheless, no singleton groups (e.g., group of 1 student in 1 school) were included in the analysis and the results of this study were helpful in identifying school-level factors associated with students' time spent in PA among urban and suburban schools. Finally, the features of the schools' neighbourhood environment examined in this thesis and found to associate with students' time spent in PA (e.g., shopping malls, walkability) may be pertinent for urban and suburban locations but not rural locations. Future research may need to focus on neighbourhood of rural schools to identify environmental features associated with students' time spent in PA.

At the environment-level, having another room for PA within schools was found to associate with increased time spent in PA among students in urban and suburban schools. One explanation for the positive association between student PA and another room for PA in schools is that secondary school students in Canada spend the majority of time indoors when at school. However, a common complaint from school staff is indoor space for PA in schools in limited (Dwyer et al., 2006). Adapting a room for PA within a school located in urban and suburban areas may be a promising solution for increasing the amount of indoor space in schools for student PA; however, this approach requires evaluation.

Attending an urban or suburban school within close proximity to facilities that provide an opportunity for social interaction with peers also appear to encourage students to walk to these establishments and thus spend more time in PA. Findings from the present study suggest exposure to a shopping mall or a fast food outlet can have a protective factor against inactivity among students attending schools located in urban and suburban areas. Previous research indicates proximity to destinations with opportunities for social interaction to associate with adolescent PA including shopping malls and fast-food outlets (Duzenli et al., 2010; Mota et al., 2005; Cradock et al., 2009; Dalton et al., 2011). More specifically, Duzenli and colleagues (2010) found shopping malls to be the most preferred environment for PA by adolescents living in urban areas in Turkey. Other research conducted in the US by Mota and colleagues (2005) also found adolescents' perceived accessibility of shops to be an important influence on PA. Nevertheless, the positive association between students' time spent in PA and close proximity to a fast food outlet may be surprising given the well-established evidence indicating eating fast food to cause a higher risk of overweight and obesity among adolescents (Taveras et al., 2005; Bowman et al., 2004). Yet a recent study examining the association between the food retail environment surrounding schools and overweight in grades 6-10 students in Canada did not find an increased likelihood of overweight (Seliske et al., 2008). Indeed, other studies examining both the proximity and density of fast food outlets to place of residence and adolescent levels of overweight and obesity have found no association (Richardson et al., 2011). Locating destinations of interest to youth, including shopping malls and fast food outlets, within close proximity to schools appears to encourage students to spend more time in PA, nevertheless, given eating fast food is known to contribute to overweight and obesity among youth, balancing the tradeoffs between exposing students to fast food outlets and increases in PA needs to be further examined before recommendations can be made.

Finally, students attending suburban schools in areas with lower walkability were found to report more time spent in PA. This finding is consistent with some previous evidence demonstrating children residing in suburban areas or small towns characterized by streets with low connectivity (e.g., cul de sacs) engage in more PA than their urban counterparts (Sandercock et al., 2010; Brockman et al., 2011) but counter to the results found for adults in international studies, showing consistently that adults living in neighbourhoods with high-walkability are more physically active (Frank et al., 2010). According to Van Dyck and colleagues (2009), who also found a negative relationship between PA and walkability among a sample of Belgian adolescents, this suggests that the associations between neighbourhood walkability and PA may be different for adolescents than for adults, which is important for the development of future environmental interventions.

Differences in student-level factors associated with students' time spent in PA were also evident across school location. There was a strong negative association between being obese and time spent in PA among students attending rural schools only. This specific association between obesity and student PA among students attending rural schools only is interesting as previous research has found a higher prevalence of overweight and obesity among adolescents in rural areas of Canada compared to urban and suburban areas (Janssen et al., 2011), but the mechanism by which the prevalence of obesity is higher among rural youth compared to urban or suburban youth is not clear. More research is needed to further untangle this relationship and identify unique barriers for obese youth to be active in rural areas compared to urban and suburban locations.

Students using active modes of transport spent significantly more time in PA across all school locations; yet, students attending urban schools reported spending more time in PA if they used either active or mixed modes of transport to school. This is not surprising as the percentage of students using active and mixed modes of transport to school in urban schools in this study is significantly higher than in suburban or rural schools. Moreover, a greater presence of common indicators known to encourage active modes of transport, such as the presence of shopping malls, fast food outlets as well as higher levels of land use mix diversity and walkability, were found in urban school environments compared to their suburban and rural counterparts.

Limitations

Several limitations of this study must be considered. First, more rural schools need to be added to the sample to increase power to potentially detect environment-level factors associated with student PA. Next, because no data on ethnicity are available within the measurement tools used, we were unable to examine how students' time spent in PA may vary across ethnic groups. Similarly, an individual-level measure of SES was not available and should be considered in future studies as area-level measures of SES have been found to be weaker predictors of adolescent PA in Canada (Janssen et al., 2006).

Furthermore, the administrator survey did not include information on whether school policy allowed students to leave school property during breaks. With this information, the relationship between destinations of interest to youth located near the school and student PA may become clearer. The administrator survey also only inquired as to whether or not school varsity sports or intramural PA programs offered to students and not the number of programs provided. Also, because the built environment information was only available within a 1-km radius of schools, some features of the built environment within school neighbourhoods may have been overlooked, especially in rural areas. Larger or various buffer sizes have been suggested to capture effects of some features of the built environment on student PA (Boone-Heinonen et al., 2010). Finally, causal relationships cannot be inferred from these cross-sectional data. Although validity of data based on self-report may be questioned, measures in the PA module have been previously demonstrated to be reliable and valid (Wong et al., 2006).

Conclusions

The key observations of the present study are that students' time spent in PA varies by school location and some aspects of the school environment have a differential impact on students' time spent in PA by school location. Adapting other rooms in schools to be used for student PA appears to be a potential solution for increasing students' time spent in PA for schools located in both urban and suburban areas. Urban and suburban schools may also benefit from students spending more time in PA if the school is situated within close proximity to a shopping mall or fast food outlet but further research is required to better understand this relationship. Finally, students attending suburban schools in neighbourhoods with high-walkability were found to report less time spent in PA. Further research including a larger number of rural schools is necessary to better understand the association between student PA and factors of the school environment by school location.

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CHAPTER 6: GENERAL DISCUSSION AND RECOMMENDATIONS

6.1 Overall Findings

The series of studies described in this thesis assessed the associations between students' time spent in PA and factors of the school environment among students in grades 9 - 12 from 76 secondary schools across Ontario. The school environment appears to be associated with students' time spent in PA overall (Study #1), as well as by gender (Study #2), and by school location (Study #3). Various factors of the school environment were also found to associate with time spent in PA among students overall, among male and female students, as well as among students attending urban and suburban schools but not rural schools. Most school-based PA studies and interventions to date have targeted individual-level factors but there is much less information on how factors of the school environment associate with student PA. Identifying significant between school variation in students' time spent in PA and the environment factors associated with this variability is important as it may contribute to improving school-based PA intervention effectiveness and support planning to target PA programming and policies for students overall as well as for specific subgroups of students, such as females.

6.1.1 Students' Time Spent in PA

As anticipated, students self-reported high levels of time spent in PA. This observation is based on the results of the criterion validity study of the SHAPES PA module student questionnaire and comparison data from the Canadian Health Measures Survey suggesting that the outcome variable, students' time spent in PA, was likely over-reported (Wong et al., 2006; Colley et al., 2011). Over-reporting in self-report measures of PA among youth is common (Wong et al., 2006; McMurray et al., 2004); nevertheless, the SHAPES PA survey used in this study has been validated for comparing youth who report more compared to less MVPA as the bias in over-reporting was consistent across students (Wong et al., 2006), and therefore is appropriate for providing insight into associations with PA. The PA results should not be used, however, to group youth as active or inactive according to externally predetermined PA time standards.

Students' time spent in PA was also examined by gender and school location, and trends found were consistent with previous research (Colley et al., 2011; Simen-Kapeu et al., 2010; Bruner et al., 2008). It is well established that males spend more time in PA than females at all ages, especially during adolescence (Strauss, Rodsilsky, Burack, and Colin, 2001). Indeed, direct measures of PA among Canadians 6-19 years indicate double the percent of males versus females meet the 60 minutes per day recommendation for PA (Colley et al., 2011). Similarly, results in this thesis showed males reported spending significantly more minutes per day in PA than females. Results of this study also indicated students attending schools in rural areas were found to spend significantly more time in PA than students attending schools in suburban areas or urban areas. Studies examining youth PA by geographic location provide some evidence for higher PA among adolescents living in rural areas when compared to their urban counterparts (Liu et al., 2006; Bruner et al., 2008), while one study showed adolescents living in suburban areas are most active (Nelson et al., 2006) and another reported no difference in youth PA by geographic location (Loucaides et al., 2007). The results of this thesis provide more evidence to support the well-established gender disparity in PA. The findings also help to describe student PA patterns by school location. Together these data can inform PA interventions to create more effective PA promotion programs targeting specific sub-populations of students.

6.1.2 Importance of the School Environment

Consistent with tenets of ecological theory (Brofenbrenner, 1979), significant between-school variability in students' time spent in PA across the 76 schools participating in this research was identified overall (3.0%), for males (2.8%) and females (2.1%), as well as for students attending urban (4.0%), suburban

(2.0%), and rural (2.1%) schools. Although the amounts of school-level variability identified in the three studies of this thesis appear modest, three previous studies examining between-school variability in PA during school recess, overall MVPA, leisure-time sports, and active transportation found similar between school variation levels of 7.0%, 8.0%, 1.1%, and 5.5%, respectively (Haug et al., 2008; Spence et al., 2010, Deforche et al., 2010). Other school-based research has also identified similar levels of significant between-school variability in student health behaviours, such as smoking (Murray et al., 2002; Murray et al., 1997) and obesity (Leatherdale and Papadakis, 2011) accounting for approximately the same magnitude of variance in the dependent variables. Thus, findings from previous PA, tobacco, and obesity studies are consistent with the levels of between school variation for PA observed in the current study.

From a population perspective, the modest amounts of between school variability found in students' time spent in PA across schools in this thesis are meaningful. They are meaningful as even small shifts in students' time spent in PA at the environment-level could result in a substantial population level impact when applied across a large number of schools and students (Rose, 1992; Leatherdale and Papadakis, 2010). With approximately 700,000 students attending more than 850 publicly funded secondary schools in Ontario each year (Ontario Ministry of Education, 2011), implementing population-level approaches could contribute modest but important improvements to student PA as small increases in time spent in PA have been shown to have health benefits (Janssen and LeBlanc, 2010). Additionally, by affecting large numbers of people, not just individuals enrolled in a particular intervention, these changes can potentially have broad-based impact on student PA that affects all students including subgroups of students who are more at-risk of not participating in PA (e.g., females, older students) (Ross et al., 2004; Stokols, 1988). Moreover, recent cost-effectiveness analyses examining PA interventions suggest the most cost-effective programs reach large numbers with simple, low-intensity campaigns (Wu et al., 2011). Given the large number of students attending schools in Ontario and the generally limited financial resources available to invest in student PA, the results of this thesis suggest population level approaches can be impactful and therefore should be considered by policy-makers and program planners when developing school-based PA interventions.

6.1.3 Factors of the School Environment associated with Students' Time Spent in PA

Results from Study #1 showed attending a school with another room for PA was found to associate with more time spent in PA among students. Of the 76 schools participating in this research, 80.3% (N=61) reported having another room for PA available to students. One potential explanation for the association between higher amounts of students' time spent in PA and another room for PA in schools is that secondary students in Ontario spend the majority of time indoors when at school. However, a common complaint from school staff is indoor space for PA in schools is limited (Dwyer et al., 2006; Jenkinson et al., 2010). Adapting a room in a school to be used for PA may be a promising solution for increasing the amount of indoor space in schools for student PA; however, this approach requires evaluation.

With the exception of another room for PA in schools, no other significant associations between PA facilities on school grounds and students' time in PA were identified in Study #1. Previous multilevel school-based studies examining the influence of school PA facilities have found a positive association with student PA (Haug et al., 2008, 2009, 2010; Nichol et al., 2009); however, each of these studies investigated PA outcome measures specific to school-related PA such as PA during recess or PA during class-time. Moreover, two of these studies investigated the association of student PA and school PA facilities separately for male and female students (Haug et al., 2010; Nichol et al., 2009). The null associations between students' time spent in PA and school PA facilities in Study #1 may indicate that the influence of the single school PA facilities included in this study on students' time spent in MVPA per day is not strong enough to be detected or may be a function of using a continuous PA outcome measure such that the impact of a school PA facility causing a 1-minute change in students' time in PA is unreasonable. Self-reported total MVPA captures a range of different activities, such as brisk walking, playing football, and running, taking place in various locations throughout the day, and sums them into one overall measure of MVPA. According to Giles-Corti and colleagues (2005), the fact that MVPA is a summary measure may prevent finding associations between specific activities and individual school PA facilities. Hence, measures of PA specific to type (e.g., running), intensity (e.g., vigorous PA), time (e.g., lunch hour), and location (e.g., walking/running track) may be needed to discern the influence of individual school PA facilities on student PA. Moreover, due to the recognized differences in male and female students' preferences for PA and the results of previous research identifying a gender effect, assessing the influence of single school PA facilities on student PA separately for males and females is warranted.

Consistent with previous research, a school PA index was created in this thesis to capture the cumulative effect of multiple school PA facilities on student PA (Haug et al., 2008; 2009, 2010; Nichol et al., 2009). Unlike previous research, however, a significant association between the school PA facilities index and students' time spent in PA was not detected in Study #1. This was unexpected as the importance of PA facilities on school grounds is evident and has been emphasized internationally in previous research (Durant et al., 2009; Everett Jones et al., 2003; Sallis et al., 2003; Trudeau and Shephard, 2005; de Vet et al., 2011). A possible explanation for the lack of association between student PA and the school PA facilities index in Study #1 of this thesis is how the school PA facilities index was constructed. Consistent with the study conducted by Haug and colleagues (2008), the school PA facilities index used in this thesis measured the cumulative effect of school PA facilities on school grounds on a continuous scale from 1 to 10. Other studies however, have used various methods for computing a school PA facilities index such as comparing schools with the fewest number of facilities to schools with the greatest number of facilities (Haug et al, 2010; Nichol et al., 2009) and calculating the proportion of students to the number of school PA facilities. Similar approaches to creating school PA facilities indices were also tested in this thesis to determine if alternative approaches to creating school PA facilities indices were more appropriate scales for examining if exposure to a high density of school PA facilities influences student PA. Results of these exploratory tests did not indicate stronger associations between school PA facilities and student PA (Table 23, Appendix GG). Nevertheless, future research examining associations between student PA and the school built environment should also consider various methods for computing a school PA facility index.

Another explanation for the null results between student PA and school PA facilities in this study may be there is no variability across schools in students' use of the facilities; however, data on students' use of school PA facilities was not collected as part of the SHAPES-ON study and therefore could not be examined. A recent observational study examining students' use of school PA facilities in four middle schools in the US reported 68% of designated school sport areas vacant during the after -school (2:30-4:30pm) period (Bocarro et al., 2011). Another observational study examining the use of school playgrounds found that although PA levels were high when children were present, overall utilization was low (Colabianchi et al., 2009). School PA facilities are believed to be an important environment to facilitate PA among youth but are only valuable when they are being used. In addition to availability, assessing students' usage of school PA facilities may assist in better understanding the relationship between school PA facilities and student PA.

The third possible explanation for the null results between student PA and school PA facilities in this study may be that the condition or quality of the school PA facilities was not captured in the data. It has been pointed out that not only the availability of school PA facilities, but also the features, conditions, and aesthetics are important to students (Tucker et al., 2009; Nichol et al., 2009); nevertheless, the relationships between student PA and school PA facilities within the constructs of quality, condition, and aesthetics are less frequently published and consequently less developed (Giles-Corti et al., 2009). Of the available research investigating the link between quality, condition, and aesthetics of school PA facilities and student PA, one study found counterintuitive positive significant associations between the poor condition of school gymnasiums (compared to neutral) and junior high school students' class-time PA, the poor and good condition of school gymnasiums (compared to neutral) and male students' free-time PA, and the poor and good condition of playing fields (compared to neutral) and female students' free-time PA (Nichol et al., 2009). Due to the cross-sectional nature of the data in the study conducted by Nichol and colleagues (2009), unestablished temporality could potentially explain the counterintuitive finding that poor field and gym conditions were associated with greater free-time PA among students; although good field and gym conditions may drive students to use these facilities, greater use of the facilities may cause them to deteriorate. Further examination of the association between quality, condition, and aesthetics of school PA facilities may provide important information for creating school environments supportive of student PA.

Results of Study #1 also showed null associations between student PA and the availability of recreation facilities and parks in the neighbourhood surrounding schools. Although it is possible that these PA facilities in the school neighbourhood are not important influences on students' time spent in PA, the lack of data in the current study explaining the quality, condition, and aesthetics of these facilities may again be a possible explanation for the null associations with student PA. Indeed, McCormack and colleagues (2010) reported that not only proximity to a park, but also its conditions and aesthetics are important for visiting a park. Moreover, qualitative research examining the condition of neighbourhood

PA facilities has also linked the better maintained and more aesthetically favourable facilities with adolescent PA (Cohen et al., 2006; Kelty et al., 2008; Whitehead et al., 2006). In a study of adolescent females in Scotland, for example, Whitehead and colleagues (2006) found that the condition of recreation facilities (e.g., maintenance and cleanliness) appeared to influence use by study participants, over and above accessibility. In other words, after some point, increasing units of PA facilities may not continue to increase student PA and the quality, condition, and aesthetics of these facilities may need to be improved.

In addition to the conditions and aesthetics of parks and recreation facilities, other characteristics of that were not captured in this thesis may also explain the null association with students' time spent in PA such as the cost of using facilities and facility programming. For example, studies examining the influence of cost for using recreation facilities and adult and adolescent PA have produced mixed results (Diez Roux et al., 2007; Boone-Heinonen and Gordon-Larsen, 2011); adult PA was found to positively associate with fee-based facilities whereas no association was found between cost of using facilities and adolescent PA. Facility programming may also be an important factor affecting the influence of recreation facilities and parks on student PA as an intervention study investigating the impact of redesigning parks on female adolescents' use of parks found an increase in use only among parks with programming (Tester and Baker, 2009). Given the small number of studies considering the influence of characteristics of recreation facilities and parks and the mixed results of the available research more research is warranted.

Results of Study #1 also indicate there was no association between student PA and the density of fast food outlets and shopping centres in the school neighbourhood. The consistent lack of association between student PA and the density of opportunity structures for PA in the neighbourhood surrounding the school may be due to the 1-km buffer size applied to define the school neighbourhood in this thesis. Since no standard method exists for assessing school neighbourhood environments in PA research, it is unclear what buffer distance around schools would be appropriate for modelling student PA. The 1-km buffer size applied in this research was chosen as recent qualitative and quantitative research suggests a buffer size of 1-km surrounding schools to be considered a reasonable walking distance for adolescents (Colabianchi et al., 2007; Cohen et al., 2006; Boone-Hennion et al., 2010; Trilk et al., 2011). This body of research includes one study using Global Positioning Systems (GPS) and accelerometers to assess the location of student PA and found the majority of student PA occurs within 1-km of the school (Maddison et al., 2010). Despite these advances in determining the location of student PA in the school environment, the most appropriate buffer size for capturing the built environment features surrounding schools that influence student PA has yet to be determined. A recent study examining adolescent PA and various buffer sizes for assessing built environment features in the adolescents' residential neighbourhood found that the objectively measured availability of PA facilities and parks at buffers of 400m, 800m, and 2000m were not associated with adolescent MVPA (Prins et al., 2011). Similar to this type of research being conducted in adolescents' residential neighbourhoods, additional research is needed to determine appropriate buffer sizes for best capturing the built environment features surrounding schools that associate with student PA before the influence of these facilities on students' time spent in PA can be determined. Moreover, assessing the specific distance between schools and built environment features (e.g., recreation facilities, parks) or refining the buffer to a shape that includes both the school and where the student lives are alternative options to consider.

Results of Study #1 showed land use mix diversity to negatively associate with students' time spent in PA. The walkability index was found to have a negative but weaker association with students' time spent in PA. These findings are opposite to the results found for adults in international and US studies, showing consistently that adults living in areas with higher land-use mix diversity or in high-walkable neighbourhoods are more physically active (Duncan et al., 2010; Sallis and Owen, 2002; De Bourdeaudhuij et al., 2003). According to Van Dyck and colleagues (2009), who also found a negative association between neighbourhood walkability and adolescent PA, this suggests that the influence of neighbourhood walkability on PA may be different for adolescents than for adults. This is plausible as environmental correlates found to associate with adult PA do not necessarily influence adolescent PA; for example, results of studies consistently demonstrate adults residing in urban settings to be more active than their suburban or rural counterparts (Patterson et al., 2004; Martin et al., 2005) whereas the results of a review of studies examining this relationship among adolescents and children are mixed (Sandercock et al., 2010). The discrepancy may cause a challenge for public health officials and urban planners when developing strategies for optimizing land-use mix diversity and walkability as the relations between these urban form features and PA for students, as reported here, are in the opposite direction to those previously reported for adult PA. Thus, the current public health and urbanist movement to create neighbourhoods with high land-use mix and walkability, with the goal of increasing PA, may have a negative effect on the PA patterns of students and is important to consider in future environmental interventions for adolescent PA. Further research investigating the relationship between student PA and walkability in school neighbourhoods is necessary. It would also be valuable to generate evidence observing changes in student PA when moving or transferring to a new school.

The negative associations between students' PA, land-use mix diversity, and walkability in the school environment are also somewhat unexpected as children and adolescents are less mobile than adults and therefore likely to be influenced by the features in their local surroundings. However, as secondary students get older and acquire their driver's licence, their primary mode of transportation may change from more active modes of transportation to less active modes (i.e., an automobile). Due to the secondary nature of this data, information on whether or not students, or their peers, have a driver's licence or access to a car as their primary mode of transportation is unavailable. Additional studies are needed to fully examine how relationships between the school built environment and PA vary among students with and without a driver's licence and access to an automobile.

One final explanation for the small negative association between walkability and student PA is the large sample size of student participants in the SHAPES-ON study and the potential for the study to be overpowered. The larger the sample size, the more likely a hypothesis test will detect a small difference, and Type I error will occur. Consequently, it is especially important to consider the practical significance of the association in public health when the sample size is large and not just the statistical significance. Results of the current study suggest student PA decreases by approximately 2.8min/day with a 1 unit increase in walkability; however, since walkability is measured as a combination of land-use mix diversity, street connectivity, and residential density, changes to these urban form factors may not be simple and potentially require substantial resources. Nevertheless, given the potential for small population-level changes to have significant impacts when applied across large numbers of individuals, the relationship must not be discounted and further analysis examining walkability and student PA should be considered.

Results from Study #1 also demonstrated null associations between students' time spent in PA and street connectivity and residential density. The null findings are consistent with most previous research including two reviews which reported null relationships between active transport to school, street connectivity, and residential density in an overwhelming majority of available studies (Wong et al., 2011; Timperio et al., 2006; Mota et al., 2007). However, a recent study conducted among students in grades 6 to 10 in Canada reported a negative association between street connectivity within 5-km of schools and students participating in at least four hours of PA per week outside of school hours (Mecready et al., 2011). Results showed students attending schools in neighbourhoods with lower street connectivity scores (i.e., quartiles 2, 3, 4) were more likely to be physically active outside of school than students from neighbourhoods with higher connectivity scores (i.e., quartile 1). Unlike the current thesis where street connectivity is defined as "the total number of street intersections within the school's geographic area" and measured as a continuous variable, the street connectivity measure in the study by Mecready and colleagues (2011) was created as a composite street connectivity scale based on intersection density, average block length, and connected node ratio, and split into quartiles. The lack of consensus among the current thesis and the study by Mecready and colleagues (2011) may be explained by the use of varying measures of connectivity and warrants replication analyzing student PA and street connectivity in the school environment in a different population.

Students' time spent in PA was found to positively associate with schools offering daily PE; students spent more time in PA if they attended schools that offered daily PE compared with students attending schools that did not offer daily PE. The association between students' time spent in PA and attending a school that offered daily PE remained significant even when adjusted for student participation in PE. In other words, students attending a school that offered daily PE reported higher average daily time spent in PA than students attending schools that did not offer daily PE, regardless of whether or not those students were taking PE.

The mechanism by which offering daily PE in schools may influence students' time spent in PA is unclear. Of note is that the only school PA programming that was significantly associated with students' time spent in PA was also the only variable related to curricular PA. Other school PA programming examined related to schools offering extra-curricular school physical activities, such as intramurals and varsity team sports, but uncovered no relationship. This finding is not consistent with the results of a natural experiment demonstrating when more opportunities to be physically active are made available at school, secondary students will respond positively by participating in these activities, and they become more physically active (Pabayo et al., 2006). It is likely the null associations between schools offering intramurals and varsity sports and student PA found in the current study is due to a lack of variability across schools or a 'ceiling effect' as 86.8% (N=66) and 76.3% (N=58) of schools offered school varsity sports and intramurals, respectively. The current thesis also did not consider the number or type of intramural and varsity sports teams offered by schools, which may be a more appropriate measure of the PA opportunities offered by schools.

An understanding of the Ontario secondary school schedules at the time of the SHAPES-ON data collection may also provide insight on the association between student PA and schools offering daily PE. Secondary school schedules are determined at the school board level or by the school administrator. At the time of the SHAPES-ON data collection, secondary schools either followed a semester or non-semestered school schedule. A semester school schedule requires students to attend the same classes daily for approximately five months of the school year (September to January, February to June) whereas a non-semestered school schedule often requires students to attend classes on alternate days throughout the entire school year. Therefore, students attending a school following a non-semestered schedule are likely not offered daily PE. This is encouraging as school schedules are modifiable and thus are amenable to intervention. Due to the secondary nature of the data used in the current thesis, data describing the school schedule were not available and therefore controlling for the influence of the school schedule on student PA was not possible. Additional research is required to determine if indeed the positive association between the provision of daily PE and student PA is a function of the school calendar.

Overall, the association between student PA and schools offering daily PE is optimistic considering that there is an emergence of education policies designed to increase the frequency of PE classes or extend the number of PE credits required for graduation from secondary school (e.g., the policy recently implemented in Manitoba, Canada) for the purposes of increasing student PA. This finding is also consistent with the advice of stakeholders who have been advocating for schools to provide daily PE classes to students (PHE Canada, 2010; WHO, 2007).

6.1.4 Gender differences in Associations between Factors of the School Environment and Students' Time Spent in PA

Due to the well-established disparities in PA by gender, experts increasing calls for more critical examinations of the built environment-PA relationship by gender, and building on the results of Study #1, separate analyses were conducted to investigate the influence of school environment factors on female and male students' PA. As stated earlier, significant between school variation in students' time spent in PA was detected for males (2.8%) and females (2.1%). Generally, the results of Study #2 indicated few main effects for environment-level factors and female and male students' PA but two contextual interactions were detected.

The environment-level factor, attending a school with another room for PA was found to associate with more time spent in PA among both females and males. This finding is consistent with Study #1 and could be due to the lack of indoor space available in schools for students to use for PA. To better understand the relationship between attending a school with another room for PA and student PA, in the exploratory analysis two-way interactions between another room for PA and student-level factors were examined for each gender. Although no interactions between attending a school with another room for PA and student-level factors were detected for male students, a significant interaction between attending a school with another room for PA and participation in flexibility activities on 3 or more days per week was significant among females. Females who participated in flexibility activities 3 or more days per week reported spending more time in PA especially if they attended a school with another room for PA (Figure 5, Appendix Y). Previous research suggests female secondary school students prefer individual and cooperative activities such as dance and yoga (Gibbons et al., 1999). Moreover, focus groups conducted with a sample of female students in grades 6 to 8 in the US revealed that female students perceived they had fewer sport options than males, and the programs, when co-educational, tended to be dominated by males (Witmer et al., 2011). Therefore, adapting a room for PA within a school may provide the extra space needed to enable additional school PE classes or school PA-programming activities that are female-only or offer activities that are known to be particularly attractive to females. Further research is needed to better understand how having another room for PA in schools contributes to students' time spent in PA by gender. Identifying the role of having another room for PA in schools may provide direction for simple yet effective school-based PA interventions that impact all students or target specific subpopulations including females who are known to be less active than males.

Using conservative energy expenditure estimates (CDC, 1999), the interaction between attending a school with another room for PA and participation in flexibility activities on 3 or more days per week suggests that female students who participated in 3 or more days per week of flexibility activities and attended a school with another room for PA would expend roughly 3,840 kcal/school year more than a female student who did not attend a school with another room for PA, about equivalent to the caloric value in one pound (0.45kg) of fat (Figure 5, Appendix Y). Given research shows children and adolescents experience an average energy gap of roughly one pound per year (Wang et al., 2006), the extra energy expenditure attributed to female students participating in flexibility-related activities at a school with another room for PA may have substantial impact for reducing excess weight gain. Moreover, this energy expenditure could be significant at a population-level when applied across the 59.6% (n=6,424) of females that reported participating in flexibility-related activities 3 or more days per week in Study #2.

Results from Study #2 show offering daily PE to positively associate with both female and male students' PA in the univariate analyses; however, offering daily PE did not remain statistically significant in the full models that were adjusted for student characteristics and environment-level confounders. Nevertheless, in the exploratory analyses examining environment-level factors found to be significant in the univariate analyses and student-level factors, a significant two-way interaction was detected for male students' PA between grade and attending a school that offers daily PE. The interaction indicates the relationship between male students' PA and grade level is significantly different for males attending schools that do and do not offer daily PE (Figure 6, Appendix Z), regardless of whether the male student is enrolled in PE. Figure 6 illustrates males who are in grades 11 and 12 engaged in less minutes of PA compared to their grade 9 counterparts but the decrease was significantly lower among males attending schools that offer daily PE compared to schools that do not offer daily PE. Although earlier research has shown that students are more likely to enrol in PE if they attend a school that offers daily PE (Hobin et al., 2010), this is the first evidence to our knowledge, to suggest that the decline in male students' PA with increasing grade level is attenuated when a male attends a school that offers daily PE.

Once again, using conservative estimates (CDC, 1999), the interaction between grade and attending a school that offers daily PE on male students' PA suggests that males in grades 11 and 12 who attended a school that offers daily PE expend roughly 3155.6 kcal/school year and 3218.3 kcal/school year more than males in grades 11 and grade 12 who did not attend a school that offers daily PE, about equivalent to the caloric value in one pound (0.45kg) of fat (Figure 6, Appendix Z). Similar to the argument made above regarding the energy gap established among adolescents, the extra energy expenditure attributed to male students' PA in grades 11 and 12 attending a school offering daily PE may have substantial impact for reducing excess weight gain. Moreover, this energy expenditure could be significant at a population-level when applied across the 72.4% (N=55) secondary schools that reported offering daily PE to students in Study #2.

It should be noted that at the time the SHAPES-ON data were collected, Ontario education policy mandated secondary school students to complete only one PE credit for graduation (Ontario Ministry of Education, 2010). Several studies have shown that once PE requirements for graduation are completed, the majority of students no longer enrol in PE (Faulkner et al., 2007); since most secondary students in Ontario complete their one PE credit required for graduation in grade 9, PE enrolment tends to decline with increasing grade level (Faulkner et al., 2007). However, higher rates of student PE enrolment have been shown to associate with students attending a school that offers daily PE (Hobin et al., 2010). Indeed, in this study more male students in grades 11 and 12 attending schools offering daily PE enrolled in PE class compared to their male counterparts attending schools not offering daily PE. An explanation for the increased enrolment in PE among male students attending schools that offer daily PE is uncertain but could be related to the school social climate. Perhaps offering daily PE in schools reflects a school environment that supports students enrolling in PE as an elective credit in senior grades. However, as noted above in section 6.1.3, it is also quite likely that schools offer daily PE due to the school schedule. Nevertheless, school schedules are modifiable and thus are amenable to intervention. Additional research is required to determine if indeed male students in senior grades are more likely to enrol in school PE when PE is offered daily, and if offering daily PE encourages male students in senior grades to spend more time in PA.

Results of Study #2 also showed that female students' time spent in PA is negatively associated with land-use mix diversity and male students' PA is negatively associated with walkability. Among adults, previous research has shown higher neighbourhood land-use mix and walkability to positively associate with PA; however, findings of studies investigating urban form features and adolescent PA are much less consistent where some studies found adolescent PA to be positively associated with land-use diversity and walkability (Cradock et al., 2009; Deforche et al., 2010; Boone-Heinonen et al., 2011), while others found a negative association (Van Dyk et al., 2010). The inconsistencies in the associations between adolescent PA and urban form features may be explained by the gender-specific associations identified in the current study. Such gender differences in how land-use mix diversity and walkability relates to students' time spent in PA could reflect 'true' effect modification (differences in facilitators and barriers to PA across subgroups). For example, a potential source of effective modification is traffic, which may be common in areas of higher land-use mix diversity and could be a more important barrier to PA among female than male students. Traffic volume was not measured in this thesis and thus could not be investigated but should be considered in future research. An explanation for the negative association between male students' PA and walkability is less clear. It is well established that male students' participation in both organized sport and PA is higher compared to female students. Perhaps if the area surrounding schools is more walkable, male students are more likely to choose to leave school grounds before and after school, and during school breaks and not participate in the school PA programming offered during these times. It is also likely that schools located in more walkable neighbourhoods are situated in areas with higher residential density and thus may have less space on school grounds for PA facilities for student PA. Since few studies have examined gender-specific associations between PA, land-use mix diversity, and walkability among adolescents (Boone-Heinonen et al., 2011), no conclusive explanation can be given for the gender effects identified.

Another explanation for the inconsistencies in studies investigating land-use mix diversity and walkability with student PA is the use of varying measures of these constructs. Unlike the current thesis that used GIS measures to capture urban form features of the school neighbourhoods and defined land-use mix diversity as the “measure of the evenness of distribution of several land-use types within the school’s geographic area”, other studies used different methods and measures. For example, Cradock and colleagues (2009) examined the density of employees in neighbourhood destinations serving youth” as a proxy measure for land-use mix diversity. Whereas, Deforche and colleagues (2010) used the Neighbourhood Environment Walkabilty Scale (NEWS) to assess land-use mix diversity by asking school administrators to report the distance to 23 facilities in the school neighbourhood such as shops, libraries, and public transport. The varying definitions of variables and measurement tools may explain why the current thesis identified a different relationship between students’ time spent in PA and land-use mix diversity and walkability.

6.1.5 School Location differences in Associations between Factors of the School Environment and Students’ Time Spent in PA

When the full data set was examined in Study #3, no significant interactions between environment-level factors and school location were detected for students’ time spent in PA. Despite the lack of interactions detected between environment-level factors and school location, additional models stratified by school location were analyzed due to the mixed results of previous studies investigating the PA discrepancies among youth across locations and expert request for more research investigating PA discrepancies among youth in urban, suburban, and rural neighbourhoods.

As stated earlier (Section 6.1.2), models stratified by school location indicated statistically significant between school-level variability in time spent in PA among students attending urban (4.0%), suburban (2.0%), and rural schools (2.1%) suggesting that characteristics of the school environment a student attends are associated with their PA. Environment-level factors associated with time spent in PA were also identified among students attending urban and suburban schools, but not rural schools. Two possible explanations for not finding a significant association between environment-level factors and the PA of students attending rural schools include issues with how variables were defined and sample size. In this thesis the school PA facilities index was created as a continuous variable, however, previous research conducted by Trilk and colleagues (2011) found female students attending rural secondary schools are more apt to be active if they attend a school with the greatest number of PA facilities in the school neighbourhood (75^{th} percentile) compared to the fewest number of PA facilities (25^{th} percentile). Exploratory analyses to test the associations between student PA and alternative methods of creating the school PA facilities index were conducted and still schools with the greatest number of PA facilities did not associate with student PA among rural schools in the current study (Appendix GG). Another potential explanation for not finding significant associations between environment-level factors and students' time spent in PA among rural schools is sample size. There were only 20 rural schools participating in this study. Experts suggest aiming for a minimum sample size of approximately 30 units at each level in multilevel analysis, particularly at the highest level, to avoid a reduction in the accuracy of point estimates for each level of factors (Bell et al., 2008; Mass and Hox, 2005); therefore, the findings suggest there may have been enough power to detect significant associations between student PA and factors of the school environment for the 30 suburban schools and 26 urban schools, but not the 20 rural schools. Nevertheless, no singleton groups (e.g., group of 1 student in 1 school) were included in the analysis and the results of this study were helpful in identifying school-level factors associated with students' time spent in PA among urban and suburban schools.

Similar to results found in Study #1 and Study #2, attending a school with another room for PA was found to significantly associate with increased time spent in PA among students in urban and suburban schools. On average, school administrators of urban and suburban schools reported 5.3 facilities to be available on school grounds. Although it is unknown what number of school PA facilities is ideal for encouraging student PA, it is possible that urban and suburban schools may have a shortage of space for student PA and providing another room for students to be active may encourage more PA. To better understand the role of offering students another room for PA, follow-up telephone conversations with school personnel who completed the school survey were conducted to provide personal anecdotes of how school space was being adapted to accommodate students' PA needs. The most frequent responses included adapting available school space, such as the cafeteria, school hallways, or stage during inclement weather for school PE programs, varsity sports, teams, intramurals, and activity clubs. More research is needed, however, to determine if indeed providing another room for PA in urban and suburban schools increases students' time spent in PA.

In total, 15.4% (N=4) of urban schools were located within 1-km of one shopping mall and 13.3% (N=4) of suburban schools were located within 1-km of one fast food outlet. Results of Study #3 show that students attending urban and suburban schools located within close proximity to one shopping mall or one fast food outlet (compared to no shopping malls or fast food outlets) reported more time spent in PA. This suggests that locating schools within close proximity to facilities that provide an opportunity for social interaction with peers could result in students' spending more time in PA by encouraging students to walk to these establishments. Previous research indicates proximity to destinations with opportunities for social interaction is associated with adolescent PA (Duzenli et al., 2010; Mota et al., 2005; Cradock et al., 2009; Dalton et al., 2011). More specifically, Duzenli and colleagues (2010) found shopping malls to be the most preferred environment for PA by adolescents living in urban areas in

Turkey. Other research conducted in the US by Mota and colleagues (2005) also found adolescents' perceived accessibility of shops to be an important influence on PA. However, the positive association between students' time spent in PA and close proximity to a fast food outlet may be counterintuitive given the well-established evidence indicating eating fast food to cause a higher risk of overweight and obesity among adolescents (Tavaras et al., 2005; Bowman et al., 2004). Yet a recent study examining the association between the food retail environment surrounding schools and overweight in grades 6 to 10 students in Canada did not find an increased likelihood of overweight (Seliske et al., 2008). Another Dutch study also found very little evidence of an association between proximity of fast food outlets to schools and students' dietary behaviours (van der Horst et al., 2008). By contrast, however, a study conducted in California, USA found students attending schools with a fast food outlet within 0.5 miles (0.8-km) were more likely to be overweight or obese (Davis and Carpenter, 2009). Nevertheless, several other studies examining both the proximity and density of fast food outlets to place of residence and adolescent levels of overweight and obesity have found no association (Sturm and Data, 2005; Crawford et al., 2008; Burdette and Whitaker, 2004). Locating destinations of interest to youth, including shopping malls and fast food outlets, within close proximity to schools appears to encourage students to spend more time in PA in the current research, yet given eating fast food is known to contribute to overweight and obesity among youth, balancing the tradeoffs between exposing students to fast food outlets and increases in PA needs to be further examined before recommendations can be made.

An explanation as to why *one* and not more shopping malls and fast food outlets were significantly associated with students' time spent in PA is unclear and requires further study. Applying various buffer sizes or measuring the specific distances between schools and various destinations of interest to youth may be needed to better capture the effects of the built environment on students' time spent in PA in urban and suburban areas. Recent research examining the density of fast food outlets surrounding schools have applied buffer sizes ranging from 400m to 2000m (Kestens and Daniel, 2010; Day and Pearce, 2011) arguing such distances reflect a reasonable walking distance for adolescents. Results of these studies reveal trends in the density of fast food outlets surrounding schools were not evident within close proximity of schools (400m) and justify the use of larger buffer sizes. Undertaking research with global positioning systems to investigate how situating schools and fast food outlets in close proximity could help explain the role of fast food outlets in the school environment on student behaviours and would provide policy-makers and program planners with much needed evidence to inform policies regarding fast food outlets and schools. Internationally, some efforts have been made to limit student exposure to fast food outlets in the school environment through urban planning measures but the efficacy of such interventions in addressing obesity concerns is uncertain. For example, in the UK a policy to target youth obesity is underway that bans fast food outlets within 400m of schools (BBC, 2011). Given that the current research suggests having a fast food outlet within 1-km of schools positively influences students' time spent in PA and previous research suggests locating schools near fast food outlets may not influence students' BMI levels, a policy banning fast food outlets close by schools may not be effective. More research is needed to elucidate the relationship between having destinations of interest to youth, especially shopping malls and fast food outlets, in close proximity to schools and students' time spent in PA.

Finally, results of Study #3 show attending a school that offers daily PE to students to positively influence student PA in suburban schools only. In other words, students attending suburban schools offering daily PE reported more time spent in PA compared to suburban schools not offering daily PE. This relationship held even when controlling for students' enrolment in school PE indicating attending a school offering daily PE positively influenced student PA irrespective of whether the student was enrolled in PE. Overall, 83.3% (N=25) of suburban schools reported offering daily PE to students compared to only 53.9% (N=14) of urban and 80.0% (N=16) of rural schools; however, the percentage of students enrolled in PE in suburban (34.3%), urban (35.0%), and rural schools (35.3%) did not show a statistically significant difference. More direct measures of student PA should be used to assess when and where students engage in PA. Moreover, qualitative research could also be conducted to investigate attitudes towards PA and perceptions of the schools' support for PA among students attending schools that offer and don't offer daily PE.

6.2 Strengths and Limitations

This cross-sectional research investigated the influence of the schools' built environment on students' time spent in PA while also considering school PE and PA programming as well as potential student- and environment-level confounders. Due to the cross-sectional nature of this research, determining causal relationships between the school environment and students' time spent in PA was not possible. Moreover, since most school boards in Ontario do not have a policy mandating students to attend specific secondary schools, students (or their parents) may have selected schools on the basis of the PA opportunities available. A longitudinal study investigating change in behaviour following change in the schools' PA environment is required to establish the causal relationship between school PA opportunities and student PA behaviour. Recently, a research team at the University of Waterloo was funded to conduct the COMPASS study, a longitudinal study designed to understand how changes in the school environment over time are associated with changes in several student behaviours, including student PA (Cancer Care Ontario, 2011). The results of this thesis, however, will be valuable for building a knowledge base regarding the relationships between the environmental factors and students' time spent in PA. Observed associations from cross-sectional studies can inform the development and design of longitudinal studies and randomized controlled trials, which are generally more expensive, labour intensive, and time consuming than cross-sectional studies.

Another limitation is that the schools participating in the SHAPES-ON project were purposively sampled. This will limit the ability to generalize the results of this research to the province. However, the purpose of this research is not to determine the prevalence of PA or any other variables but to explore relationships between the school environment and students' time spent in PA. The high student response rates within schools suggest that the data are likely representative of the participating schools. The large sample size and number of schools in the SHAPES-ON study is definitely a strength of the study, although due to the large sample size of students, small effects that are statistically significant should be interpreted with caution and their practical significance considered. Another strength of the current sample is that the schools were from geographically diverse areas in Ontario. Past Canadian studies examining the association between the school environment and student PA have settled for small sample sizes (N=8)(Fein et al., 2004).

The use of self-reported PA is another limitation of this research. The sometimes sporadic nature of PA can make it difficult to recall duration, intensity, and frequency accurately. Furthermore, self-reported PA data are subject to social desirability and misinterpretation of questions. However, more direct measures of PA also have drawbacks including an inability to distinguish intensity of PA (i.e., double labeled water), inaccuracy for certain physical activities (e.g., pedometers and accelerometers are inaccurate for cycling), and inability to measure some activities (e.g., pedometers and accelerometers cannot be worn during swimming). Many of the tools used to assess PA directly are also prohibitively expensive for large-scale data collection. Thus, self-report surveys are frequently used in assessing PA for large-scale data collections because of ease of administration, low cost, unobtrusiveness, and versatility. The use of valid and reliable self-report tools, such as the SHAPES PA module student questionnaire, will help to ensure that the data collected are valid and reliable and constitute another strength of this study. Nevertheless, results of criterion validity testing and comparison with data from the Canadian Health Measures Survey suggest that the PA outcome variable was likely over-reported by students (Wong et al., 2006; Colley et al., 2011). Although this prevented using the data to accurately estimate PA levels, it did not preclude using the data to provide insight into associations with PA. To prevent misclassification of students' PA levels, the data were used as a continuous variable rather than using externally determined cut-points to classify students into PA levels. The limitation of this approach was that it assumed that all students over-reported to the same extent. But, this may not have been an accurate assumption. For example, evidence of systematic over-reporting of PA among overweight females compared to normal weight females has been previously reported (McMurray, 2008). An examination of the SHAPES PA module student questionnaire and missing data (n=588) identified that respondents with missing PA data were more likely to be male (p=0.02) and not enrolled in PE ($p<0.0001$) compared to respondents with PA data (Table 25, Appendix II), so these students might be less active, and the data in this analysis could slightly overestimate PA. The respondents with missing PA data were not different in terms of age, grade, or weight status ($p>0.05$).

There are also limitations associated with the school environment questionnaire used in this study. The questionnaire measuring school environment variables in this research was not yet validated at the time of data collection; thus, results should be treated with caution as school administrators may have interpreted the questions differently. However, items from the school environment questionnaire used in this research assess the provision of school PA programming and the availability of PA-related facilities on school grounds. Previous research evaluating self-report environment tools have found concrete environmental measures within a defined boundary (e.g., access to a running track in the school yard) tend to highly correlate with more objective measures as compared to less concrete measures (e.g., quality of school PA programming or facilities) or measures of resources in areas that are not well defined and potentially less familiar (e.g., PA-facilities in the neighbourhood surrounding the school) (Brownson et al., 2009). Moreover, the Propel Centre for Population Health Research has recently developed and tested a school environment survey largely based on the survey items in the CLFRI School Capacity Survey. Testing of Propel's new school environment survey demonstrate a sufficiently high level of reliability and validity (Kroeker et al., 2008).

GIS-assessed measures of the built environment within a 1-km circular buffer of schools are used in this study. These objective measures enable examination of built environment effects in large population studies because they do not rely on resource-intensive neighbourhood audits or other forms of direct observation (Giles-Corti and Donovan, 2002), and avoid limitations of perceived measures of the environment (Duncan and Mummery, 2005; Owen et al., 2004). However, since no standard method exists for assessment of environments, it is unclear which type of buffer should be used (circular versus street network buffers) and what buffer distance around schools would be appropriate when assessing adolescent PA. A circular buffer is measured as the Euclidean distance surrounding a point of interest and captures all features of the built environment within this area (Huston et al., 2003). On the other hand, a street network buffer is constructed along line-based road networks based on the assumption that walking occurs on sidewalks along roads (Huston et al., 2003). In the author's experience as a secondary school teacher in Ontario, students often use short cuts through schoolyards, between shopping plazas, and across parking lots to access destinations within the school environment. Such footways linking schools with destinations are not captured in street network data; therefore, applying circular buffers may arguably be the best approach for capturing a comprehensive representation of the students' school environment. However, the 1-km school buffer zone may not have provided a complete picture of the PA opportunity structures accessible to secondary students, who may have access to transportation taking them beyond the buffer. This may be especially true for students attending schools in rural areas where schools are located outside of town and features of the built environment are not located within the 1-km school buffer zone and may have been overlooked.

The use of secondary data is another limitation. Since the SHAPES PA module student questionnaire, School Capacity Survey, and the SHAPES-ON project were not designed specifically for this research, data are not available for all variables of interest. For example, the SES of the students, as well as the school neighbourhoods, has been associated with student PA outcomes (Richmond et al., 2006; Mota et al., in press; Toftegaard-Stockel et al., 2010). Although an approximation of school SES can be calculated from population census data and the school postal codes, there are no corresponding student SES data available. Having the postal codes of students' place of residence would provide an approximation of student SES, as well as a better approximation of school mean SES. At the environment-level, school policy information specific to whether or not students are permitted to leave school grounds during school breaks was not collected. This information would help to better understand the role of the built environment in the neighbourhood surrounding schools. School policy data regarding school boundaries was also not collected. Some school boards in Ontario allow secondary students to choose the school they attend based on programs and courses offered (e.g., sports programs, technology courses) whereas other school boards assign students to attend certain schools based on geographical boundaries. It would be valuable to know if students in the SHAPES-ON study were able to select the school they attended or if they attended the school within their assigned school boundary. However, the main advantages of using secondary data for this research are being able to access a large high quality data set in an affordable and timely manner. The large sample size of students and schools allowed for sufficient power in the subgroup analyses by gender as there is a relatively equal distribution between genders. Additionally, the large sample size and design of the SHAPES-ON project enabled the use of hierarchical modeling to examine features of the school environment associated with student PA while controlling for student composition. There is much knowledge to be gained by using this statistical technique to examine the application of an ecological-based approach to student PA behaviour.

The PA outcome variable used in this study is a measure of overall volume of student PA (i.e., minutes of MVPA per day), of which there are associated challenges. For example, experts provide theoretical and conceptual arguments to suggest self-reported PA outcomes specific to setting and intensity will increase the predicative capacity of models examining the PA-environment relationship (Giles-Corti et al., 2005; Owen et al., 2004). For this research, a PA outcome that is specific to the school environment as well as type and intensity of interest (e.g., running on running track on school grounds after school) may have improved model predictability. It is well known that youth PA takes place in diverse settings, and therefore understanding the type and location of PA, and matching it to the characteristics of the location, could improve measurement and clarify relationships between factors of the built environment that are behaviour specific correlates of PA. One type of PA that has been particularly well studied in this regard is active commuting to school. However, studies using measures of specific types of PA also need to be interpreted with caution because of the possibility of substitution between different types of PA, whereby an individual is hypothesized to maintain relatively constant total PA over time by compensating for PA in one time period with a corresponding reduction in activity in another period (Baggett et al., 2010). Therefore, an advantage of PA outcomes measuring overall volume of PA is that this outcome measure potentially captures students' overall PA behaviours over a period of time. Other reasons an overall PA outcome measure was chosen for this study is that the SHAPES PA module student questionnaire does not ask about setting-specific or type of PA and testing of the SHAPES PA module student questionnaire did not find students' time spent performing vigorous PA to significantly correlate with accelerometer-measured PA (Wong et al., 2006). Also, an examination of the between-school variability in students' average daily time spent in MVPA calculated for weekdays compared to 7-days per week did not detect significant differences. Therefore, the overall PA outcome measure used in this study is proven valid and will strengthen findings when significance is found between factors of the school environment and student PA.

Finally, additional components of the school environment such as school-community partnerships were not included in the analyses. Consistent with the tenets of Ecological Theory, Ontario's Foundations for a Healthy School framework recognizes the need to adopt a broader 'whole school' approach in promoting PA that seeks to identify the influential aspects of the school environment, in terms of schools' curriculum and instruction, built environment, social environment, and school-community partnerships, so that they can be modified. The current thesis extends previous research by examining factors within three of four pillars within Ontario's Healthy Schools Framework. More specifically, this thesis investigated the influence of factors of the school built environment on student PA, while also considering school PE (curriculum) and PA programming (social environment), school environment factors that have been previously identified as important correlates of student PA. The next progression in this research would be to investigate how the fourth pillar of Ontario's Foundations for a Healthy Schools framework, school-community partnerships, promotes or inhibits PA among secondary school students. School-community partnerships include schools partnering with public health units, community-based recreation clubs and organizations, and providing staff within ongoing training and support. Previous research has demonstrated that community coalitions can affect youth behaviour (Young et al., 2007; Naylor et al., 2009) including encouraging elementary students to engage in high levels of PA (Leatherdale et al., 2010). The study by Leatherdale and colleagues (2010) is timely given a province-wide school PE policy in Manitoba, Canada recently mandated students to complete a PE credit each year of secondary school that can be completed in school or in the community (Manitoba Education, 2008). Examining the influence of school-community partnerships on student PA independently and when also considering factors of the schools' built environment, social environment, and, curriculum and instruction would provide information to inform PA promotion strategies and better elucidate the relationship between the school environment and student PA.

6.3 Recommendations and Implications for Policy, Practice, and Research

Characteristics of the school environment influence student PA. Since adolescents spend a large part of their waking day at school, school environments may be particularly important in influencing students' time spent in PA. Consequently, specific school environment features that are amenable to programmatic and policy interventions must be identified. Results of this thesis provide data that links factors of school built environments and students' time spent in PA while also considering school PE and PA programming as well as potential student- and environment-level confounders. Responsibility for creating school environments that are more conducive to student PA needs to be shared across schools, government, and community partners. Recommendations are framed below according to policy, practice, and research.

6.3.1 Policy Recommendations

Modifying the built environment of schools to support more active lifestyles has been highlighted as a means to improve student's time spent in PA. Indeed, the Canadian Federal/Provincial/Territorial Framework for Action to Promote Healthy Weights recommended making schools' social and built environments more supportive of PA by providing students with school PE, PA programming, and PA facilities whenever possible (Public Health Agency of Canada, 2010). Findings from this research suggest relatively simple changes in schools could positively influence student PA. More specifically, adapting another room for student PA was consistently shown to encourage students to spend more time in PA. Overall, students attending schools with another room for PA were found to report spending an average of almost 12 minutes more in MVPA per day than students attending schools without this facility. Additionally, findings showed female students who participate in 3 or more days per week of flexibility activities and attended a school with another room for PA reported spending an average of almost 17 minutes more in MVPA per day than their female counterparts attending schools without another room for PA. Findings also showed that students attending urban and suburban schools with another for PA engaged in 17 and 12 minutes more of PA per day than students attending urban and suburban schools without this facility. These results may inform education policies that support school space allocation. Policy-makers, school practitioners, and researchers could collaborate to best decide how school space, which is often limited, can be used to maximize PA participation among youth, especially female youth who tend to be less active than males.

Results of this thesis also suggest students attending schools that offer daily PE reported spending an average of 7 minutes more in MVPA, regardless of whether the students are enrolled in PE. Moreover, male students in grades 11 and 12 attending schools offering daily PE reported spending an average of approximately 14 minutes more in MVPA than their male counterparts attending schools not offering daily PE. School course schedules are created by the school board or school administrator. At the time of the SHAPES-ON data collection, secondary schools either followed a semester or non-semestered school schedule. A semester school schedule requires students to attend the same classes daily for approximately five months of the school year whereas a non-semestered school schedule requires students to attend classes on alternate days throughout the entire school year. Therefore, students attending a school following a non-semestered schedule would not be offered daily PE. If offering daily PE indeed influences students to be more active regardless of whether they are enrolled in PE, school policy-makers may want to consider the trade-offs of altering school schedules to follow a semester system and offer daily PE to students.

Finally, results of analyses by school location also suggest that students attending urban and suburban schools are more active when schools are located within close proximity to destinations of interest to youth such as shopping malls and fast food outlets. More specifically, students attending urban schools located within 1-km of one shopping mall reported an average of more than 23 minutes of MVPA per day. Similarly, students attending suburban schools located within 1-km of fast food outlets reported an average of more than 18 minutes of MVPA per day. Although locating schools close to fast food outlets to increase student PA may seem counterintuitive, results of research examining students' weight status and attending schools in close proximity to fast food outlets are mixed. These findings are important to policy-makers considering international efforts have been made to limit student exposure to fast food outlets in the school environment through urban planning measures. In the UK a policy to target youth obesity is underway that bans fast food outlets within 400m of schools. Given that the current research suggests students attending schools located within close proximity to destinations of interest to youth, including shopping malls and fast food outlets, positively influences students' time spent in PA and previous research indicates locating schools near fast food outlets does not influence students' BMI levels, a policy banning such establishments close by schools may not be effective.

6.3.2 Practice Recommendations

Although the research investigating the impact of the built environment within the school environment on student PA is in its infancy and is not able to determine causation or make definitive conclusions, action, even imperfect action, is urgently needed to combat students' inadequate time spent in PA. Findings from this thesis confirm previous suggestions that the school environment has a modest, yet significant association with student PA. This is evidenced by the small amounts of variability between schools in student PA (2-4%); however, the contribution of these potential changes across schools may be great.

Since students attending a particular school can be influenced by that setting, favourable modifications to schools may produce small but impactful changes in behaviour of entire student populations. Therefore, identifying and modifying school environments to produce positive changes in student PA is important. Due to the dynamic nature of interactions between factors at student and environment levels, it would not be individual student characteristics or school environment characteristics alone that influence a particular behaviour, but rather the combination and interaction of different factors that result in behaviour such as PA. As such, multilevel interventions targeting characteristics of individual students and school environments are likely to be the most effective in changing student PA. This multilevel approach to health promotion within schools is consistent with Ontario's Foundations for a Healthy Schools Framework (Ontario Ministry of Education, 2009).

Findings from this research imply that aspects of the school built environment are related to student PA, particularly providing another room for PA. It was demonstrated that students' spend almost 12 minutes more per day in MVPA when attending a school that provides another room for PA compared to a school that does not provide this facility. As such, adapting school space for students' to be active before, after, or during school hours may be a relatively simple yet effective intervention for increasing students' time spent in PA.

Another relatively simple modification that could be made to increase students' time spent in PA is offering daily PE to students. Students attending schools offering more PE reported more time spent in PA, especially male students in senior grades. Fortunately, school course calendars are created by school boards or school administrators and are amenable to change. School staff responsible for making decisions about the school course schedule may want to consider the findings that support offering daily school PE as an approach for creating a more activity friendly school environment.

When decisions about building, renovating, or modifying the school environment are being made students should be consulted. Building on students' own ideas about what would be included in a PA-friendly school environment is believed to improve adolescent interest in and motivation for being active (Haug et al., 2008). Given discrepancies in student PA by gender and school location were detected, it is important to encourage input from all students including females and rural youth when making decisions about PA promotion in the school environment.

In addition to the changes suggested within schools, modifications in the neighbourhood surrounding schools could also be considered. Results of the current thesis demonstrate students' reported less time spent in PA when attending schools located in neighbourhoods of high land-use mix diversity and walkability. Although more research is needed to support this finding, a challenge public health officials and urban planners will face when developing strategies for optimizing land-use mix diversity and walkability is that the relations between these urban form features and PA for students, as reported here, are in the opposite direction to those previously reported for adult PA. Thus, the current public health and urbanist movement to create neighbourhoods with high land-use mix and walkability, with the goal of increasing PA, may have a negative effect on the PA patterns of students. Development of neighbourhoods that are conducive to PA in all age groups, while challenging, have the potential to substantially ameliorate the health of the population.

Finally, to assist schools in creating a healthy school environment, the Canadian Joint Consortium for School Health, a collaboration across education and health ministries in government from across Canada, has developed the Healthy School Planner. The Healthy School Planner is a free online tool that helps schools assess the health of their school and supports them in developing a long-term action plan for making improvements in the school's built environment, social environment, curriculum and programs, and community partnerships in regards to PA, healthy eating, and tobacco control. The tool emerged out of the global school movement called "Comprehensive School Health" which recognizes that healthy children are better able to learn, and that schools can directly influence children's health through the creation of a healthy school environment. In theory, the tool is completed by a team consisting of school administrators, teachers, staff and parents. As of October 2011, at least some portion of the Healthy School Planner had been completed 777 times by school teams from across Canada, with the PA portion of the Healthy School Planner being completed 259 times (verbal communication with Dana Zummach, coordinator of the Healthy School Planner at Propel Centre for Population Health Impact of the University of Waterloo).

6.3.3 Research Recommendations

Overall, there is an urgent need for more research examining the influence of the school environment on student PA. The first priority for this field is to improve the precision of conceptual models and sophistication of theories so that the mechanisms by which specific factors are presumed to affect student PA behaviours can be identified. The current thesis applied a combination of the EnRG framework and Ontario's Foundations for a Healthy School framework to hypothesize the association between student PA and the school environment (Kremers et al., 2006; Ontario Ministry of Education, 2009). Given the EnRG framework was developed with the specific intention of informing hierarchical models of intervention research in the domains of diet and PA by providing hypothesized pathways linking environmental and individual influences, the framework was useful in that it acknowledges the unidirectional environmental determinism whereby student PA is spontaneously performed as a result of direct cues and opportunities in the school environment. The EnRG framework also emphasizes the potential importance of moderating effects of target group characteristics (e.g., gender, location) on the environment-PA relationship. Ontario's Foundations for a Healthy School framework assisted in conceptualizing school environments and identifying potential environmental influences. More theory-oriented research applying the EnRG framework and Ontario's Foundations for a Healthy School framework to study the environment-PA relationship of students is needed to guide empirical work in an informed way. More specifically, the current thesis did not explore factors within the school-community partnerships pillar of Ontario's Foundations for a Healthy School framework and did not examine the meditational side of the EnRG framework that postulates there is an indirect path between the environment and PA, whereby behaviour-specific cognitions, such as attitudes and perceived behaviour control are thought to play a mediating role. To further advance the field, additional features of the school environment that include school-community partnerships could be included to broaden the scope of the study. Moreover, factors of the school environment might also be combined with psychosocial variables to propose meditational models that can be tested to develop theories of how environment influences behaviour.

Developing setting-specific conceptual frameworks for modeling PA behaviours, such as Ontario's Foundations for a Healthy School framework, is one approach recommended for improving the predictive capacity of ecological approaches. Within a setting-specific conceptual framework, the model targets a setting specific to the population group of interest. To improve the predictive capacity of such setting-specific conceptual frameworks, however, researchers investigating the factors of the built environment within the school setting and student PA could consider a particular type of PA behaviour of interest, where this behaviour occurs in the school environment, and when this behaviour occurs. For example, researchers have experienced success predicting behaviours related to walking to school among secondary school students by examining school environment features believed to specifically influence walking among students before and after school hours (Greves et al., 2007, Dalton et al., 2011). Investigating specific school-related PA behaviours to a higher level of specificity first before combining in one overall framework may help enhance the predictive capacity of conceptual frameworks for understanding student PA.

In addition to theory-oriented research investigating the predictability of setting-specific conceptual models, measurement tools that increase the specificity of PA measures may also be helpful for accurately capturing the influence of the school environment. For example, the self-reported generalized measure of PA that was implemented in this thesis may not be sensitive to specific environmental attributes of the school environment. Consequently, the null associations detected between the majority of school environment features and student PA may reflect a lack of specificity in the PA measure used rather than the absence of an association. The proposed correlates investigated in this thesis may have more explanatory power for objective PA measures, such as accelerometers, or self-reported PA measures specific to the school context (e.g., during PE class), to a type of activity (e.g., running), or to a designated time period (e.g., during school breaks). Collecting more direct measures of PA using new equipment that incorporates geographic positioning systems (GPS) and accelerometers, for example, may facilitate the ability to obtain setting-specific measures of PA by making it possible to know exactly when and where PA occurred; albeit since such tools are expensive and endure other pragmatic barriers such as a lost signal on GPS units (Oliver et al., 2010). The advantages and challenges of available measurement instruments would need to be weighed against the specific research question(s) to be addressed and on an ‘accuracy-practicality trade-off’.

This thesis did examine the influence of having 14 school PA facilities available on school grounds as well as the density of four PA-related features within a 1-km buffer of schools on student PA. Of the 18 PA-related facilities in the school environment examined in this thesis, providing another room for PA was consistently found to associate with student PA overall, while offering daily PE was found to positively influence male students in senior grades and locating schools near one shopping mall and one fast food outlet was associated with the PA of students attending urban and suburban schools, respectively. Further research is needed to confirm these relationships and better inform researchers of the potential mechanisms under which these factors operate under.

Although qualitative research conducted by Ries and colleagues (2008) found that adolescents identified proximity of facilities as a major determining factor with regard to facility use, the null associations between student PA and PA facilities in the school environment in this thesis may suggest that measuring the proximity and density of these features is not sufficient. Future research should consider extending the scope of factors under investigation beyond proximity and density to include safety, functionality, and aesthetic characteristics of built environment features from the perspective of adolescents. Results from previous studies examining the association between adolescent PA and built environment factors within the residential neighbourhood predominantly and some in the school neighbourhood support this recommendation as factors such as conditions of PA facilities have been found to be associated with adolescents' PA levels Ferreira et al., 2006; Jago et al., 2005). Moreover, students' usage of school PA facilities should also be examined in future work. A recent study examining student PA and school PA facilities used SOPLAY (System for Observing Play and Leisure Activity among Youth) and reported very limited use of school PA facilities among students during after school hours and concluded the number and proximity of such features in the school environment may be not be sufficient to influence students to spend more time in PA (Bocarro et al., in press). Integrating characteristics of safety, functionality, and aesthetics as well as students' use of school PA facilities with measures of proximity and density of PA facilities may improve accuracy of results and improve our understanding of the influence of school PA facilities on student PA.

Establishing appropriate boundaries or buffer sizes of school environments is another area of research that needs to advance to improve the quality and comparability of studies investigating the association between student PA and the school built environment. Experts believe it may be likely the most relevant geographic scale will differ by built environment variable (e.g., walkability, distance to park) and by school location (i.e., urban, suburban, rural). Therefore, it may be useful if more investigators evaluated and reported results using multiple geographic scales (e.g., 0.5-, 1-, 2-, 3km buffers) when examining school environments using objective or observational methods. Moreover, comparing results produced using network buffers compared to circular buffers surrounding schools may also be valuable.

Applying objective and perceived measures for assessing facets of the built environment is another issue. Evidence in the broader built environment literature suggests that perceived, observed, and objectively measured built environment correlates are all important for predicting youth PA as it may be possible that any single measure or category of measures may not be optimal for capturing environmental variables within different settings or geographic al scales. Additionally, assessing a feature of the built environment multiple times using multiple measures could help to strengthen confidence in results. Accordingly, future research should consider collecting a combination of subjective, observed, and objective measures of the school built environment. Collecting this comprehensive data would be ideal to allow the appropriate examination of elements within the built environment; however, collecting data using a combination of measures to assess features of the school built environment multiple times could be burdensome to schools and time consuming for researchers , especially among large samples of schools.

A block-wise modeling approach was used to add and create models in this thesis. Even though adding blocks of variables using this block-wise modelling approach was based in ecological theory, there are some alternative variable selection approaches that could be considered in future research to select prominent groups of predictors and create parsimonious models. For example, the Lasso approach could be used in conjunction with a block-wise modeling approach to aid in making decisions on how to add or remove variables from each block as they are added to the model. Like other model selection techniques (e.g., forward selection, step-wise selection) that operate by penalizing large models, the Lasso method weighs how closely a candidate model fits the data (i.e., the value of the loss of function) against how big the model is; yet, it differs from other variable selection approaches in that the Lasso method uses a penalty related to the sum of the absolute values of the regression coefficients (Burgette et al., 2011). This is advantageous in that it can yield models that are less variable but still interpretable.

Cross-sectional designs have been used predominantly to examine the influence of the school built environment on student PA. Because controlled experiments within the school built environment are often not logistically, ethically, or economically feasible, natural experiments may be a promising next step for generating evidence to inform environmental interventions in PA promotion at the population-level. For example, given the findings in this thesis suggest an association between more time spent in PA among students attending schools providing another room for PA or located with close proximity to shopping malls and fast food outlets, natural experiments may be appropriate such that when changes are being made to the school environment, whether renovating or adapting existing environments or constructing new developments on school grounds or in the school neighbourhood, researchers should view these changes as critical opportunities to analyze their impacts on student PA. To fully benefit from these natural experiments, it would be wise for researchers to collaborate with policy and practitioners in education, urban design or transportation, and health in an ongoing and deliberate manner to stay abreast of upcoming changes within the school environment.

Lastly, qualitative investigations and case studies could also contribute to understanding the environment-PA relationship. When properly employed such designs can collect rich data relevant for improving the conceptual understanding and thus leading to better understanding of data employed in typical quantitative investigations. Moreover, use of participatory research methods, which involve stakeholders in both the design and interpretation of research, is an important way to incorporate the perspectives of the research participants (e.g., students, school staff) and add to our understanding of seeming contradictions in the results (e.g., proximity to fast food outlets and more time spent in PA among students).

6.4 Conclusions

This thesis provides novel Canadian information on the relationship between the school environment and student PA. This was the first study to investigate, in depth, the role of the school environment on student PA among grade nine to 12 students in Ontario, Canada. Moreover, no previous Canadian research has investigated both the built environment on school grounds and the in the neighbourhood surrounding the school, and its association with student PA. The growing concern for healthy lifestyles suggests that this research is timely, unique, and has the ability to potential drive future healthy intervention strategies geared at improving the lives of Canadian adolescents.

Over the last few years, promoting activity-friendly school environments has become a strong public health message. Internationally through the Global Strategy on Diet, PA, and Health, the WHO has identified the school setting as an important environment for the promotion of PA and an integrated part of an overall strategy to prevent and manage non-communicable diseases (WHO, 2008). Among other aids to facilitate capacity building at regional and national levels, the WHO in collaboration with the Public Health Agency of Canada and Health Canada developed a School Policy Framework to guide policy-makers at national and subnational levels in the development and implementation of policies that promote PA in the school setting through changes in environment, behaviour, and education (WHO, 2008, Candeais et al., 2010). Most recently, the Canadian Federal/Provincial/Territorial Framework for Action to Promote Healthy Weights recommended making schools' social and built environments more supportive of PA by providing students with the school PE, PA programming, and PA –related facilities whenever possible (Public Health Agency of Canada, 2010). To assist schools in creating a healthy school environment, the Canadian Joint Consortium for School Health, a collaboration of education and health governments from across Canada, has developed the Healthy School Planner (Joint Consortium for School Health, 2010). The Healthy School Planner is a free online tool that helps schools assess the health of their school and support them in developing an action plan for making improvements in the school's built environment, social environment, curriculum and programs, and community partnerships. These efforts not only promote healthier school environments overall but also emphasize the importance of environment changes for sustainable population-level changes in student PA.

In conclusion, the studies described in this thesis assessed the associations between the school environment and student PA. The main findings of this thesis provide suggestive evidence to support the view that the school environment is important for understanding student PA behaviours. Results indicate that attending a school offering daily PE and providing another room for PA to be positively associated with students' time in PA, while land-use mix diversity and walkability in the school neighbourhood to be negatively associated with students' time spent in PA. Differences in the results by gender and school location also provide some evidence to support the view the school environment appears to matter differently for student PA by gender and depending on school location. This was the first Canadian study to investigate both the built environment on school grounds and the in the neighbourhood surrounding the school, and its association with student PA. The current study lends needed support to Canadian public health recommendations to "create activity-friendly school environments" whenever possible (Public Health Agency of Canada, 2010).

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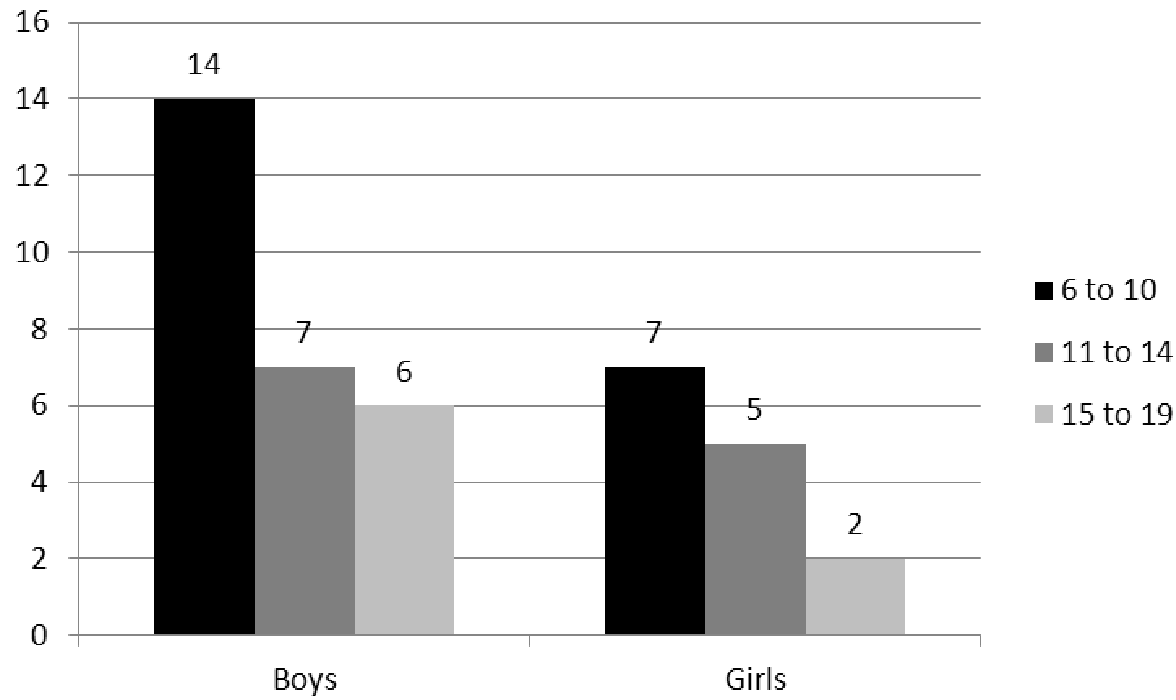
APPENDIX A

Figure 1. Percentage with at least 60 minutes of moderate-to-vigorous physical activity on at least 6 days a week, by age group and sex, household population aged 6 to 19 years, Canada, March 2007 to February 2009.



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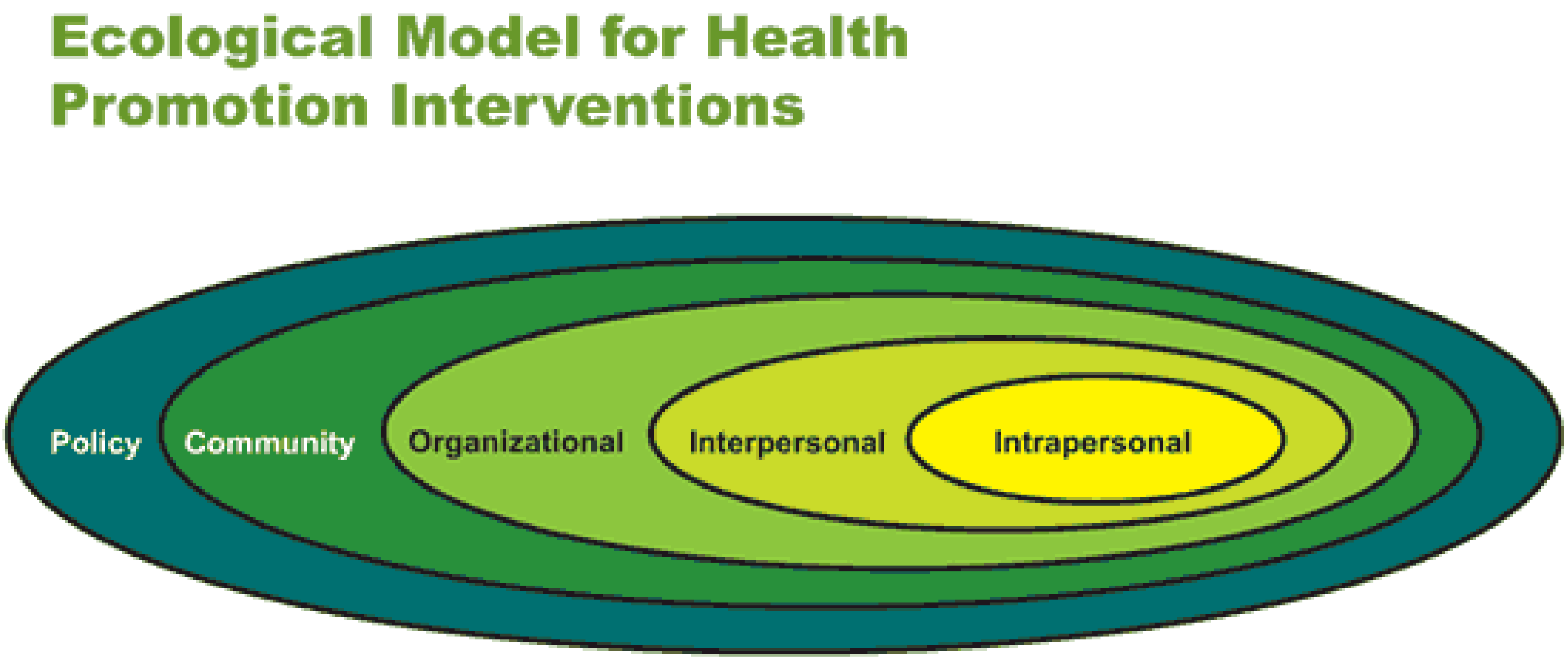
APPENDIX B

Figure 2. Ecological Model for Health Promotion Interventions.



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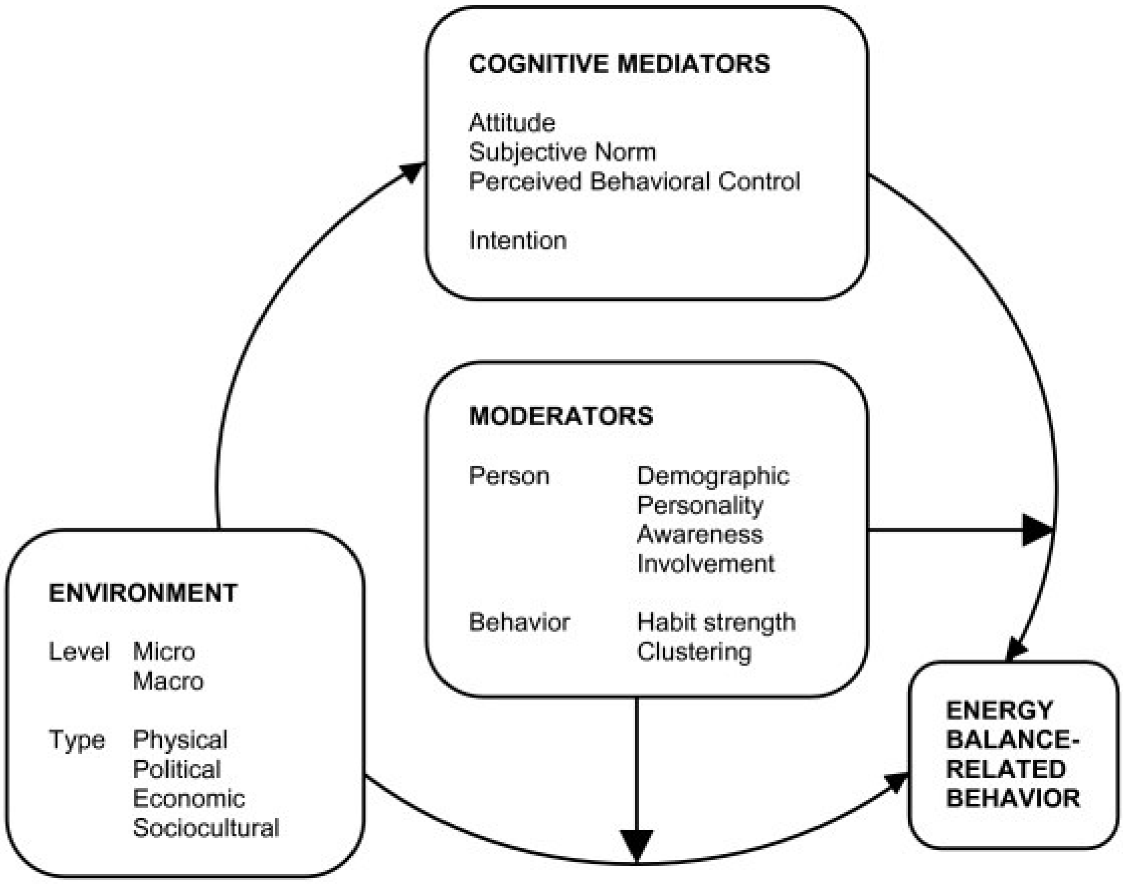
APPENDIX C

Figure 3. Environmental Research Framework for Weight Gain Prevention.



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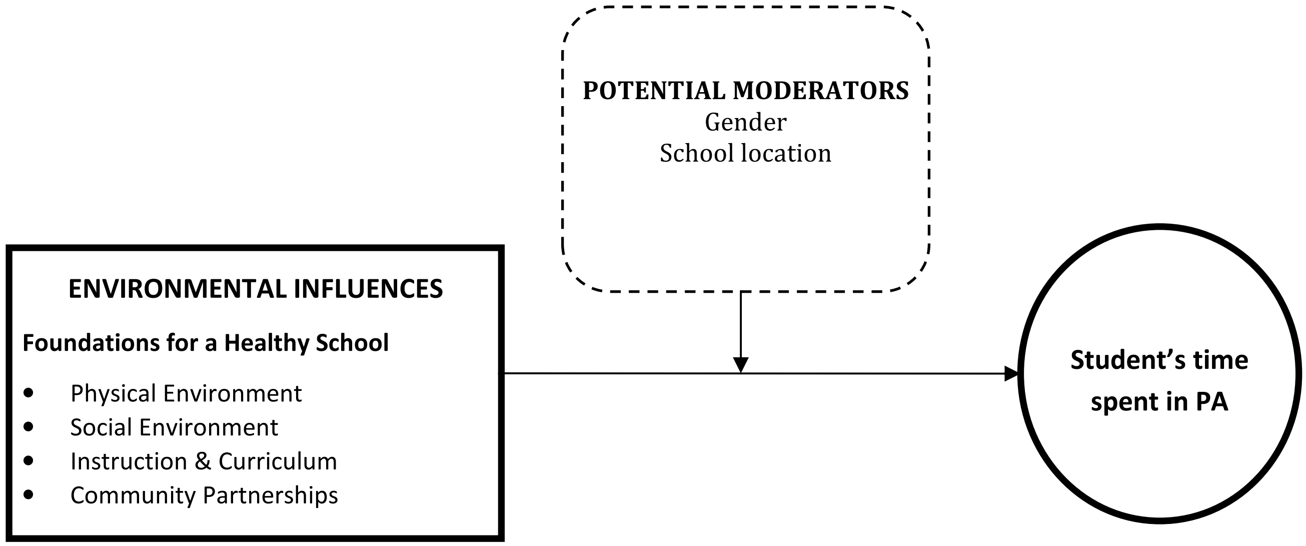
APPENDIX D

Figure 4. Modified EnRG Framework for examining Student PA and School Environment



APPENDIX E. Table 1. School-based multilevel studies examining associations between student physical activity and environment-level predictors on school grounds

Pub Year	Authors	Purpose	Study Design / Control for Bias	Confounders	Data Collection Methods	Analysis	Plausible?	ICC	Significant School-level Factors	OVERALL SCORE and Rating
2009	Nichol et al. 2005/06 HSBC Study Canada	Examine if having a PE policy, PA-related programs and availability of PA facilities are associated with MVPA in class-time and MVPA in free-time at school	HIGH MODERATE N= 154 schools n= 7,638 students 79% response rate nationally representative grades 6-10	gender, grade, family SES, school population size, school safety, urban vs rural location	MODERATE self-reported PA and environment; used valid and reliable survey; validity and reliability of administrator/ teacher survey not tested	grade- and gender-stratified bivariate multilevel logistic regressions	MODERATE Referred to ecological model; Instruments pretested; self-reported PA and environment	NA	Students attending secondary schools with more PA opportunities had higher class-time PA; Boys attending schools with a playing field and more PA opportunities had higher class- and free-time PA; Girls attending schools with good or poor quality playing fields and 4+ varsity sports had higher free-time PA	MODERATE
2010	Haug et al. 2005/06 HSBC Study Norway	Examine if the availability of PA facilities is associated with MVPA at recess and lunch break	HIGH MODERATE N= 130 schools n= 16,471 students (specific # of secondary schools and students not provided) 71% response rate nationally representative grades 8-10	gender, grade	MODERATE self-reported PA and environment; used valid and reliable PA survey; validity and reliability of administrator/ teacher survey not tested	gender- and grade-specific bivariate multilevel logistic regression	MODERATE Referred to ecological model; Instruments piloted and pretested; self-reported PA and environment	NA	Higher PA for boys attending schools with soccer fields, playground equipment, sledding hill and area for hopscotch. Higher PA for girls attending schools with sledding hill. Overall, students attending schools with more PA facilities had almost 3.0 higher odds of being active	MODERATE
2006	Richmond et al. Add Health USA	Examine if racial disparities within schools are associated with MVPA	LOW MODERATE N= not given n= 17,007 students white, non-Hispanic, black non-Hispanic; response rate not given; nationally representative sample grades 9-12	race, family SES, smoking status, age, BMI	MODERATE self-reported PA and environment; used valid reliable Add Health survey; validity and reliability of administrator/ teacher survey not tested	gender-specific multilevel linear regression	MODERATE Conceptual model not mentioned; PA instrument pretested; self-reported PA and environment	NA	Higher PA for girls attending schools with higher school SES; Higher PA for boys attending schools with higher school SES and diverse racial compositions	MODERATE
2006	Robertson-Willson et al. SHAPES-ON Study Ontario, Canada	Examine demographic, behavioral, psycho-social, and environmental correlates of active commuting to school	LOW MODERATE N= 76 schools n= 21,345 62% response rate convienent sample grades 9-12	temperature, precipitation, season, gender, smoking status,	MODERATE self-reported active commute to school; reliability and validity not tested for outcome measure or of administator survey	setting-based multilevel logistic regression	LOW MODERATE Guided by socio-ecological model; Instrument not tested for outcome measure	NA	Less likely to actively commute to school if attending a rural school; No school-level factors associated with active commuting to school in results by school setting	LOW MODERATE
2010	Spence et al. Web-SPAN Alberta, Canada	Examine the role of self-efficacy in explaning gender differences in PA	STRONG N=117 schools n=4779 students 95% response rate random sample of schools grades 7-10	gender, age, BMI, self-efficacy	HIGH MODERATE self-reported PA; used valid and reliable PAQ-C survey	multilevel linear regression	MODERATE Guided by SCT; PA instrument pre-tested; self-reported PA	8.0%	Both self-efficacy and gender were round to be assocaited with PA. Gender was found to moderate the relationship between self-efficacy and PA whereas self-efficacy was found to mediate the relationship between gender and PA.	HIGH MODERATE
2007	Loucaides et al. Ontario and Alberta, Canada	Examine differnces in correlates of PA between Canadian urban and rural students	MODERATE N= 8 schools n= 2688 Response rates: 81.6% urban schools 80.9% rural schools convienent sample grades 9-12	temperature, gender, perception of ability and health, self-efficacy, interest in activities, concerns about weight, taking PE, travel to school, use of rec time for PA, homework, part-time job, friends' and families' PA	STRONG self-reported PA, objectively measured school location; used valid and reliable Godin Leisure-Time Exercise Questionnaire	school-location specific bivariate and multilevel linear regression	MODERATE Referred to ecological model; Instruments pretested; self-reported PA; objectively determined school location	NA	No significant differences in MVPA between urban and rural schools. No other school environment factors examined.	MODERATE
2007	Wong 2005/06 SHAPES-ON Study Ontario, Canada	Examine if school rate of participation in PE, intramurals, and varsity sports are associated with MVPA	MODERATE N= 76 schools n= 51,222 74% response rate convienent sample grades 9-12	gender, grade	STRONG self-reported PA and environment; used valid and reliable SHAPES PA module	multilevel linear regression	STRONG Guided by ecological models, SCT, Precede/Proceed; Instrument piloted and pretested; self-reported PA	1.9%	Higher MVPA for students attending schools with higher rates of PE enrollment, lower school-level SES, and larger school populations. The association between PE participation rate and PA was stronger for males than females.	STRONG

APPENDIX F **Table 2. School-based multilevel studies examining associations between student physical activity and environment-level predictors in school neighbourhood**

Pub Year	Authors	Purpose	Study Design / Control for Bias	Confounders	Data Collection Methods	Analysis	Plausible?	ICC	Significant Neighbourhood Factors	OVERALL SCORE
2010	Nichol et al. Canada	Examine if individual and group perceptions of neighbourhood safety, availabilty of PA facilities are associated with MVPA PA outside of school	STRONG N= 182 schools n= 9,114 students 94% response rate nationally representative sample grades 6-10 cross-sectional	gender, grade, family SES, perceived neighbourhood aesthetics, neighbourhood SES, geographic location	HIGH MODERATE self-reported PA; used valid and reliable HSBC survey; GIS data and self-report perceived environment factors	multilevel linear regression	MODERATE Conceptual models not given; PA instruments pre-tested, objective measures of environment, enviroment survey not pretested	NA	Among secondary school students, higher levels of individal perceptions of safety associated with higher PA; Among boy and girls in grades 6-10 and students attending urban schools, higher levels of individual and group perceptions of safety associated with higher PA.	MODERATE
2009	Cradock et al. USA	Examine if neighbourhood design features are associated with MVPA on weekends	WEAK N=10 schools n= 152 students response rate not given random sample grade 8	age, BMI, race, intervention/ control status, day of week	STRONG followed valid and reliable accelerometry procedures, GIS methods used	multilevel linear regression	HIGH MODERATE Conceptual model not given; instrument protocols pretested; objective measures of PA and environment	NA	Higher MVPA for adolescents attending schools in neighbourhoods with greater densities of employees in destinations serving youth	MODERATE
2009	Deforche et al. Belgium	Examine if perceptions of social and physical environment and level of self-efficacy associated with active transport and leisure-time sports	WEAK N= 20 schools n= 1445 students response rate not given random sample grade 12	family SES, gender	STRONG self-reported; used valid and reliable PAQ to create active transport and leisure-time sports indices; valid and reliable NEWS scale	multilevel linear regression	MODERATE Guided by ecological models, SCT; instruments pretested; self-reported PA and environment	active transport = 5.5% Leisure-time sports = 1.1%	Higher levels of active transport associated with higher land use mix diversity, street connectivity, more attractive environments, better access to PA facilities and higher satisfaction with neighbourhood. Higher levels of leisure-time sports associated with pereived safety from traffic, and better access to PA facilities. Lower perceived safety and poorer access to PA facilities were only associated with lower active transport among youth with lower self-efficacy	MODERATE

APPENDIX G Table 3. School-based multilevel studies examining associations between student physical activity, environment-level predictors in school and neighbourhood

Pub Year	Authors	Purpose	Study Design / Control for Bias	Confounders	Data Collection Methods	Analysis	Plausible?	ICC	Significant Neighbourhood Factors	OVERALL SCORE and Rating
2008	Haug et al. Norway 2005/06 HSBC study	Examine if the availability of school and neighbourhood PA facilities, and students' interests in school PA are associated with MVPA during recess and lunch break	MODERATE N= 68 schools n= 1,347 students 69% response rate nationally representative grades 6-10 cross-sectional	interests in school PA, family SES, gender	STRONG self-reported PA; used validated and reliable HSBC survey; validity and reliability of administrator survey not tested	blockwise hierachical logistic regression	MODERATE Guided by YPAP and ecological models; PA instrument pretested; administrator survey not pretested	7.0%	Higher PA associated with more PA facilities, open fields, outdoor obstacle course, playground equipment, and room with cardio equipment and weights. Students' interests in school PA moderated the effect of facilities on adolescent PA.	MODERATE
2009	Haug et al. Norway 2005/06 HSBC study	Examine if having written school PA policy, PE classes 5 days per week, organized PA in non-curricular school time, school and neighbourhood PA facilities, and students' interests in school PA are associated with MVPA during recess and lunch break	MODERATE N= 68 schools n= 1,347 students 69% response rate nationally representative grades 6-10 cross-sectional	interests in school PA, family SES, gender	STRONG self-reported PA; used validated and reliable HSBC survey; validity and reliability of administrator survey not tested	blockwise hierachical logistic regression	MODERATE Referred to ecological and Health Promoting Schools models; PA instrument pretested; administrator survey not pretested; indices created for explanatory variables	NA	Student PA associated with environmental and policy indices as well as schools organizing PA in non-curricular school time ≥3 a week	MODERATE
2004	Fein et al. Alberta, Canada	Examine if the availability of home, neighbourhood and school PA environment, and perceived importance of PA environment are associated with MVPA	LOW MODERATE N= 4 schools n= 610 students 71% response rate rural area grades 9-12 cross-sectional	sex, age, self-efficacy, peer and family PA, relationship with PE teacher	LOW MODERATE self-reported PA; used validated and reliable Godin Leisure-time Survey; validated environment survey with additional questions; validity and reliability of modified survey not tested	blockwise hierachical linear regression	LOW MODERATE Referred to ecological model; PA instrument pretested; modified environment survey not pretested	NA	Higher PA associated with perceived importance of school environment for PA; sex appears to moderate relationship between perceived importance of school environment and PA.	WEAK-MODERATE

APPENDIX H Table 4. Summary of Environment-level Factors associated with Student Physical Activity categorized within the Foundations for a Healthy School Framework

				Environment-level Factors associated with Student Physical Activity		
	Pub Year	Authors	Age/Grade	Healthy Physical Environment	Sociocultural Environment	Instruction and Curriculum
School	2007	Wong 2005/06 SHAPES-ON Study Ontario, Canada	gr 9-12		+ lower school SES + larger school population	+higher school rate of PE enrolment
	2010	Haug et al. 2005/06 HSBC Study Norway	gr 8-10	+ soccer fields + playground equipment + sledding hill + area for hopscotch + greater # of outdoor facilities		
	2006	Richmond et al. Add Health USA	gr 7-12		+ higher school SES	
	2009	Nichol et al. 2005/06 HSBC Study Canada	gr 6-10	+ playing field + quality of playing field + greater # of PA opportunities (having a school PA policy, ≥4 varsity sports, a playing field, a playing field in good condition, a gymnasium, a gymnasium in good condition)		+ ≥4 varsity sports
Neighbourhood	2010	Nichol et al. Canada	gr 6-10		+ higher levels of group perceptions of safety	
	2009	Cradock et al. USA	gr 8	+ greater densities of employees in destinations serving youth		
	2009	Deforche et al. Belgium		+ higher land use mix diversity + street connectivity + more attractive environments + better access to PA facilities + higher level of perceived safety from traffic		
School & Neighbourhood	2008	Haug et al. Norway 2005/06 HSBC study	gr 8	+ greater # of PA facilities + open fields + outdoor obstacle course + playground equipment + room with cardio and weight equipment		
	2009	Haug et al. Norway 2005/06 HSBC study	gr 8	+ environmental index including 16 natural and built characteristics + policy index including schools' involvement in a PA project, having a PA policy, offering PE classes 5 days/wk, offering organized PA in non-curricular school time (e.g., intramurals)		
	2004	Fein et al. Alberta, Canada	gr 9-12		+perceived importance of school environment for PA	

APPENDIX I

SHAPES PHYSICAL ACTIVITY MODULE STUDENT QUESTIONNAIRE

SHAPES - Physical Activity

For each question, mark your answer by making a dark pencil mark that fills the circle completely. Fill in only one (1) circle for each question unless the instructions tell you to do something different.
<u>This survey is anonymous, so please do not put your name on any of the pages.</u>

Improper Marks — **Please** — Use an HB Pencil Only — Proper Mark

The name of my school is: ____

1. What grade are you in?
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10
- ○ 11
- ○ 12

2. How old are you?
- ○ 11 or younger
- ○ 12
- ○ 13
- ○ 14
- ○ 15
- ○ 16
- ○ 17
- ○ 18 or older

3. Are you male or female?
- ○ Male
- ○ Female

4. How physically active do you consider your <u>father</u> (or stepfather or foster father) to be? Think about the father you see the most.
- ○ Active
- ○ Somewhat active
- ○ Inactive
- ○ I have no father

5. How physically active do you consider your <u>mother</u> (or stepmother or foster mother) to be? Think about the mother you see the most.
- ○ Active
- ○ Somewhat active
- ○ Inactive
- ○ I have no mother

6. How much do your parent(s) or guardian(s) encourage you to be physically active?
- ○ Strongly encourage
- ○ Encourage
- ○ Do not encourage or discourage
- ○ Discourage
- ○ Strongly discourage

7. How much do your parent(s) or guardian(s) support you in being physically active? (e.g., driving you to team games, buying you sporting equipment, etc.)
- ○ Very supportive
- ○ Supportive
- ○ Unsupportive
- ○ Very unsupportive

8. <u>In the last 7 days</u>, how did you *usually* get to and from school?
- ○ Actively (e.g. walk, bike, skateboard)
- ○ Inactively (e.g. car, bus, public transit)
- ○ Mixed (actively and inactively)

9. Your closest friends are the friends you like to spend the most time with. How many of your 5 closest friends are <u>physically active</u>?
- ○ None
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5

PLEASE DO NOT WRITE IN THIS AREA

10. In the last 7 days, how many days did you do exercises to *strengthen or tone your muscles*, such as push-ups, sit-ups, yoga, or weight lifting?

- ◯ 0 days
- ◯ 1 day
- ◯ 2 days
- ◯ 3 days
- ◯ 4 days
- ◯ 5 days
- ◯ 6 days
- ◯ 7 days

11. In the last 7 days, how many days did you do exercises *for flexibility*, such as stretching or yoga?

- ◯ 0 days
- ◯ 1 day
- ◯ 2 days
- ◯ 3 days
- ◯ 4 days
- ◯ 5 days
- ◯ 6 days
- ◯ 7 days

12. How tall are you without your shoes on? (Please write your height on the line and then fill in the appropriate numbers for your height in feet and inches OR centimeters.)

"My height is ___________________"

Example: 5 ft 7in

Height	
Feet	Inches
0	● 0
1	1 1
2	2
3	3
4	4
●	5
6	6
7	●
	8
	9

Height	
Feet	Inches
0	0 0
1	1 1
2	2
3	3
4	4
5	5
6	6
7	7
	8
	9

OR

Height
Centimeters
0 0 0
1 1 1
2 2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9

13. How much do you weigh without your shoes on? (Please write your weight on the line and then fill in the appropriate numbers for your weight in pounds OR kilograms.)

"My weight is ___________________"

Example: 127lbs

Weight
Pounds
0 0 0
● 1 1
2 ● 2
3 3 3
4 4
5 5
6 6
7 ●
8 8
9 9

Weight
Pounds
0 0 0
1 1 1
2 2 2
3 3 3
4 4
5 5
6 6
7 7
8 8
9 9

OR

Weight
Kilograms
0 0 0
1 1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9

14. Mark how much time you spent watching TV/movies, playing video/computer games, surfing the internet, instant messaging or talking on the phone on each of the last 7 days.

For example: if you spent 3 hours doing these activities on Monday, you would need to fill in the 3 hour circle, as shown below.

	Hours per Day									
Monday	0	1	2	●	4	5	6	7	8	9

	Hours per Day									
Monday	0	1	2	3	4	5	6	7	8	9
Tuesday	0	1	2	3	4	5	6	7	8	9
Wednesday	0	1	2	3	4	5	6	7	8	9
Thursday	0	1	2	3	4	5	6	7	8	9
Friday	0	1	2	3	4	5	6	7	8	9
Saturday	0	1	2	3	4	5	6	7	8	9
Sunday	0	1	2	3	4	5	6	7	8	9

15. In the last 7 days, how much *total time* did you spend reading, not counting at work, at school or on homework? (Include reading books, magazines and newspapers)

- ◯ None
- ◯ Less than 1 hour
- ◯ From 1 to 6 hours
- ◯ From 7 to 13 hours
- ◯ 14 or more hours

16. In the last 7 days, how much *total time* did you spend doing homework?

- ◯ None
- ◯ Less than 1 hour
- ◯ From 1 to 6 hours
- ◯ From 7 to 13 hours
- ◯ 14 or more hours

17. Were you sick in the last 7 days, or did anything prevent you from doing your normal physical activities?

- ◯ Yes
- ◯ No

18. In general, compared to other people your age, how would you rate your athletic ability?

- ◯ Excellent
- ◯ Good
- ◯ Fair
- ◯ Poor

19. Do you consider yourself:

- ◯ Very overweight
- ◯ Slightly overweight
- ◯ About the right weight
- ◯ Slightly underweight
- ◯ Very underweight

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

20. Mark how many minutes of <u>HARD</u> physical activity you did on <u>each of the last 7 days</u>. This includes physical activity during physical education class, lunch, recess, after school, evenings and spare time.

For example: if you did 1 hour and 15 minutes of hard activity on Monday, you will need to fill in the 1 hour circle and the 15 minute circle, as shown below:

	Hours					Minutes			
Monday	⓪	●	②	③	④	⓪	●	㉚	㊺

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

21. Were <u>the last 7 days</u> a typical week in terms of the amount of <u>HARD</u> physical activity that you <u>usually</u> do?

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

<u>MODERATE</u> physical activities are lower intensity activities such as walking, biking to school, and recreational swimming.

22. Mark how many minutes of <u>MODERATE</u> physical activity you did on <u>each of the last 7 days</u>. This includes physical activity during physical education class, lunch, recess, after school, evenings and spare time.

For example: if you did 2 hours and 45 minutes of moderate activity on Monday, you will need to fill in the 2 hour circle and the 45 minute circle, as shown below:

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

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

23. Were <u>the last 7 days</u> a typical week in terms of the amount of <u>MODERATE</u> physical activity that you *usually* do?

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

24. Do you participate in intramurals/house league sports at school?

- ◯ Yes
- ◯ No

25. Do you participate in school team/varsity sports?

- ◯ Yes
- ◯ No

26. Do you participate in <u>other</u> physical activities at school (e.g., play in gym, play outside)?

- ◯ Yes
- ◯ No

27. Do you participate in league or team sports outside of school?

- ◯ Yes
- ◯ No

28. Do you participate in individual physical activities outside of school (e.g., jogging, yoga, aerobics)?

- ◯ Yes
- ◯ No

29. What do you think of the number of sports offered at your school?

- ◯ Does not matter to me
- ◯ Too few
- ◯ Just right
- ◯ Too many

30. In a *typical* Physical Education class, how much time are you actually active?

- ◯ I am not taking a physical education class
- ◯ Less than 15 minutes
- ◯ 15 to 30 minutes
- ◯ 31 to 45 minutes
- ◯ 46 to 60 minutes
- ◯ More than 1 hour

31. How many Physical Education classes did you have <u>in the last 7 days</u>?

- ◯ 0 classes
- ◯ 1 class
- ◯ 2 classes
- ◯ 3 classes
- ◯ 4 classes
- ◯ 5 classes

	32. In your school, how much emphasis is placed on:	None	A little	Some	A lot	I don't know
60	a) Student participation in competitive sports?	○	○	○	○	○
59	b) Student participation in recreational sports?	○	○	○	○	○
58	c) Developing positive attitudes about physical activity?	○	○	○	○	○
57	d) Developing students' self-esteem (e.g., feeling good about yourself)?	○	○	○	○	○
56	e) Informing students about opportunities to be physically active (e.g., bulletin boards, announcements)?	○	○	○	○	○

	33. Do the subjects offered in your school teach students about:	Yes	No	I don't know
51	a) Benefits of physical activity?	○	○	○
50	b) Illnesses related to an inactive lifestyle?	○	○	○
49	c) Influence of families on physical activity?	○	○	○
48	d) Influence of the media on physical activity?	○	○	○
47	e) Influence of friends on physical activity?	○	○	○

	34. How strongly do you agree or disagree with each of the following statements?	Strongly agree	Agree	Disagree	Strongly disagree
43	a) Students should have opportunities to participate in physical activity each day.	○	○	○	○
42	b) Physical education should be a required subject at school.	○	○	○	○
41	c) Students should participate in a physical education class at school every day.	○	○	○	○
40	d) The indoor physical activity facilities at this school meet my needs.	○	○	○	○
39	e) The outdoor physical activity facilities at this school meet my needs.	○	○	○	○
38	f) The facilities at this school accommodate physical activity even when the weather is extreme (e.g., raining or snowing).	○	○	○	○

	35. How strongly do you agree or disagree with each of the following statements?	Strongly agree	Agree	Disagree	Strongly disagree
33	a) I feel close to people at my school.	○	○	○	○
32	b) I feel I am part of my school.	○	○	○	○
31	c) I am happy to be at my school.	○	○	○	○
30	d) I feel the teachers at my school treat me fairly.	○	○	○	○
29	e) I feel safe in my school.	○	○	○	○

36. Have you ever been curious about smoking a cigarette?

26 ○ Yes ○ No

24 **37. Have you ever smoked a cigarette, even just a**
23 **few puffs?**
22 ○ Yes ○ No

38. Have you ever smoked a whole cigarette?

19 ○ Yes ○ No ○ I have never smoked

18

17 **39. Have you smoked 100 or more whole cigarettes in your**
16 **life?**
15 ○ Yes ○ No ○ I have never smoked

40. Think about the last 30 days. Did you smoke a
12 **cigarette, even just a few puffs?**
11 ○ Every day ○ 1 or 2 days
10 ○ Almost every day ○ Not at all
9 ○ Some days

7 **41. Are you a smoker?**
6 ○ Yes ○ No

42. Your closest friends are the friends you like to spend the most time with. How many of your 5 closest friends smoke cigarettes?

- ○ None
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5

43. Do you think in the future you might try smoking cigarettes?

- ○ I already smoke
- ○ Definitely yes
- ○ Probably yes
- ○ Probably not
- ○ Definitely not

44. If one of your best friends was to offer you a cigarette, would you smoke it?

- ○ Definitely yes
- ○ Probably yes
- ○ Probably not
- ○ Definitely not

45. At any time during the next year do you think that you will smoke a cigarette?

- ○ Definitely yes
- ○ Probably yes
- ○ Probably not
- ○ Definitely not

PLEASE DO NOT WRITE IN THIS AREA

3

1

APPENDIX J

School Capacity Survey

SHAPES-Ontario

Canadian Fitness and Lifestyle Research Institute

School Capacity Survey

Facilities for Physical Activity

1. Does your school have access to any of the following for students *on or off* school grounds for use *during school hours*?

	Yes, on grounds	Yes, off grounds	No	Don't, Know
Gymnasium?	1☐	2☐	3☐	9☐
Other room which is used for physical activity, such as a classroom, portable, auditorium or cafeteria?	1☐	2☐	3☐	9☐
Dance studio?	1☐	2☐	3☐	9☐
Swimming pool?	1☐	2☐	3☐	9☐
Weight equipment?	1☐	2☐	3☐	9☐
Playing fields which can be used for soccer, rugby, football, etc.?	1☐	2☐	3☐	9☐
Baseball diamond?	1☐	2☐	3☐	9☐
Outdoor basketball hoops?	1☐	2☐	3☐	9☐
Running track?	1☐	2☐	3☐	9☐
Tennis court?	1☐	2☐	3☐	9☐
Area with playground equipment?	1☐	2☐	3☐	9☐
Paved area used for active games such as hopscotch?	1☐	2☐	3☐	9☐
Showers available for use before and after physical activity?	1☐	2☐	3☐	9☐
Change rooms available for use before and after physical activity?	1☐	2☐	3☐	9☐
Lockers available for use during physical activity?	1☐	2☐	3☐	9☐
Bicycle racks?	1☐	2☐	3☐	9☐
Skating rink?	1☐	2☐	3☐	9☐
Municipal sports and recreation facility?	1☐	2☐	3☐	9☐
Community centre?	1☐	2☐	3☐	9☐
Walking or bicycling trails nearby?	1☐	2☐	3☐	9☐
Other? Please specify____	1☐	2☐		|__|__|

2. a) In your opinion, how well do each of the following physical activity facilities *on your school grounds* meet students' needs?

	Not at all well				Very well	Not applicable
Indoor and outdoor facilities for physical education and extracurricular physical activity programs	1	2	3	4	5	8
Indoor and outdoor facilities for other physical activity and play	1	2	3	4	5	8
Facilities to accommodate physical activity even when the weather is extreme (snow, temperature)	1	2	3	4	5	8

b) In your opinion, does lack of space for physical activities at your school lead to …

	Yes	No
overcrowding?	1☐	2☐
safety concerns?	1☐	2☐

3. Are students allowed to use school physical activity facilities *outside of school hours*?

1☐ yes, indoor 2☐ yes, outdoor 3☐ no

4. **Do community groups or individuals in the community have access to school facilities that can be used for physical activity *outside of school hours*?**

No | **Yes**
₂☐ No   ₁☐ Yes ➔ **Which of these groups are required to pay user fees to have such access?**
- 1☐ No groups have to pay
- 2☐ Children and youth groups do not have to pay, but adult groups do
- 3☐ All groups or individuals using these facilities outside of school hours pay
- 4☐ Other, please describe: ___________________________________ |__|__|
- 9☐ Don't know

Physical Education, Extracurricular Activities and Physical Activity Programs

For these questions, *junior* refers to students in the younger grades **in your school**, while *senior* refers to those who are older. A later question

5. **a) In a typical week, about what percentage of *junior* students in your school take at least one physical education class?** _______ %

   b) In a typical week, about what percentage of *senior* students in your school take at least one physical education class? _______ %

6. **a) In a typical week, about how many times does a typical *junior* student in your school take part in a physical education class?** ________ average times per week

   b) In a typical week, about how many times does a typical *senior* student in your school take part in a physical education class? ________ average times per week

7. **a) About how many weeks per school year does a typical *junior* student take physical education classes?**
   ________ weeks per year

   b) About how many weeks per school year does a typical *senior* student take physical education classes?
   ________ weeks per year

8. **How long is a typical physical education class for junior and senior grades in your school?**
   ________ minutes per class for *junior* grades
   ________ minutes per class for *senior* grades

9. **a) In a typical physical education class, about what percentage of the time do students spend standing around waiting to receive instruction or waiting for their turn?** ________ %

   b) In a typical physical education class, about what percentage of the time do students spend actually engaged in physical activity? ________ %

10. **Compared to other classes taught in your school, is the student-teacher ratio for physical education classes…**
    - 1☐ Substantially higher (i.e. at least one and half times the number or more)
    - 2☐ Somewhat higher
    - 3☐ About the same
    - 4☐ Somewhat lower
    - 5☐ Substantially lower

11. Does the physical education program include…

	Junior Grades Yes	Junior Grades No	Junior Grades Not Applicable	Senior Grades Yes	Senior Grades No	Senior Grades Not Applicable
Basic movement skills (running, skipping, throwing, striking)	1☐	2☐	8☐	1☐	2☐	8☐
Specialized movement skills (a swim stroke, a tennis serve, etc)	1☐	2☐	8☐	1☐	2☐	8☐
Physical activities that develop health-related fitness (i.e. cardiovascular endurance, flexibility, muscular endurance and strength, healthy body composition)	1☐	2☐	8☐	1☐	2☐	8☐
Fitness testing	1☐	2☐	8☐	1☐	2☐	8☐
A variety of individual activities (e.g. dance, running, swimming)	1☐	2☐	8☐	1☐	2☐	8☐
A variety of team or dual sports (e.g. tennis, soccer, softball)	1☐	2☐	8☐	1☐	2☐	8☐
A variety of seasonal activities (e.g. golf, hockey, skiing)	1☐	2☐	8☐	1☐	2☐	8☐
Other (specify)________________________________	1☐	2☐	8☐	1☐	2☐	8☐

|__|__|

12. About what percentage of physical education classes in the school year involve…

Structured activities (i.e., those that involve instruction) _______%

Unstructured activities (i.e., no instruction or coaching, e.g., free ball play, free dance) _______%

13. Does your school provide intramural, inter-school activities, or other physical activity outings (e.g. ski trips)?

	Yes	No
Intramural activities	1☐	2☐
Between school activities	1☐	2☐

➘ If yes, is transportation provided by the school or school board? **Yes** 1☐ **No** 2☐

	Yes	No
Other physical activity outings	1☐	2☐

➘ If yes, is transportation provided by the school or school board? **Yes** 1☐ **No** 2☐

14. a)Are students and/or their families responsible for at least part of the costs of…?

	Yes	No
Transportation	1☐	2☐
Equipment	1☐	2☐
Admission (i.e. for skiing, etc.)	1☐	2☐
Other, please specify ___________________________		

|__|__|

b) To the best of your knowledge, does the fact that students or their families pay some of the costs, prevent any students from participating?

1☐ No   2☐ Yes, a few   3☐ Yes, quite a few   4☐ Yes, very many   9☐ Don't know

c) To the best of your knowledge, does the school or school community provide financial assistance to students who are unable to pay?

1☐ Yes   2☐ No   9☐ Don't know

15. From your own observation of the school grounds, about what percentage of the students engage in physical activity during each of the following times…

	0-25%	26-50%	51-75%	76-100%	Don't Know
Before school	1☐	2☐	3☐	4☐	9☐
After school	1☐	2☐	3☐	4☐	9☐
Recess	1☐	2☐	3☐	4☐	9☐
Lunch	1☐	2☐	3☐	4☐	9☐

16. In addition to the intramural, between school and physical activity outings reported in question 13, are there other physical activity offerings before or after school or during recess or lunch?

1☐ Yes   2☐ No   8☐ Don't know

17. **Who coordinates the physical activities offered at these times:**

1☐ a teacher(s) or staff member(s)?
2☐ student(s)?
3☐ a monitor payed by the municipality?
8☐ volunteer(s) Please specify: ___________________________ |__|__|

18. **In your school, how much emphasis is placed on…**	**No emphasis**				**Total emphasis**	**Not applicable**
Student participation in recreational team sports?	1	2	3	4	5	8
Student participation in competitive team sports?	1	2	3	4	5	8
Developing strong sports teams that represent the school?	1	2	3	4	5	8
Developing teamwork among students?	1	2	3	4	5	8
Developing skills for lifelong physical activity?	1	2	3	4	5	8
Developing leadership among students?	1	2	3	4	5	8
Involving students in regular physical activity?	1	2	3	4	5	8
Building student's motor skills?	1	2	3	4	5	8
Developing positive attitudes about physical activity?	1	2	3	4	5	8
Developing students' self-esteem?	1	2	3	4	5	8
Developing enjoyment of physical activity?	1	2	3	4	5	8
Developing fair play in sports and physical activity?	1	2	3	4	5	8
Increasing girls' participation in sports and physical activity?	1	2	3	4	5	8

19. **Do the subjects offered in your school teach students about…**	**Yes**	**No**	**Don't know**
Benefits of physical activity?	1☐	2☐	8☐
Enjoyment of physical activity?	1☐	2☐	8☐
Opportunities for physical activity in the community?	1☐	2☐	8☐
Phases of a workout (warm up, workout, cool down)?	1☐	2☐	8☐
Safety (e.g., preventing injury, avoiding heat stroke, basic first aid)?	1☐	2☐	8☐
Illnesses related to a sedentary lifestyle?	1☐	2☐	8☐
Influence of families on physical activity?	1☐	2☐	8☐
Influence of culture and the media on physical activity?	1☐	2☐	8☐
How students can influence or support others to be active?	1☐	2☐	8☐
Goal-setting and monitoring skills for physical activity?	1☐	2☐	8☐

20. **Does your school publicize information about or organize student participation in special physical activity events in the community (e.g., SummerActive, Jeux de l'Acadie, International Walk to School Day)?**

1☐ Yes 2☐ No 9☐ Don't Know

21. **To the best of your knowledge, over the past 12 months, has your school done any of the following …**	**Yes**	**No**	**Don't know**
Incorporated physical activity in lesson plans of other subjects?	1☐	2☐	8☐
Bring in physical activity or health professionals as guest speakers?	1☐	2☐	8☐
Assigned homework involving physical activity?	1☐	2☐	8☐
Provided information to students on opportunities to be active (e.g., bulletin boards, Web pages, public address announcements)	1☐	2☐	8☐
Provided information for parents and families on how to be active (e.g., flyers, newsletters)	1☐	2☐	8☐
Provided a forum for students to communicate with each other on physical activity (e.g., finding a partner for physical activity, what's going on)	1☐	2☐	8☐
Provided examples of physical activity that draw from different cultural and ethnic backgrounds	1☐	2☐	8☐
Promoted community physical activity programs to students and their families	1☐	2☐	8☐
Provided credit to a student(s) for course work for training or certification in community-based physical activity programs or activities (e.g. lifeguard, instructor, coach)	1☐	2☐	8☐

Provided physical activity counseling or individualized training programs for students (e.g., weight training programs)	1☐	2☐	8☐

Training and Professional Development to Encourage Physical Activity

22. Who teaches physical education in your school?

	Yes	No
Principal or vice-principal	1☐	2☐
Classroom teachers	1☐	2☐
Volunteer(s) (parents or individuals from the community)	1☐	2☐
Physical education specialist(s)	1☐	2☐
Other, please specify ______________________________ `		|__|__|

23. If your school uses physical education specialist(s), about how many physical education classes are taught by these specialists? 1☐ Very few 2☐ Some 3☐ Most 4☐ All

24. Are there health promotion programs for school faculty and staff (e.g. healthy weight management, how to incorporate physical activity into everyday life, etc.)? 1☐ Yes 2☐ No 8☐ Don't Know

25. In the past 12 months, have teachers and staff at your school been provided with…	**No**	**Yes, all staff**	**Yes, physical education staff only**	**Of those teachers/staff members who were given this opportunity, about what percentage participated?**
Information and resources on current research and current guidelines for physical activity?	1☐	2☐	3☐	______%
Information on how to promote physical activity through various media, including presentations	1☐	2☐	3☐	______%
Certification for staff *involved in students'* physical activities?	1☐	2☐	3☐	______%
Ongoing professional development on active living or physical education *by a trained staff person*?	1☐	2☐	3☐	______%
Specific instruction by *outside experts* in physical activity (instructors, and other types of fitness professionals) on how to promote active living?	1☐	2☐	3☐	______%

School Policies and the Social Environment for Physical Activity

26. Does your school have policies or programs which support …	**Yes**	**No**	**Don't Know**
Physically active students to act as role models for their peers	1☐	2☐	9☐
Parents to be role models for their children's physical activity	1☐	2☐	9☐
Parents to incorporate physical activity into family events	1☐	2☐	9☐
Teachers to act as role models for physical activity	1☐	2☐	9☐
Parents to coach or help out with extra-curricular physical activities	1☐	2☐	9☐
Parents to attend their children's' physical activities (e.g. watching their basketball game, etc.)	1☐ 9☐	2☐	

Teachers, parents, students and the community to be involved in organizing or planning events, school services and facilities related to physical activity	1☐	2☐	9☐
Teachers and staff to be physically active	1☐	2☐	9☐

27. When building new schools or when renovating, does your school board consult with any local community groups, municipal recreation departments and the like to ensure that community needs are considered?

1☐ Yes 2☐ No 8☐ Don't know

28. Does your school or school board have an agreement with one or more municipalities regarding shared use of school or municipal facilities?

1☐ Yes 2☐ No 8☐ Don't know

29. To what extent do concerns about liability cause the school to limit the kinds of physical activity in which students can participate (for example, concerns regarding transporting students to physical activity or the issues related to the use of facilities and equipment)?

1☐ Not at all 2☐ A Little 3☐ Somewhat 4☐ Quite a bit 5☐ A great deal 8☐ Not applicable

30. Does your school…	**Yes**	**No**
Provide certificates or rewards for students who participate in physical activities	1☐	2☐
Provide awards or trophies recognizing students' efforts in physical activities (i.e. "Most improved")	1☐	2☐
Host social events in order to publicly recognize individuals who participate in physical activities	1☐	2☐

31. Does your school, school board, or Ministry of Education have policies (either generally understood or written) on physical activity, which require the school to do the following:	**Yes, Written**	**Yes, Understood**	**None**	**Not Applicable**	**Don't Know**
Provide daily physical education to all students?	1☐	2☐	3☐	8☐	9☐
Provide a range of physical activities for students (e.g. competitive and non-competitive activities, structured and unstructured, skill development for lifelong participation)	1☐	2☐	3☐	8☐	9☐
Provide daily recess for all students?	1☐	2☐	3☐	8☐	9☐
Ensure ongoing funding for adequate equipment to meet the needs of students?	1☐	2☐	3☐	8☐	9☐
Ensure appropriate supervision of physical activity programs for students?	1☐	2☐	3☐	8☐	9☐

31. Does your school, school board, or Ministry of Education have policies (either generally understood or written) on physical activity, which require the school to do the following:

	Yes, Written	Yes, Understood	None	Not Applicable	Don't Know
Ensure a formal mechanism for staff health and wellness programs?	1☐	2☐	3☐	8☐	9☐
Hire teachers who have formal qualifications in teaching physical activity and motor skills?	1☐	2☐	3☐	8☐	9☐
Hire teachers who have university qualifications in teaching physical activity and motor skills?	1☐	2☐	3☐	8☐	9☐
Allow students to access school physical activity facilities after school hours?	1☐	2☐	3☐	8☐	9☐
Provide staff counseling for physical activity?	1☐	2☐	3☐	8☐	9☐
Disallow participation in similar sports in other venues, if students are already engaged in it at school (i.e. minor league participation if on school team)?	1☐	2☐	3☐	8☐	9☐
Disallow community use of school facilities	1☐	2☐	3☐	8☐	9☐
Adhere to national or provincial safety standards regarding school facilities, such as playground equipment, playing fields, gymnasiums, bicycle racks, etc?	1☐	2☐	3☐	8☐	9☐
Discourage user fees associated with school sports, so that all students who want to play, can play	1☐	2☐	3☐	8☐	9☐
Provide opportunities for active transportation of students to and from school, such as the "Walking School Bus"	1☐	2☐	3☐	8☐	9☐

32. How often is canceling gym or some other scheduled physical activity used as a disciplinary measure in your school (e.g. no recess or physical education class if work is not completed)?

1☐ Never 2☐ Infrequently 3☐ Occasionally 4☐ Frequently

33. How often is physical activity ever used as a reward in your school (e.g. extra recess or gym, or a sports event, as a reward for good behaviour, or academic achievement)?

1☐ Never 2☐ Infrequently 3☐ Occasionally 4☐ Frequently

34. **How frequently do you evaluate your school physical activity programs, facilities, and instruction to ensure that these meet the students' needs?**

1☐ Never (go to question 36)
2☐ Once every few years
3☐ Once a year
4☐ Twice a year
5☐ More than twice a year. Please specify____________ |__|__|

35. **When you evaluate your school physical activity programs, do you assess the extent to which they are consistent with each of the following …**

	Yes	No
Current provincial/territorial curriculum standards?	1☐	2☐
National or international physical activity guidelines for children and youth?	1☐	2☐
QDPE Recognition Award Standards?	1☐	2☐
Other (specify)____	|__|__|	

36. **To what extent do you agree or disagree with the following statements?**

	Strongly disagree				Strongly agree
Students should have opportunities to participate in physical activity each day	1	2	3	4	5
There is not enough time on school curricula to include physical education classes	1	2	3	4	5
Physical education should be a required subject in the school curriculum	1	2	3	4	5
Opportunities for physical activity should be integrated into the curricula of other subjects	1	2	3	4	5
Students should participate in a physical education class at school once per week	1	2	3	4	5
Students should participate in a physical education class at school each day	1	2	3	4	5

37. **In your opinion, what is the minimum amount of time that students should be taught physical education *per week*?** __________ minutes

Demographics

38. **How many students are enrolled in your school?** __________ Students

39. **How many teachers are employed at your school?** ___________Teachers (full time equivalents)

40. **How many specialist physical education teachers are employed at your school?**
_____ Specialist Physical Education Teachers

41. **What grades levels are taught at your school?** Grades _____________to________

42. **What type of school board is your school governed by?**

a) 1☐ Public 2☐ Catholic 3☐ Other, please specify: _________________________ |__|__|
b) 1☐ English 2☐ French 3☐ Other, please specify: _________________________ |__|__|

43. Is your school:

1☐ English
2☐ French
3☐ Bilingual (French/English)
4☐ Immersion (English or French)
8☐ Other, please specify ___________________________ |__|__|

44. What is the size of the city or town in which the school is situated?

1☐ Less than 1,000 residents
3☐ 5,000-9,999 residents
5☐ 75,000-299,999 residents
2☐ 1000-4,999 residents
4☐ 10,000-74,999 residents
6☐ 300,000 or more residents

45. Would you categorize your school setting as….

1☐ Inner City/Urban 2☐ Suburban 3☐ Rural 8☐ other (please specify) ___________ |__|__|

46. Roughly what proportion of students in your school would be from…

a) lower income families?	1☐ Very many	2☐ Many	3☐ Some	4☐ Few	5☐ None
b) high income families?	1☐ Very many	2☐ Many	3☐ Some	4☐ Few	5☐ None

47. Are you a….

1☐ teacher
2☐ physical education specialist
3☐ school principal
4☐ school administrator
5☐ other (please specify) ___________ |__|__|

48. Within what province or territory is your school located?

1☐ Newfoundland
2☐ Prince Edward Island
3☐ Nova Scotia
4☐ New Brunswick
5☐ Quebec
6☐ Ontario
7☐ Manitoba
8☐ Saskatchewan
9☐ Alberta
10☐ British Columbia
11☐ Yukon
12☐ Northwest Territories
13☐ Nunavut

Please return this questionnaire by fax to
(519) 746-8171 (Attn: XXXXX), or to
our data collector, who will be in your school on

Thank you very much for your participation.

APPENDIX K

SHAPES-ON Parent Letter

PHR population health research group

ideas for health | innovations in data, evidence & applications

[DATE]

Dear Parent/Guardian:

This letter describes a research study being conducted at your son/daughter's school on **[Data Collection Date]** by the Population Health Research Group (PHR) at the University of Waterloo in partnership with your local public health unit. This project is being conducted in up to 100 secondary schools across Ontario. The purpose of the study is to assess youths' awareness of and attitudes toward smoking and youth smoking rates, and to assess youth participation in and attitudes toward physical activity. This research will provide valuable information that will assist schools and public health departments to plan programs to prevent tobacco use and increase physical activity levels in schools, and will serve as the foundation for future evaluation activities in the province.

To assist you in your decision about your son/daughter's involvement, the following details about the study are provided:

- We will be implementing the School Health Action and Planning Education System (SHAPES) survey to all grade 9 to 12 classes in your school.
- Classes will be randomly selected to complete one of two SHAPES questionnaires. Both questionnaires include questions about tobacco use and physical activity; however, one questionnaire focuses more on tobacco use and the other more on physical activity.
- The questionnaires will take 10-20 minutes to complete during class time. All participating students will complete the questionnaires at the same time on a date selected by the school.
- The questionnaires are anonymous. Student names will not be on the questionnaires. The staff at [School Name] assisted us by sending out these letters on our behalf.
- Individual student responses will be kept completely confidential, and no individual results will be made available to school or other personnel. Prior to leaving the classroom, questionnaires are sealed in an envelope. All data are published in group form so that it will not be possible to determine the responses from any individual student.
- Questionnaires will be stored securely at the University of Waterloo for seven years. Electronic data will be retained indefinitely in a secure location.
- We have received permission from the school board and the school principal to conduct this research. The research has been reviewed and ethics clearance has been granted by the Office of Research Ethics at the University of Waterloo.
- There are no anticipated risks associated with participation in this project. Should you have any concerns or comments resulting from your son or daughter's participation in this study, please contact Dr. Susan Sykes, Director of Research Ethics at the University of Waterloo at (519) 888-4567 ext. 6005.

Final decision on participation is that of parents and students. If you and your son/daughter agree to participate now but later change your mind, either you or your son/daughter can withdraw at any time. Your co-operation in considering permitting your son or daughter to take part in this research is greatly appreciated. However, there is no penalty of any kind if he/she does not participate. A student will not be included in the study if a parent or guardian declines his/her participation or if the student does not agree to take part. If you have any questions or desire further information with respect to this study, you may contact Jessica Reid at the number below or visit the project website at: **www.shapes.uwaterloo.ca\ontario.**

Sincerely,

Project Manager University of Waterloo	Co-Principal Investigator University of Waterloo	Co-Principal Investigator Cancer Care Ontario

POPULATION HEALTH RESEARCH GROUP
University of Waterloo | LHN 2704, 200 University Avenue West, Waterloo, Ontario N2L 3G1
Tel. 519-888-4747 | Fax. 519-746-8171 | www.phr.uwaterloo.ca

APPENDIX L

Quality Control Procedures

Quality Control Steps of Survey Processing
at the Health Behaviour Research Group

The following summarizes quality control steps for survey processing at the Health Behaviour Research Group (HBR) at the University of Waterloo. In recent years, survey processing has been revised to increase efficiency while maintaining high levels of quality control. Efficiency is especially important because of (1) the increase in volume of surveys to be processed as a result of the uptake of the School Smoking Profile (SSP) and (2) the subsequent need to automate school-level feedback to ensure timely and accurate reports .

Since the 2000-01 school year, the SSP has been administered in over 350 elementary and secondary schools. Over 120 000 students have participated. HBR also processes several other school-based surveys including the School Physical Activity Profile which is being developed along the same model as the SSP. For these surveys, we have created the necessary syntax to permit a seamless transfer of data from SAS statistical software into a school feedback report template. Customized school feedback reports are created in minutes and then manually edited to ensure accuracy and consistency of the text to school-specific data. This process allows us to return school-level data to schools within weeks of data collection.

All surveys are machine scanned using Optical Mark Read (OMR) technology. The OMR scanner produces a text data file that is converted to a SAS data set. SAS programs have been written to facilitate many of the following quality control steps.

Visual scanning is the process of physically going through the surveys and darkening responses or filling in improper marks with correct marks (e.g., filling the circle vs. a check mark). During this process, the perforated booklets are separated and oriented into an organized pile in preparation for the OMR scan. Bundles are organized and labeled by school id number. This school id number is added to the respondent records using a SAS program. Visual scanning is performed by trained casual staff.

Before a bundle of questionnaires is machine scanned, a standard is inserted for every 20 - 25 questionnaires. Standards are questionnaires that have been filled out, scanned, checked and saved to file in preparation for survey processing. By linking scan id, a SAS program compares the standard file to standards within bundles to ensure the proper scan program is used and that the calibration of the OMR scanner remains constant.

Each bundle of questionnaires is scanned twice and then a bundle report is generated to be reviewed by trained staff. The process of creating and reviewing bundle reports and then making corrections is known as bundle checking. A SAS program is used to list all (1) discrepancies between the two machine scans (e.g., a light mark picked up in only one scan), (2) uncodeable responses (e.g., two bubbles filled in for a single question), and (3) scan id numbers in the bundle to make sure that a survey was not missed. These lists are then checked back to the physical surveys and corrections are made as needed to the data file.

Staff are trained to make corrections according to strict criteria. For example, they must distinguish between true uncodeables that are not corrected (e.g., the respondent chooses two answers) and those which are machine errors that should be corrected (e.g., the respondent erased one mark and choose another answer but the OMR picked up the erased mark too). After corrections have been made a SAS program is run to print out a comparison between the original scanned data and the new corrected data. The list of changes should correspond to the bundle report. This list of corrections as well as the bundle report is stored with the questionnaires. Logbooks and a quality control record are routinely kept to track the number of corrections made and to monitor the process of merging data files to create a school-level file.

We recently evaluated this process. In this exercise, we were able to quantify the individual and synergistic contributions of these quality control activities to determine the optimal protocol for survey processing. We determined that the error rate in the machine scanned datais0.01% prior to corrections being made to the dataset. We make the corrections. We continue to monitor the scanning process and make improvements to ensure both accuracy and efficiency.

For more information:

Senior Project Manager
Health Behaviour Research Group
University of Waterloo
Waterloo, ON N1R 7G5

(519) 888-4567 ext.XXXX

email.uwaterloo.ca

APPENDIX M Table 5. Operational definitions of built environment variables measured within 1-km buffer of schools.

Variable Name	Operational Definition	Scale of Measurement	Equation	Data Source
Density of PA opportunity structures	Total number of opportunities available in the school's geographic area.	1-km circular buffer surrounding school	Number of opportunities / kilometer	Enhanced points of interest file from the Desktop Mapping Technologies Incorporation
Land-use mix diversity	Using the method provided by Frank and Engelke (2001), LUM is a measure of the evenness of distribution of several land-use types (i.e., residential, commercial, industrial, institutional and open space) within the study's geographic area. In general, values of LUM vary on a continuous scale between 0 and 1, with one indicating even distribution of all land-use categories (heterogeneity) and zero implying a single type of land-use (homogeneity). The formula is showed in [a].	1-km circular buffer surrounding school	Equation below[a]	CanMap RouteLogistics (CMRL) spatial information database on land-uses
Street connectivity	Total number of street intersections within the school's geographic area.	1-km circular buffer surrounding school	Number of intersections / kilometer	CanMap RouteLogistics (CMRL) spatial information database on land-uses
Residential density	Total number of private dwellings per square kilometer in the schools given census tract.	Census block group	Number of occupied households / kilometer	2006 Canadian census data
Walkability index	Using the method provided by Frank et al. (2005), the walkability index is the sum of z-scores for the residential density, street network connectivity and land use mix variables. Higher values of the walkability index indicate a more walkable built environment. The formula is showed in [b].	1-km circular buffer surrounding school	Equation below[b]	CanMap RouteLogistics (CMRL) spatial information database on land-uses

[a]Land-use mix diversity= (-1) x ((square footage of commercial / total square footage of commercial residential, and office) ln (square footage of commercial / total square footage of commercial, residential, and office) + (square footage of office / total square footage of commercial residential, and office) ln (square footage of office / total square footage of commercial residential, and office) + (square footage of residential / total square footage of commercial, residential, and office) ln (square footage of residential / total square footage of commercial, residential, and office)) / ln (n3); where n3 = 0 through 3 depending on the number of different land uses present.

[b]Walkability index= (6 x z-score of land-use mix) + (z-score of residential density) + (z-score of intersection density).

APPENDIX N Table 6. Descriptive statistics for student-level factors.

Student-level factors	Students n= 22117 % (n)	Females n=10925 % (n)	Males N=11192 % (n)	Chi-square/ t-test Testing sex differences
Grade				
9	27.6 (6120)	27.4 (2995)	27.9 (3125)	X^2= 1.9
10	26.6 (5893)	27.0 (2946)	26.3 (2947)	p= 0.59
11	23.0 (5082)	23.1 (2525)	22.9 (2557)	
12	22.8 (5022)	22.5 (2459)	22.9 (2563)	
Body Mass Index (BMI)				
Underweight	1.5 (332)	1.4 (147)	1.7 (185)	X^2= 330.4
Overweight	16.6 (3667)	13.2 (1445)	19.9 (2222)	p<0.0001
Obese	6.6 (1446)	4.8 (523)	8.2 (923)	
Healthy weight	75.4 (16672)	80.6 (8810)	70.2 (7862)	
Mode of Transportation to School				
Active	20.3 (4496)	23.7 (2651)	16.9 (1845)	X^2= 178.6
Mixed	22.3 (4937)	20.2 (2257)	24.5 (2680)	p<0.0001
Inactive	57.4 (12684)	58.6 (6400)	56.1 (6284)	
Enrolled in PE				
Yes	34.9 (7714)	31.7 (3459)	38.0 (4255)	X^2= 98.4
No	65.1 (14403)	68.3 (7466)	62.0 (6937)	p<0.0001
Physical Activity Time*				
Average minutes of moderate to vigorous PA per day	151.0 (96.4)	134.8 (88.1)	166.9 (101.4)	t= 25.1 p<0.0001

*Mean (SD) presented for continuous variable.

APPENDIX O Table 7. Descriptive statistics for the sample of secondary schools (N= 76).

Environment-level factors	% (N) / Mean (SD; Range)
School social environment	
Offer daily PE	
Yes	72.4 (55)
No	27.6 (21)
Offer intramural activities	
Yes	76.3 (58)
No	23.4 (18)
Offer varsity sports	
Yes	86.8 (66)
No	13.2 (10)
School built environment	
Other room for PA	80.3 (61)
Dance studio	36.8 (28)
Swimming pool	6.6 (5)
Baseball diamond	36.8 (28)
Outdoor hoops	51.3 (39)
Tennis court	19.7 (15)
Paved area for games	46.1 (35)
Bicycle racks	82.9 (63)
Skating rink	7.9 (6)
Running/walking track	86.8 (66)
School PA Facilities Index*	5.4 (1.7, 1 – 10)
Neighbourhood built environment	
Fast food outlets*	2.8 (3.5, 0 – 15)
Recreation facilities*	1.6 (2.5, 0 – 13)
Shopping malls*	0.4 (0.8, 0 – 4)
Parks*	0.6 (1.4, 0 – 9)
Street connectivity*	148.9 (81.3, 0 – 360.0)
Land-use mix diversity*	0.5 (0.2, 0 – 0.8)
Residential density*	808.2 (778.2, 0.9 – 3906.0)
Walkability Index*	0.2 (5.7; -18.8, 12.4)
Potential school-level confounders	
SES*	13.0 (8.8; 2.1-47.7)
School location	
Urban	34.2 (26)
Suburban	39.5 (30)
Rural	26.3 (20)
Season of data collection	
Winter	11.8 (9)
Spring	19.7 (15)
Fall	68.4 (52)

*Mean (SD;Range) presented for continuous variables

APPENDIX P Table 8. Univariate analyses for environment-level factors in relation to students' time spent in PA.

Environment-level factors	Estimate (SE)	p-value
School social environment		
Offer daily PE	**8.88 (4.31)**	**0.0432[a]**
Offer intramurals	-4.46 (4.57)	0.3320
Offer interschool sports	2.83 (6.10)	0.6437
School built environment		
Other room for PA	**8.35 (4.97)**	**0.0973[a]**
Dance studio	-2.25 (4.06)	0.5805
Swimming pool	4.60 (7.93)	0.5638
Baseball diamond	-3.16 (4.08)	0.4407
Outdoor hoops	-2.85 (3.94)	0.4718
Tennis court	-2.69 (4.90)	0.5845
Paved area for games	-1.73 (3.95)	0.6621
Bicycle racks	-2.32 (5.35)	0.6659
Skating rink	4.46 (7.30)	0.5432
Running/walking track	-1.85 (5.93)	0.7560
School PA facilities index	0.51 (1.14)	0.6591
Neighbourhood built environment		
Fast food outlets	-0.28 (0.57)	0.6176
Recreation facilities	-0.86 (0.78)	0.2741
Shopping malls	2.19 (2.48)	0.2805
Parks	3.55 (4.33)	0.4146
Street connectivity	**-0.04 (0.02)**	**0.1170[a]**
Land-use mix diversity	**-19.20 (11.81)**	**0.1082[a]**
Residential density	-0.01 (0.00)	0.4655
Walkability index	**-1.81 (1.21)**	**0.1394[a]**

Note: [a]$p<0.2$

APPENDIX Q Table 9. Multilevel regression analysis for students' time spent in PA and student- and environment-level factors (n=22,117).

Characteristics		Student Variables	Student and School Social Environment Variables	Student, School Social Environment, and School Built Environment Variables	Student, School Social Environment, and School & Neighbourhood Built Environment Variables	Student, School Social Environment, School & Neighbourhood Built Environment Variables, controlling for Confounders
		β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
Student-Level						
Gender	Female	REF	REF	REF	REF	REF
	Male	28.27 (1.25)[c]	28.28 (1.25)[c]	28.26 (1.25)[c]	28.24(1.25)[c]	28.20 (1.25)[c]
Grade	9	REF	REF	REF	REF	REF
	10	-4.15 (1.70)[a]	-4.16 (1.70)[a]	-4.17 (1.70)[a]	-4.17 (1.70)[b]	-4.17 (1.70)[b]
	11	-12.38 (1.77)[c]	-12.39 (1.77)[c]	-12.40 (1.77)[c]	-12.38 (1.77)[c]	-12.38 (1.77)[c]
	12	-21.24 (1.81)[c]	-21.6 (1.81)[c]	-21.26 (1.81)[c]	-21.24(1.81)[c]	-21.19 (1.81)[c]
Weight status	Healthy weight	REF	REF	REF	REF	REF
	Underweight	-2.66 (5.07)	-2.63 (5.07)	-2.60 (5.07)	-2.59 (5.07)	-2.49 (5.07)
	Overweight	-1.73 (1.68)	-1.74 (1.68)	-1.73 (1.68)	-1.73 (1.68)	-1.74 (1.68)
	Obese	-7.97 (2.52)[b]	-7.98 (2.52)[b]	-7.99 (2.52)[b]	-7.99 (2.75)[b]	-7.95 (2.52)[b]
Mode of transport to school	Inactive	REF	REF	REF	REF	REF
	Active	14.92 (1.67)[c]	14.86 (1.67)[c]	14.90 (1.67)[c]	14.92 (1.67)[c]	14.92 (1.67)[c]
	Mixed	7.42 (1.56)[c]	7.37 (1.56)[c]	7.39 (1.56)[c]	7.45 (1.56)	7.49 (1.56)
Enrolled in PE	No	REF	REF	REF	REF	REF
	Yes	39.06 (1.35)	39.05 (1.35)[c]	39.06 (1.35)[c]	39.09 (1.35)[c]	39.16 (1.35)[c]
Environment-Level						
Offer daily PE	No		REF	REF	REF	REF
	Yes		7.85 (4.085)	8.00 (3.96)[a]	8.56 (3.88)[a]	7.45 (3.75)[a]
Other room for PA	No			REF	REF	REF
	Yes			8.57 (4.56)	8.87 (4.46)[a]	11.49 (4.23)[b]
Land-use mix diversity					-22.93 (10.59)[a]	-20.82 (10.66)[a]
Street connectivity					*excluded to create more parsimonious model	*excluded to create more parsimonious model
-2LL[d]		262526*	262518*	262509*	262498*	262461*

Note: [a]p<0.05; [b]p<0.01, [c]p<0.001, [d]-2LL: -2 Log Likelihood (*indicates significant improvement in model fit at p<*0*.05); Controlling for potential school-level confounders: area-level SES, school location (rural, suburban, urban), and season of data collection (winter, fall, spring).

Appnedix R. Table 10. Multilevel regression analysis for students' time spent in PA, student- and environment-level factors including walkability index (n=22,117).

Characteristics		Student Variables	Student and School Social Environment Variables	Student, School Social Environment, and School Built Environment Variables	Student, School Social Environment, and School & Neighbourhood Built Environment Variables	Student, School Social Environment, School & Neighbourhood Built Environment Variables, controlling for Confounders
		β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
Student-Level						
Gender	Female	REF	REF	REF	REF	REF
	Male	28.27 (1.25)[c]	28.28 (1.25)[c]	28.26 (1.25)[c]	28.22(1.25)[c]	28.17 (1.26)[c]
Grade	9	REF	REF	REF	REF	REF
	10	-4.15 (1.70)[a]	-4.16 (1.70)[a]	-4.17 (1.70)[a]	-4.17 (1.70)[b]	-4.15 (1.71)[b]
	11	-12.38 (1.77)[c]	-12.39 (1.77)[c]	-12.40 (1.77)[c]	-12.38 (1.77)[c]	-12.57 (1.77)[c]
	12	-21.24 (1.81)[c]	-21.6 (1.81)[c]	-21.26 (1.81)[c]	-21.26 (1.81)[c]	-21.34 (1.82)[c]
Weight status	Healthy weight	REF	REF	REF	REF	REF
	Underweight	-2.66 (5.07)	-2.63 (5.07)	-2.60 (5.07)	-2.60 (5.07)	-2.32 (5.09)
	Overweight	-1.73 (1.68)	-1.74 (1.68)	-1.73 (1.68)	-1.73 (1.68)	-1.76 (1.68)
	Obese	-7.97 (2.52)[b]	-7.98 (2.52)[b]	-7.99 (2.52)[b]	-8.00 (2.52)[b]	-8.19 (2.53)[b]
Mode of transport to school	Inactive	REF	REF	REF	REF	REF
	Active	14.92 (1.67)[c]	14.86 (1.67)[c]	14.90 (1.67)[c]	14.96 (1.68)[c]	14.98 (1.67)[c]
	Mixed	7.42 (1.56)[c]	7.37 (1.56)[c]	7.39 (1.56)[c]	7.48 (1.56)	7.60 (1.57)
Enrolled in PE	No	REF	REF	REF	REF	REF
	Yes	39.06 (1.35)	39.05 (1.35)[c]	39.06 (1.35)[c]	39.07 (1.35)[c]	38.99 (1.35)[c]
Environment-Level						
Offer daily PE	No		REF	REF	REF	REF
	Yes		7.85 (4.085)	8.00 (3.96)[a]	8.57 (3.83)[a]	7.44 (3.69)[a]
Other room for PA	No			REF	REF	REF
	Yes			8.57 (4.56)	8.45 (4.41)	11.35 (4.17)[b]
Walkability index					-2.45(0.95)[a]	-2.79 (1.00)[a]
-2LL[d]		262526*	262518*	262509*	262501*	260756*

Note: [a]p<0.05; [b]p<0.01, [c]p<0.001, [d]-2LL: -2 Log Likelihood (*indicates significant improvement in model fit at p<0.05); Controlling for potential school-level confounders: area-level SES, school location (rural, suburban, urban), and season of data collection (winter, fall, spring).

APPENDIX S. Table 11. Descriptive statistics for student respondents.

Student Characteristic	Females n=10781 % (n)	Males N=10973 % (n)	Chi-square / t-test (sex differences)
Grade			
9	27.3 (2938)	27.6 (3035)	
10	26.9 (2902)	26.4 (2890)	X^2= 1.14, p<0.7670
11	23.2 (2499)	23.0 (2521)	
12	22.6 (2442)	23.0 (2527)	
Body Mass Index (BMI)			
Underweight	1.3 (145)	1.7 (181)	
Overweight	13.3 (1433)	19.8 (2171)	X^2= 77.07, p<0.0001
Obese	4.8 (518)	8.2 (903)	
Healthy weight	80.6 (8685)	70.3 (7718)	
Mode of Transportation to School			
Active	16.8 (1816)	23.7 (2600)	X^2= 178.87,p<0.0001
Mixed	24.6 (2650)	20.2 (2212)	
Inactive	58.6 (6315)	56.1 (6161)	
Enrolled in school PE			
Yes	31.4 (3391)	38.0 (4163)	
No	68.6 (7390)	62.0 (6810)	X^2= 100.73, p<0.0001
Participates in school intramurals			
Yes	27.9 (3003)	38.2 (4193)	
No	72.1 (7778)	61.8 (6780)	X^2= 279.63, p<0.0001
Participates in school varsity teams			
Yes	37.5 (4043)	45.0 (4932)	
No	62.5 (6738)	55.0 (6041)	X^2= 124.86, p<0.0001
Participates in flexibility activities			
Less than 3 days per week	40.4 (4357)	48.7 (5341)	
At least 3 days per week	59.6 (6424)	51.3 (5632)	X^2= 148.18, p<0.0001
Participates in strength training			
Less than 3 days per week	36.6 (3948)	27.9 (3056)	
At least 3 days per week	63.4 (6833)	72.1 (7917)	X^2= 191.68, p<0.0001
Physical Activity Time*			
Average minutes of moderate to vigorous PA per day	134.7 (88.1)	166.8 (101.2)	t=24.9, p<0.0001

* Mean (SD; Range) presented for continuous variable

APPENDIX T

Table 12. School descriptives and univariate analyses examining associations between students' time spent in PA and environment-level factors.

		Univariate analyses			
	School Descriptives (N=76)	**Females (N=76, n=10,781)**		**Males (N=76, n= 10,973)**	
School Characteristic	**% (N) / Mean (SD; Range)**	**β (SE)**	**p-value**	**β (SE)**	**p-value**
School curriculum and instruction					
Offer daily PE	72.4 (55)	**7.82 (3.83)**	**0.0445**[a]	**9.36 (4.95)**	**0.0629**[a]
Offer intramurals	76.3 (58)	**-4.95 (3.98)**	**0.2177**[a]	-4.61 (5.19)	0.3782
Offer interschool sports	86.8 (66)	0.12 (5.38)	0.9816	4.02 (6.96)	0.5652
School built environment					
Other room for PA	80.3 (61)	**7.18 (4.48)**	**0.1132**[a]	**8.20 (5.80)**	**0.1613**[a]
Dance studio	36.8 (28)	-1.71 (3.58)	0.6349	-2.82 (4.59)	0.5410
Swimming pool	6.6 (5)	1.42 (7.06)	0.8410	5.47 (8.95)	0.5435
Baseball diamond	36.8 (28)	-1.89 (3.62)	0.6054	-2.87 (4.65)	0.5390
Outdoor hoops	51.3 (39)	-0.77 (3.50)	0.8265	-3.18 (4.47)	0.4795
Tennis court	19.7 (15)	-4.42 (4.31)	0.3089	-2.06 (5.54)	0.7110
Paved area for games	46.1 (35)	1.09 (3.50)	0.7558	-4.27 (4.45)	0.3412
Bicycle racks	82.9 (63)	-2.76 (4.80)	0.5672	-0.67 (6.14)	0.9132
Skating rink	7.9 (6)	5.75 (6.41)	0.3730	2.92 (8.27)	0.7246
Running/walking track	86.8 (66)	-0.16 (5.34)	0.9755	-1.11 (6.75)	0.8693
School PA facilities index	5.4 (1.7, 1 – 10)	0.10 (1.02)	0.9199	0.68 (1.30)	0.6014
Neighbourhood built environment					
Fast food outlets	2.8 (3.5, 0 – 15)	-0.02 (0.50)	0.9685	-0.26 (0.64)	0.6817
Recreation facilities	1.6 (2.5, 0 – 13)	-0.55 (0.69)	0.4259	-0.69 (0.89)	0.4451
Shopping malls	0.4 (0.8, 0 – 4)	2.44 (2.19)	0.2692	2.36 (2.82)	0.4060
Parks	0.6 (1.4, 0 – 9)	2.13 (3.81)	0.5781	3.97 (4.84)	0.4145
Street connectivity	148.9 (81.3, 0 – 360.0)	**-0.03 (0.02)**	**0.1634**[a]	**-0.04 (0.03)**	**0.1386**[a]
Land-use mix diversity	0.5 (0.2, 0 – 0.8)	**-22.66 (10.60)**	**0.0355**[a]	-11.38 (13.76)	0.4107
Residential density	808.2 (778.2, 0.9 – 3906.0)	0.00 (0.00)	0.6825	0.00 (0.00)	0.2791
Walkability index	0.2 (5.7; -18.8 - 12,4)	**-1.66 (0.98)**	**0.0943**[a]	**-2.47 (0.36)**	**0.0480**[a]

Note:[a]p<0.2

APPENDIX U. Table 13. Multilevel regression analysis for female students' time spent in PA (n=10,781).

Characteristics		Student Variables	Student and School Social Environment Variables	Student, School Social Environment, and School Built Environment Variables	Student, School Social Environment, and School & Neighbourhood Built Environment Variables	Student, School Social Environment, School & Neighbourhood Built Environment Variables, and Confounders
		β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
Student-level						
Grade	9	REF	REF	REF	REF	REF
	10	-2.11 (2.18)	-2.13 (2.18)	-2.13 (2.18)	-2.15 (2.18)	-2.11 (2.18)
	11	-7.81 (2.28)[c]	-7.81 (2.28)[c]	-7.81 (2.28)[c]	-7.79 (2.28)[c]	-7.77 (2.28)[c]
	12	-13.00 (2.35)[c]	-13.00 (2.35)[c]	-12.94 (2.35)[c]	-12.88 (2.35)[c]	-12.77 (2.34)[c]
Weight status	Healthy weight	REF	REF	REF	REF	REF
	Underweight	10.55 (6.76)	10.54 (6.76)	10.57 (6.76)	10.63 (6.76)	10.86 (6.76)
	Overweight	-0.10 (2.31)	-0.10 (2.31)	-0.10 (2.31)	-0.09 (2.31)	-0.15 (2.31)
	Obese	3.14 (3.68)	3.17 (3.68)	3.23 (3.68)	3.17 (3.68)	3.06 (3.68)
Mode of transport to school	Non-active	REF	REF	REF	REF	REF
	Active	18.00 (2.23)[c]	18.02 (2.23)[c]	18.10 (2.23)[c]	18.09 (2.23)[c]	18.28 (2.23)[c]
	Mixed	3.72 (1.90)[a]	3.68 (1.90)[a]	3.75 (1.90)[a]	3.85 (1.90)[a]	4.00 (1.90)[a]
Enrolled in PE	No	REF	REF	REF	REF	REF
	Yes	23.87 (1.86)[c]	23.90 (1.86)[c]	23.90 (1.86)[c]	23.94 (1.86)[c]	24.10 (1.86)[c]
Participating in school intramurals	No	REF	REF	REF	REF	REF
	Yes	18.36 (2.19)[c]	18.31 (2.19)[c]	18.34 (2.19)[c]	18.31 (2.19)[c]	18.32 (2.19)[c]
Participating in school varsity teams	No	REF	REF	REF	REF	REF
	Yes	9.26 (2.03)[c]	9.28 (2.03)[c]	9.32 (2.03)[c]	9.33 (2.03)[c]	9.36 (2.03)[c]
Engaging in flexibility activities	<3 days/week	REF	REF	REF	REF	REF
	≥3 days/week	26.90 (1.90)[c]	26.94 (1.90)[c]	26.95 (1.90)[c]	26.93 (1.90)[c]	26.96 (1.90)[c]
Engaging in strength activities	<3 days/week	REF	REF	REF	REF	REF
	≥3 days/week	22.96 (1.96)[c]	22.93 (1.96)[c]	22.91 (1.96)[c]	22.95 (1.96)[c]	22.91 (1.96)[c]
Environment-level						
Offer daily PE	No		REF	REF	REF	REF
	Yes		5.26 (3.91)	5.37 (3.79)	6.31 (3.70)	5.68 (3.65)
Offer intramurals	No		REF	REF	REF	REF
	Yes		-5.65 (4.01)	-5.74 (3.88)	-4.26 (3.81)	-6.86 (3.86)
Other room for PA	No			REF	REF	REF
	Yes			9.43 (4.23)[a]	9.46 (4.10)[a]	12.51 (3.96)[b]
Land-use mix diversity					-24.88 (9.93)[b]	-26.14 (10.19)[b]
Street connectivity					*removed to create more parsimonious model	removed to create more parsimonious model
-2LL		125247	125233*	125223*	125210*	125181*

Note: [a]p<0.05; [b]p<0.01, [c]p<0.001, [d]-2LL: -2 Log Likelihood; Controlling for: area-level SES, school location (rural, suburban, urban), and season of data collection (winter, fall, spring).

APPENDIX V. Table 14. Mutlilevel regression analysis for female students' time spent in PA including walkability index (n=10,781).

Characteristics		Student Variables	Student and School Social Environment Variables	Student, School Social Environment, and School Built Environment Variables	Student, School Social Environment, and School & Neighbourhood Built Environment Variables	Student, School Social Environment, School & Neighbourhood Built Environment Variables, and Confounders
		β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
Student-level						
Grade	9	REF	REF	REF	REF	REF
	10	-2.11 (2.18)	-2.13 (2.18)	-2.13 (2.18)	-2.17 (2.18)	-2.16(2.18)
	11	-7.81 (2.28)[c]	-7.81 (2.28)[c]	-7.81 (2.28)[c]	-7.77 (2.28)[c]	-7.73 (2.28)[c]
	12	-13.00 (2.35)[c]	-13.00 (2.35)[c]	-12.94 (2.35)[c]	-12.95 (2.35)[c]	-12.86 (2.35)[c]
Weight status	Healthy weight	REF	REF	REF	REF	REF
	Underweight	10.55 (6.76)	10.54 (6.76)	10.57 (6.76)	10.55 (6.76)	10.71 (6.76)
	Overweight	-0.10 (2.31)	-0.10 (2.31)	-0.10 (2.31)	-0.07 (2.31)	-0.09 (2.31)
	Obese	3.14 (3.68)	3.17 (3.68)	3.23 (3.68)	3.18 (3.68)	3.08 (3.68)
Mode of transport to school	Non-active	REF	REF	REF	REF	REF
	Active	18.00 (2.23)[c]	18.02 (2.23)[c]	18.10 (2.23)[c]	18.15 (2.23)[c]	18.34 (2.23)[c]
	Mixed	3.72 (1.90)[a]	3.68 (1.90)[a]	3.75 (1.90)[a]	3.84 (1.90)[a]	3.97 (1.90)[a]
Enrolled in PE	No	REF	REF	REF	REF	REF
	Yes	23.87 (1.86)[c]	23.90 (1.86)[c]	23.90 (1.86)[c]	23.92 (1.86)[c]	24.08 (1.86)[c]
Participating in school intramurals	No	REF	REF	REF	REF	REF
	Yes	18.36 (2.19)[c]	18.31 (2.19)[c]	18.34 (2.19)[c]	18.32 (2.19)[c]	18.28 (2.19)[c]
Participating in school varsity teams	No	REF	REF	REF	REF	REF
	Yes	9.26 (2.03)[c]	9.28 (2.03)[c]	9.32 (2.03)[c]	9.36 (2.03)[c]	9.40 (2.03)[c]
Engaging in flexibility activities	<3 days/week	REF	REF	REF	REF	REF
	≥3 days/week	26.90 (1.90)[c]	26.94 (1.90)[c]	26.95 (1.90)[c]	26.91 (1.90)[c]	26.91 (1.90)[c]
Engaging in strength activities	<3 days/week	REF	REF	REF	REF	REF
	≥3 days/week	22.96 (1.96)[c]	22.93 (1.96)[c]	22.91 (1.96)[c]	22.92 (1.96)[c]	22.86 (1.96)[c]
Environment-level						
Offer daily PE	No		REF	REF	REF	REF
	Yes		5.26 (3.91)	5.37 (3.79)	6.02 (3.74)	5.06 (3.81)
Offer intramurals	No		REF	REF	REF	REF
	Yes		-5.65 (4.01)	-5.74 (3.88)	-4.83 (3.84)	-7.54 (4.06)
Other room for PA	No			REF	REF	REF
	Yes			9.43 (4.23)[a]	9.09 (4.16)[a]	10.97 (4.11)[b]
Walkability index					-1.75 (0.92)	-1.89 (0.95)
-2LL		125247	125233*	125223*	125218*	126189*

Note: [a]p<0.05; [b]p<0.01, [c]p<0.001, [d]-2LL: -2 Log Likelihood; Controlling for: area-level SES, school location (rural, suburban, urban), and season of data collection (winter, fall, spring).

APPENDIX W. Table 15. Multilevel regression analysis for male students' time spent in PA (n= 10,973).

Characteristics		Student Variables	Student and School Social Environment Variables	Student, School Social Environment, and School Built Environment Variables	Student, School Social Environment, and School & Neighbourhood Built Environment Variables	Student, School Social Environment, School & Neighbourhood Built Environment Variables, and Confounders
		β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
Student-level						
Grade	9	REF	REF	REF	REF	REF
	10	-4.64 (2.46)	-4.63 (2.46)	-4.69 (2.46)	-4.64 (2.46)	-4.67 (2.46)
	11	-10.60 (2.54)^{c}	-10.61 (2.54)^{c}	-10.63 (2.54)^{c}	-10.61 (2.54)^{c}	-10.59 (2.54)^{c}
	12	-19.96 (2.59)^{c}	-20.00 (2.59)^{c}	-20.02 (2.59)^{c}	-20.02 (2.59)^{c}	-19.86 (2.59)^{c}
Weight status	Healthy weight	REF	REF	REF	REF	REF
	Underweight	4.20 (7.02)	4.26 (7.02)	4.33 (7.02)	4.32 (7.02)	4.38 (7.02)
	Overweight	-3.70 (2.26)	-3.71 (2.26)	-3.71 (2.26)	-3.71 (2.26)	-3.74 (2.26)
	Obese	-8.73 (3.29)^{c}	-8.72 (3.29)^{b}	-8.77 (3.29)^{b}	-8.78 (3.29)^{b}	-8.63 (3.29)^{b}
	Non-active	REF	REF	REF	REF	REF
Mode of transport to	Active	11.48 (2.29)^{c}	11.39 (2.29)^{c}	11.46 (2.29)^{c}	11.70 (2.29)^{c}	11.69 (2.37)^{c}
school	Mixed	6.20 (2.36)^{b}	6.12 (2.36)^{b}	6.18 (2.35)^{b}	6.37 (2.36)^{b}	6.41 (2.36)^{b}
Enrolled in PE	No	REF	REF	REF	REF	REF
	Yes	19.80 (1.97)^{c}	19.76 (1.97)^{c}	19.78 (1.97)^{c}	19.76 (1.97)^{c}	19.83 (1.97)^{c}
Participation in school	No	REF	REF	REF	REF	REF
intramurals	Yes	23.80 (2.28)^{c}	23.77 (2.28)^{c}	23.81 (2.28)^{c}	23.79 (2.23)^{c}	23.78 (2.28)^{c}
Participation in school	No	REF	REF	REF	REF	REF
varsity teams	Yes	12.38 (2.23)^{c}	12.39 (2.23)^{c}	12.41 (2.23)^{c}	12.41 (2.23)^{c}	12.36 (2.23)^{c}
Engaging in flexibility	<3 days/week	REF	REF	REF	REF	REF
activities	≥3 days/week	23.10 (1.99)^{c}	23.10 (1.99)^{c}	23.13 (1.99)^{c}	23.11 (1.99)^{c}	23.18 (1.99)^{c}
Engaging in strength	<3 days/week	REF	REF	REF	REF	REF
activities	≥3 days/week	33.84 (2.21)^{c}	33.87 (2.21)^{c}	33.84 (2.21)^{c}	33.85 (2.21)^{c}	33.83 (2.21)^{c}
Environment-level						
Offering daily PE	No		REF	REF	REF	REF
	Yes		9.28 (4.91)	9.52 (4.77)^{a}	9.19 (4.72)	7.65 (4.50)
Other room for PA	No			REF	REF	REF
	Yes			11.66 (5.55)^{a}	10.47 (5.54)^{a}	13.32 (5.21)^{b}
Street connectivity					-0.04 (0.03)	-0.03 (0.03)
-2LL		130634	130626*	130616*	130615	130581*

Note: $^{a}p<0.05$; $^{b}p<0.01$, $^{c}p<0.001$, ^{d}-2LL: -2 Log Likelihood; Controlling for: area-level SES, school location (rural, suburban, urban), and season of data collection (winter, fall, spring).

APPENDIX X. Table 16. Multilevel regression analysis for male students' time spent in PA including walkability index (n= 10,973).

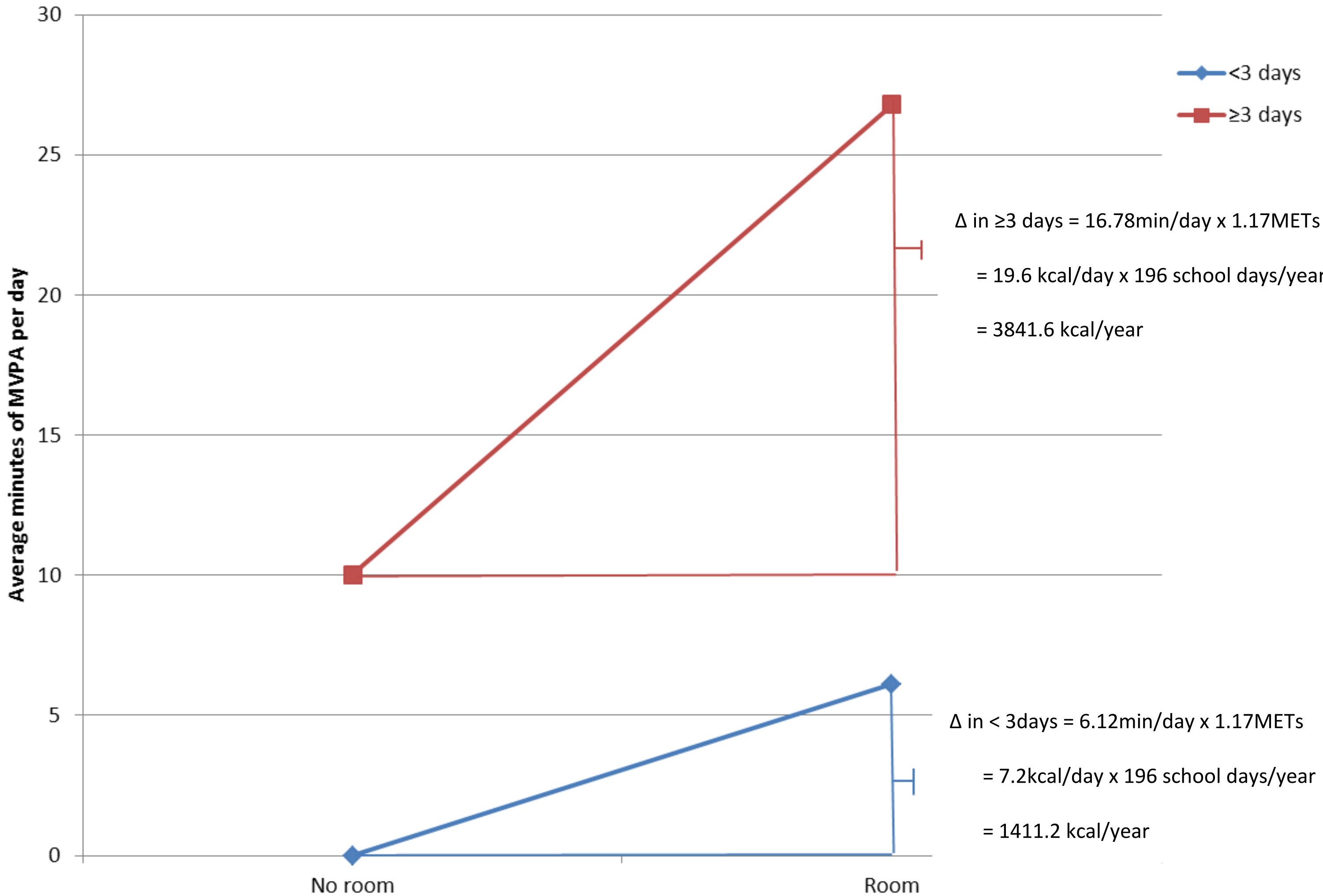
Characteristics		Student Variables	Student and School Social Environment Variables	Student, School Social Environment, and School Built Environment Variables	Student, School Social Environment, and School & Neighbourhood Built Environment Variables	Student, School Social Environment, School & Neighbourhood Built Environment Variables, and Confounders
		β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
Student-level						
Grade	9	REF	REF	REF	REF	REF
	10	-4.64 (2.46)	-4.63 (2.46)	-4.69 (2.46)	-4.61 (2.46)	-4.56 (2.46)
	11	-10.60 (2.54)[c]	-10.61 (2.54)[c]	-10.63 (2.54)[c]	-10.59 (2.54)[c]	-10.49 (2.54)[c]
	12	-19.96 (2.59)[c]	-20.00 (2.59)[c]	-20.02 (2.59)[c]	-20.02 (2.59)[c]	-19.87 (2.59)[c]
Weight status	Healthy weight	REF	REF	REF	REF	REF
	Underweight	4.20 (7.02)	4.26 (7.02)	4.33 (7.02)	4.35 (7.02)	4.48 (7.02)
	Overweight	-3.70 (2.26)	-3.71 (2.26)	-3.71 (2.26)	-3.72 (2.26)	-3.74 (2.26)
	Obese	-8.73 (3.29)[c]	-8.72 (3.29)[b]	-8.77 (3.29)[b]	-8.79 (3.29)[b]	-8.63 (3.29)[b]
Mode of transport to school	Non-active	REF	REF	REF	REF	REF
	Active	11.48 (2.29)[c]	11.39 (2.29)[c]	11.46 (2.29)[c]	11.61 (2.29)[c]	11.58 (2.28)[c]
	Mixed	6.20 (2.36)[b]	6.12 (2.36)[b]	6.18 (2.35)[b]	6.35 (2.35)[b]	6.40 (2.35)[b]
Enrolled in PE	No	REF	REF	REF	REF	REF
	Yes	19.80 (1.97)[c]	19.76 (1.97)[c]	19.78 (1.97)[c]	19.81 (1.97)[c]	19.88 (1.97)[c]
Participation in school intramurals	No	REF	REF	REF	REF	REF
	Yes	23.80 (2.28)[c]	23.77 (2.28)[c]	23.81 (2.28)[c]	23.72 (2.28)[c]	23.73 (2.28)[c]
Participation in school varsity teams	No	REF	REF	REF	REF	REF
	Yes	12.38 (2.23)[c]	12.39 (2.23)[c]	12.41 (2.23)[c]	12.49 (2.23)[c]	12.43 (2.23)[c]
Engaging in flexibility activities	<3 days/week	REF	REF	REF	REF	REF
	≥3 days/week	23.10 (1.99)[c]	23.10 (1.99)[c]	23.13 (1.99)[c]	23.08 (1.99)[c]	23.14 (1.99)[c]
Engaging in strength activities	<3 days/week	REF	REF	REF	REF	REF
	≥3 days/week	33.84 (2.21)[c]	33.87 (2.21)[c]	33.84 (2.21)[c]	33.89 (2.21)[c]	33.88 (2.21)[c]
Environment-level						
Offering daily PE	No		REF	REF	REF	REF
	Yes		9.28 (4.91)	9.52 (4.77)[a]	10.17 (4.60)[a]	8.65 (4.40)[a]
Other room for PA	No			REF	REF	REF
	Yes			11.66 (5.55)[a]	11.28 (5.35)[a]	12.39 (5.00)[b]
Walkability index					-3.02 (1.15)[a]	-3.11 (1.18)[a]
-2LL		130634	130626*	130616*	130607*	130569*

Note: [a]p<0.05; [b]p<0.01, [c]p<0.001, [d]-2LL: -2 Log Likelihood; Controlling for: area-level SES, school location (rural, suburban, urban), and season of data collection (winter, fall, spring).

APPENDIX Y

Figure 5. Contextual Interaction between participation in flexibility-related activities and attending a school with another room for PA.

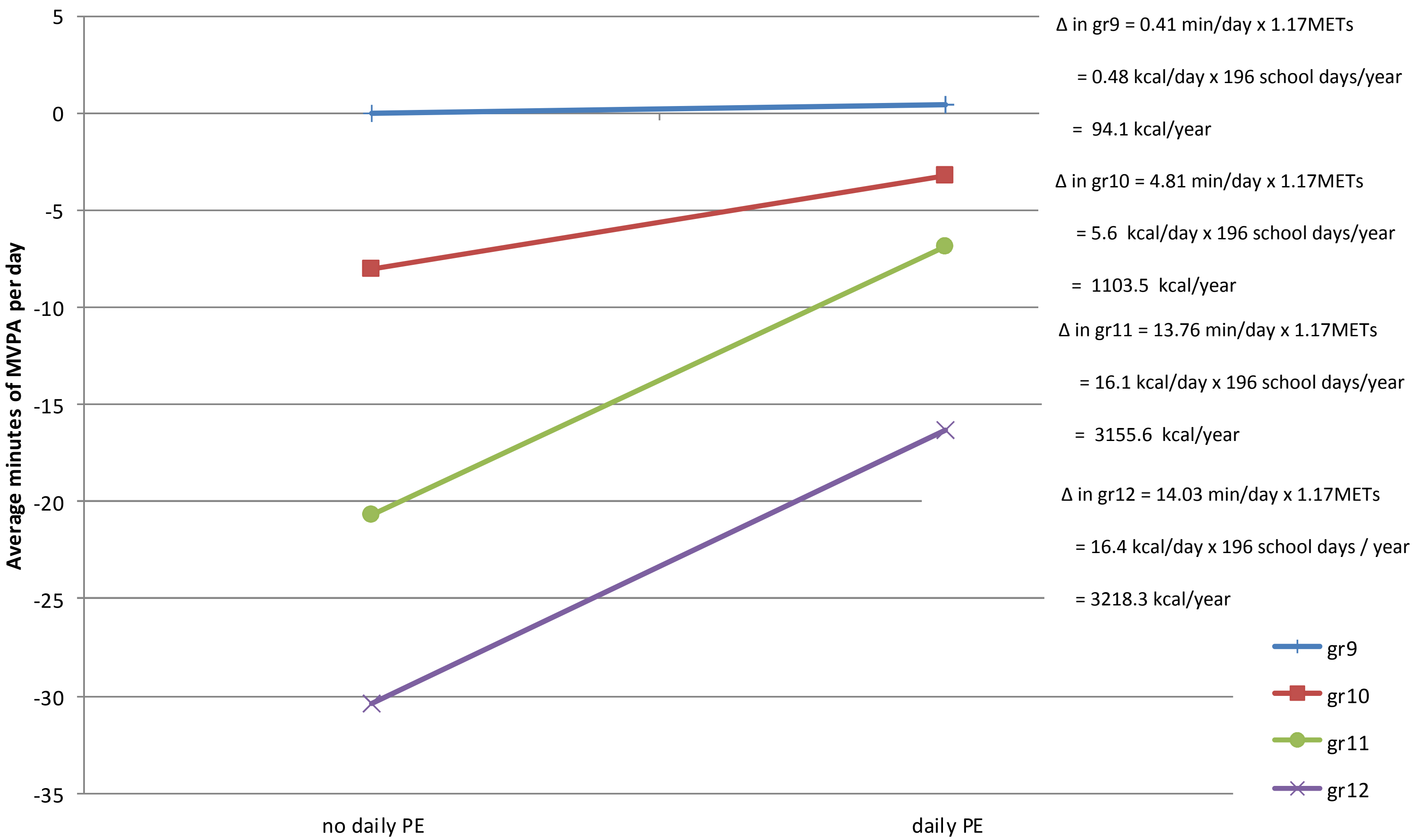
Using the model estimates, the female students' time spent in PA can be estimated as a function of both participating in flexibility activities and attending a school with another room for PA. In Figure 5, the model-based estimates of a female student relative to a hypothetical female student who participates in flexibility activities and attends a school without a another room for PA are presented.



APPENDIX Z

Figure 6 Contextual Interaction between grade and attending a school offering daily PE.

Using the model estimates, the average minutes of MVPA per day for male students can be estimated as a function of both grade and attending a school offering PE daily (5 days/week). In Figure 6, the model-based estimates of a male student relative to a hypothetical male student who is grade 9 and attends a school that does not offer PE daily are presented.



APPENDIX AA Table 17. Descriptive statistics for student respondents.

Student Characteristic	Urban n=6829 % (n)	Suburban n=10422 % (n)	Rural n=4503 % (n)	Chi-square / Fisher's / ANOVA
Gender				
Female	50.4 (3439)	49.7 (5178)	48.1 (2164)	X^2= 5.88,
Male	49.6 (3390)	50.3 (5244)	51.9 (2339)	p<0.053
Grade				
9	27.8 (1897)	27.1 (2829)	27.7 (1247)	X^2= 7.47,
10	25.9 (1767)	27.1 (2829)	26.6 (1196)	p<0.2799
11	22.8 (1559)	23.4 (2443)	22.6 (1018)	
12	23.5 (1606)	22.3 (2321)	23.1 (1042)	
Body Mass Index (BMI)				
Underweight	1.7 (114)	1.5 (156)	1.2 (56)	X^2= 10.85,
Overweight	16.8 (1145)	16.1 (1682)	17.3 (777)	p<0.0931
Obese	6.9 (468)	6.2 (646)	6.8 (307)	
Healthy weight	74.7 (5102)	76.2 (7938)	74.9 (3363)	
Mode of Transportation to School				
Active	23.4 (1596)	19.7 (2057)	16.9 (763)	X^2= 164.15,
Mixed	24.6 (1677)	22.3 (2328)	19.1 (857)	p<0.0001
Inactive	52.0 (3556)	58.0 (6037)	64.0 (2883)	
Enrolled in school PE				
Yes	35.0 (2390)	34.3 (3576)	35.3 (1588)	X^2= 1.59,
No	65.0 (4439)	65.7 (6846)	64.7 (2915)	p=0.4519
Participates in school intramurals				
Yes	32.4 (2210)	33.1 (3451)	33.4 (1503)	X^2= 1.56,
No	67.6 (4619)	66.9 (6971)	66.6 (3000)	p=0.4576
Participates in school varsity teams				
Yes	41.0 (2802)	41.5 (4327)	40.9 (1840)	X^2= 0.72,
No	59.0 (4027)	58.5 (6095)	59.1 (2663)	p=0.6975
Participates in yoga and stretching				
Less than 3 days per week	45.0 (3072)	44.2 (4609)	44.8 (2017)	X^2= 1.07,
At least 3 days per week	55.0 (3757)	55.8 (5813)	55.2 (2486)	p=0.5856
Participates in strength training				
Less than 3 days per week	32.5 (2222)	32.2 (3352)	31.8 (1430)	X^2= 0.77,
At least 3 days per week	67.5 (4607)	67.8 (7070)	68.2 (3073)	p=0.6809
Physical Activity Time*				
Average minutes of moderate to vigorous PA per day	148.0 (96.3)	150.9 (95.4)	155.6 (97.7)	F=16.47, p<0.0001

* Mean (SD; Range) presented for continuous variable

APPENDIX BB Table 18. Descriptive statistics for the sample of secondary schools.

School Characteristic		Urban Schools N=26 % (N) / Mean (SD; Range)	Suburban Schools N=30 % (N) / Mean (SD; Range)	Rural Schools N=20 % (N) / Mean (SD; Range)	Chi-square / ANOVA
School Social Environment					
Offer daily PE class					
Yes		53.9 (14)	83.3 (25)	80.0 (16)	X^2=6.85, p=0.0326
No		46.2 (12)	16.7 (5)	20.0 (4)	
Offer intramural Activities					
Yes		84.6 (22)	63.3 (19)	85.0 (17)	X^2=4.62,
No		15.4 (4)	36.7 (11)	15.0 (3)	p=0.099
Offer varsity Sports					
Yes		96.2 (25)	86.7 (26)	80.0 (16)	X^2=2.86, p=0.0909
No		3.9 (1)	13.3 (4)	20.0 (4)	
School Built Environment					
Other room for PA		80.8 (21)	90.0 (27)	65.0 (13)	X^2=4.74, p=0.0934
Dance studio		46.2 (12)	40.0 (12)	20.0 (4)	X^2=3.54, p=0.1707
Swimming pool		7.7 (2)	6.7 (2)	5.0 (1)	X^2=0.13, p=0.9352
Baseball diamond		50.0 (13)	23.3 (7)	40.0 (8)	X^2=4.37, p=0.1123
Outdoor hoops		53.9 (14)	43.3 (13)	60.0 (12)	X^2=1.44, p=0.4878
Tennis court		23.1 (6)	23.3 (7)	10.0 (2)	X^2=1.63, p=0.4437
Paved area for games		46.2 (12)	40.0 (12)	55.0 (11)	X^2=1.09, p=0.5807
Bicycle racks		80.8 (21)	90.0 (27)	75.0 (15)	X^2=2.03, p=0.3624
Skating rink		7.7 (2)	6.7 (2)	10.0 (2)	X^2=0.19, p=0.9114
Running/walking track		73.1 (19)	93.3 (28)	95.0 (19)	X^2=6.58, p=0.0372
School PA Facilities Index		5.3 (2.0, 1 – 10)	5.3 (1.5, 2 – 8)	5.9 (1.8, 2 – 9)	F=0.99, p=0.3226
Neighbourhood Built Environment					
Fast food outlets	0	19.2 (5)	53.3 (16)	50. (10)	F=6.51
	1	11.5 (3)	13.3 (4)	10.0 (2)	p=0.0128
	2	11.5 (3)	10.0 (3)	40.0 (8)	
	≥3	57.7 (15)	23.3 (7)		
Recreation facilities	0	19.2 (5)	50.0 (15)	75.0 (15)	F=2.92
	1	38.5 (10)	30.0 (9)	25.0 (5)	p=0.0919
	≥2	42.3 (11)	20.0 (6)		
Shopping malls	0	61.5 (16)	83.3 (25)	90.0 (18)	F=7.10
	1	15.4 (4)	16.7 (5)	10.0 (2)	p=0.0094
	≥2	23.1 (6)			
Parks	0	92.3 (24)	100.0 (30)	85.0 (17)	F=0.20
	≥1	7.7 (2)		15.0 (3)	p=0.6549
Street connectivity		201.8 (72.9, 0 – 360.0)	128.8 (70.6, 0 – 332.0)	110.2 (74.0, 0 – 226.0)	F=19.06 *p*<.0001
Land-use mix diversity		0.5 (0.1, 0.21 – 0.78)	0.4 (0.1, 0.13 – 0.66)	0.3 (0.2, 0 – 0.76)	F=10.30 p=0.0020
Residential density		532.7 (415.2, 0.9 – 1467.3)	1064.7 (951.9, 5.1 – 3906.0)	781.8 (756.3, 5.5 – 2702.7)	F=1.61 p=0.2086
Walkability index		0.72 (1.31, -1.7, 3.4)	0.03 (1.66, -3.7, 3.2)	-0.98 (2.28, -5.2, 3.5)	F=10.77 p=0.016

APPENDIX CC **Table 19. Univariate Analyses for associations between students' time spent in PA and school characteristics (categorical BE for all schools).**

	All schools (N=76, n=21754)		Urban Schools (N=26, n=6829)		Suburban Schools (N=30, n=10422)		Rural Schools (N=20, n=4503)	
School Characteristic	**β (SE)**	**p-value**	**β (SE)**	**p-value**	**β (SE)**	**p-value**	**β (SE)**	**p-value**
School social environment								
Offer daily PE (ref=No)	**8.88 (4.31)**	**p=0.0432**[a]	8.94 (8.05)	p=0.2784	**14.33 (6.80)**	**p=0.0437**	-.36 (9.26)	p=0.9699
Offer intramurals (ref=No)	-4.46 (4.57)	p=0.3320	-6.82 (11.05)	p=0.5439	-6.04 (5.51)	p=0.2825	0.30 (10.87)	p=0.9785
Offer varsity sports (ref=No)	2.83 (6.10)	p=0.6437	-8.13 (20.72)	p=0.6990	0.36 (8.02)	p=0.9645	**14.48 (8.67)**	**p=0.1141**[a]
School built environment								
Other room for PA (ref=No)	**8.35 (4.97)**	**p=0.0973**[a]	**19.06 (9.78)**	**p=0.0637**[a]	**15.55 (8.52)**	**p=0.0787**[a]	-0.72 (8.06)	p=0.9298
Dance studio (ref=No)	-2.25 (4.06)	p=0.5805	3.35 (8.18)	p=0.6861	1.73 (5.53)	p=0.7571	**-14.98 (8.14)**	**p=0.0873**[a]
Swimming pool (ref=No)	4.60 (7.93)	p=0.5638	22.07 (14.35)	p=0.1394	-10.90 (10.55)	p=0.3105	5.85 (18.62)	p=0.7562
Baseball diamond (ref=No)	-3.16 (4.08)	p=0.4407	-6.11 (8.12)	p=0.4594	-2.38 (6.42)	p=0.7141	-2.25 (7.59)	p=0.7709
Outdoor hoops (ref=No)	-2.85 (3.94)	p=0.4718	-2.40 (8.21)	p=0.7731	5.59 (5.38)	p=0.3077	**-15.34 (6.65)**	**p=0.0347**[a]
Tennis court (ref=No)	-2.69 (4.90)	p=0.5845	-8.71 (9.47)	p=0.3680	0.41 (6.45)	p=0.9500	12.79 (11.83)	p=0.2965
Paved area for games (ref=No)	-1.73 (3.95)	p=0.6621	3.86 (8.22)	p=0.6432	-2.36 (5.52)	p=0.6725	**-11.43 (6.98)**	**p=0.1203**[a]
Bicycle racks (ref=No)	-2.32 (5.35)	p=0.6659	-6.17 (10.58)	p=0.5656	3.93 (8.94)	p=0.6640	-1.51 (8.77)	p=0.8649
Skating rink (ref=No)	4.46 (7.30)	p=0.5432	8.54 (15.01)	p=0.5756	10.37 (10.63)	p=0.3375	-10.15 (12.50)	p=0.4278
Running/walking track (ref=No)	-1.85 (5.93)	p=0.7560	-10.97 (9.00)	p=0.2356	5.28 (11.16)	p=0.6395	12.82 (20.14)	p=0.5284
School PA facilities index*	0.51 (1.14)	p=0.6591	-0.05 (2.14)	p=0.9812	-1.39 (1.86)	p=0.4605	**2.73 (1.94)**	**p=0.1794**[a]
Neighbourhood built environment								
Fast food outlets (ref=0)								
1	7.47 (3.11)	p=0.2513	13.40 (15.24)	p=0.3893	**13.28 (8.11)**	**p=0.1137**[a]	0.26 (5.46)	p=0.9841
2	5.85 (7.55)	p=0.4413	**23.05 (15.14)**	**p=0.1436**[a]	3.04 (9.11)	p=0.7410	-4.43 (8.18)	p=0.5956
≥3	-0.27 (4.44)	p=0.9511	11.80 (10.90)	p=0.2913	-1.32 (6.69)	p=0.8455	*Not applicable	
Recreation facilities (ref=0)								
1	**-12.50 (4.67)**	**p=0.0092**[a]	-13.90 (11.32)	p=0.2327	**-9.03 (6.10)**	**p=0.1505**[a]	10.26 (8.07)	p=0.2226
≥2	-5.18 (4.61)	p=0.2646	-3.32 (11.13)	p=0.7687	-0.18 (7.02)	p=0.9796	*Not applicable	
Shopping malls (ref=0)								
1	1.15 (6.07)	p=0.8499	**17.95 (10.92)**	**p=0.1162**[a]	1.57 (7.27)	p=0.8305	6.05 (11.71)	p=0.6138
≥2	5.86 (6.62)	p=0.3789	**11.68 (9.65)**	**p=0.2390**[a]	*Not applicable		*Not applicable	
Parks (ref=0)								
≥1	5.63 (7.93)	p=0.4803	-12.99 (14.81)	p=0.3906	*No parks present		3.88 (10.21)	p=0.7089
Street connectivity*	**-0.04 (0.02)**	**p=0.1170**[a]	-0.03 (0.06)	p=0.6582	**-0.06 (0.04)**	**p=0.1183**[a]	0.02 (0.05)	p=0.7461
Land-use mix diversity*	**-19.20 (11.81)**	**p=0.1082**[a]	3.54 (28.74)	p=0.9032	-14.50 (20.06)	p=0.4757	**-24.27 (18.28)**	**p=0.1997**[a]
Residential density*	-0.01 (0.00)	p=0.4655	0.00 (0.00)	p=0.9631	-0.00 (0.00)	p=0.2717	-0.00 (0.01)	p=0.8015
Walkability index*	**-2.35 (1.06)**	**p=0.0301**[a]	-0.67 (3.16)	p=0.8332	**-3.30 (1.51)**	**p=0.0038**[a]	-1.10 (1.71)	p=0.5285

Note: [a] p<0.2; *continuous measures.

APPENDIX DD Table 20. Multilevel regression analysis for students' time spent in PA and interactions between environment factors and location (full data set).

		Interaction with Daily PE	Interaction with Room	Interaction with Land-use mix diversity	Interaction with Walkability index
Characteristics		β (SE)	β (SE)	β (SE)	β (SE)
Student-level					
Gender	Female	REF	REF	REF	REF
	Male	25.43 (1.23)[c]	25.43 (1.22)[c]	25.43 (1.23)[c]	25.40 (1.23)[c]
Grade	9	REF	REF	REF	REF
	10	-3.63 (1.64)[a]	-3.61 (1.64)[a]	-3.63 (1.64)[a]	-3.64 (1.64)[a]
	11	-9.42 (1.71)[c]	-9.42 (1.71)[c]	-9.43 (1.71)[c]	-9.41 (1.70)[c]
	12	-16.84 (1.75)[c]	-16.53 (1.75)[c]	-16.53 (1.75)[c]	-16.57 (1.75)[c]
Weight status	Healthy weight	REF	REF	REF	REF
	Underweight	6.66 (4.88)	6.66 (4.88)	6.67 (4.88)	6.68 (4.88)
	Overweight	-2.02 (1.61)	-2.02 (1.61)	-2.01 (1.61)	-1.97 (1.61)
	Obese	-4.28 (2.43)	-4.28 (2.43)	-4.27 (2.43)	-4.25 (2.43)
Mode of transport to school	Non-active	REF	REF	REF	REF
	Active	14.41 (1.60)[c]	14.37 (1.60)[c]	14.40 (1.60)[c]	14.54 (1.60)[c]
	Mixed	5.14 (1.51)[c]	5.12 (1.50)[c]	5.15 (1.51)[c]	5.21 (1.50)[c]
Enrolled in PE	No	REF	REF	REF	REF
	Yes	21.82 (1.35)[c]	21.81 (1.35)[c]	21.82 (1.35)[c]	21.78 (1.35)[c]
	No	REF	REF	REF	REF
School intramurals	Yes	21.43 (1.58)[c]	21.44 (1.58)[c]	21.43 (1.58)[c]	21.44 (1.58)[c]
	No	REF	REF	REF	REF
School varsity teams	Yes	10.73 (1.51)[c]	10.70 (1.51)[c]	10.71 (1.51)[c]	10.76 (1.51)[c]
	<3 days/week	REF	REF	REF	REF
Flexibility activities	≥3 days/week	24.48 (1.38)[c]	24.48 (1.38)[c]	24.49 (1.38)[c]	24.48 (1.38)[c]
	<3 days/week	REF	REF	REF	REF
Strength activities	≥3 days/week	28.32 (1.47)[c]	28.32 (1.47)[c]	28.33 (1.47)[c]	28.32 (1.47)[c]
Environment-level					
Offer daily PE	No	REF	REF	REF	REF
	Yes	7.29 (7.90)[a]	7.40 (3.74)[a]	7.89 (3.68)[a]	9.66 (3.54)[a]
Another room for PA	No	REF	REF	REF	REF
	Yes	12.87 (4.19)[b]	5.63 (6.87)[b]	14.00 (4.17)[b]	13.12 (3.95)[b]
Land-use mix diversity*		-23.00 (10.46)[a]	-22.42 (10.63)[a]	-19.35 (16.16)	-0.64 (1.37)[c]
School location	Rural	REF	REF	REF	REF
	Suburban	-14.84 (9.14)[a]	-19.45 (9.67)[b]	-14.73 (11.05)	-12.23 (4.11)
	Urban	-6.24 (8.38)	-17.57 (9.21)[a]	4.03 (12.95)	-8.98 (4.78)
Offer daily PE*suburban		6.34 (10.29)			
Offer daily PE*urban		-3.36 (9.70)			
Another room for PA*suburban			12.60 (10.73)		
Another room for PA*urban			12.11 (9.81)		
Land-use mix diversity*suburban				10.08 (24.27)	
Land-use mix diversity*urban				-24.75 (26.08)	
Walkability index*suburban					-2.56 (1.97)
Walkability index*urban					-3.94 (2.94)

Note: [a]p<0.05; [b]p<0.01; [c]p<0.001; Controlling for: area-level SES, season of data collection (winter, fall, spring)

APPENDIX EE. Table 21. Multilevel regression analysis for students' time spent in PA and school characteristics by school location (stratified models).

Urban Schools			Suburban Schools			Rural Schools		
		Final Model (N=26, n=6829)			Final Model (N=30, n=10422)			Final Model (N=20, n=4503)
Characteristics		β (SE)	Characteristics		β (SE)	Characteristics		β (SE)
Student-level		β (SE)	Student-level			Student-level		
Gender	Female	REF	Gender	Female	REF	Gender	Female	REF
	Male	22.82 (2.19)[c]		Male	27.04 (1.76)[c]		Male	24.97 (2.79)[c]
Grade	9	REF	Grade	9	REF	Grade	9	REF
	10	-9.47 (2.91)[c]		10	0.04 (2.35)		10	-3.31 (3.71)
	11	-12.19 (3.02)[c]		11	-8.78 (2.44)[c]		11	-7.04 (3.88)
	12	-14.72 (3.04)[c]		12	-17.53 (2.54)[c]		12	-17.80 (3.93)[c]
Weight status	Healthy weight	REF	Weight status	Healthy weight	REF	Weight status	Healthy weight	REF
	Underweight	7.60 (8.18)		Underweight	11.10 (7.00)		Underweight	-7.38 (12.16)
	Overweight	-4.07 (2.84)		Overweight	-1.10 (2.33)		Overweight	-0.83 (3.60)
	Obese	-3.08 (4.21)		Obese	-2.15 (3.57)		Obese	-11.74 (5.41)[a]
Mode of transport to school	Non-active	REF	Mode of transport to school	Non-active	REF	Mode of transport to school	Non-active	REF
	Active	17.16 (2.74)[c]		Active	11.19 (2.31)[c]		Active	19.11 (3.83)[c]
	Mixed	10.59 (2.61)[c]		Mixed	1.24 (2.15)		Mixed	6.17 (3.59)
Enrolled in PE	No	REF	Enrolled in PE	No	REF	Enrolled in PE	No	REF
	Yes	23.63 (2.41)[c]		Yes	20.21 (1.94)[c]		Yes	23.19(3.06)[c]
School intramurals	No	REF	School intramurals	No	REF	School intramurals	No	REF
	Yes	22.77 (2.85)[c]		Yes	22.97 (2.23)[c]		Yes	15.44 (3.66)[c]
School varsity teams								
	No	REF	School varsity teams	No	REF	School varsity teams	No	REF
	Yes	10.40 (2.70)[c]		Yes	10.41 (2.14)[c]		Yes	11.87 (3.49)[c]
Flexibility activities	<3 days/week	REF	Flexibility activities	<3 days/week	REF	Flexibility activities	<3 days/week	REF
	≥3 days/week	22.85 (2.43)[c]		≥3 days/week	27.69 (1.97)[c]		≥3 days/week	19.05 (3.12)[c]
Strength activities	<3 days/week	REF	Strength activities	<3 days/week	REF	Strength activities	<3 days/week	REF
	≥3 days/week	31.71 (2.62)[c]		≥3 days/week	25.44 (2.11)[c]		≥3 days/week	29.95 (3.32)[c]
Environment-level			Environment-level			Environment-level		
Another room for PA	No	REF	Offer daily PE	No	REF	Offer varsity sports	No	REF
	Yes	17.35 (7.29)[a]		Yes	12.23 (5.27)[a]		Yes	13.35 (7.17)
Fast food outlets	0	*removed to create more parsimonious model	Another room for PA	No	REF	Dance studio	No	*removed to create more parsimonious model
	1			Yes	19.34 (7.46)[a]		Yes	
	≥2		Fast food outlets	0	REF	Paved area for games	No	*removed to create more parsimonious model
				1	18.80 (6.07)[b]		Yes	
Shopping	0	REF		2	-0.96 (6.66)	Outdoor hoops	No	*removed to create more parsimonious model
	1	23.15 (7.89)[a]		≥3	-0.11 (5.96)		Yes	
	≥2	12.81 (6.86)	Street connectivity*		-0.07 (0.04)	Land-use Mix*		*removed to create more parsimonious model

Note: [a]p<0.05; [b]p<0.01; [c]p<0.001; *continuous measures; Controlling for: area-level SES, season of data collection (winter, fall, spring)

APPENDIX FF. Table 22. Multilevel regression analysis for students' time spent in PA by school location including walkability index (stratified models).

Urban Schools			Suburban Schools			Rural Schools		
		Final Model (N=26, n=6829)			Final Model (N=30, n=10422)			Final Model (N=20, n=4503)
Characteristics		β (SE)	Characteristics		β (SE)	Characteristics		β (SE)
Student-level			Student-level			Student-level		
Gender	Female	REF	Gender	Female	REF	Gender	Female	REF
	Male	22.78 (2.19)[c]		Male	27.02 (1.76)[c]		Male	24.97 (2.79)[c]
Grade	9	REF	Grade	9	REF	Grade	9	REF
	10	-9.46 (2.91)[c]		10	0.03 (2.35)		10	-3.31 (3.71)
	11	-12.11 (3.02)[c]		11	-8.83 (2.44)[c]		11	-7.04 (3.88)
	12	-14.74 (3.04)[c]		12	-17.56 (2.54)[c]		12	-17.80 (3.93)[c]
Weight status	Healthy weight	REF	Weight status	Healthy weight	REF	Weight status	Healthy weight	REF
	Underweight	7.62 (8.18)		Underweight	11.25 (7.00)		Underweight	-7.38 (12.16)
	Overweight	-4.05 (2.84)		Overweight	-1.04 (2.33)		Overweight	-0.83 (3.60)
	Obese	-3.06 (4.21)		Obese	-2.16 (3.57)		Obese	-11.74 (5.41)[a]
Mode of transport to school	Non-active	REF	Mode of transport to school	Non-active	REF	Mode of transport to school	Non-active	REF
	Active	17.48 (2.75)[c]		Active	10.68 (2.30)[c]		Active	19.11 (3.83)[c]
	Mixed	10.84 (2.61)[c]		Mixed	0.89 (2.14)		Mixed	6.17 (3.59)
Enrolled in PE	No	REF	Enrolled in PE	No	REF	Enrolled in PE	No	REF
	Yes	23.63 (2.41)[c]		Yes	20.25 (1.94)[c]		Yes	23.19(3.06)[c]
School intramurals	No	REF	School intramurals	No	REF	School intramurals	No	REF
	Yes	22.76 (2.85)[c]		Yes	22.94 (2.23)[c]		Yes	15.44 (3.66)[c]
School varsity teams	No	REF	School varsity teams	No	REF	School varsity teams	No	REF
	Yes	10.41 (2.70)[c]		Yes	10.54 (2.14)[c]		Yes	11.87 (3.49)[c]
Flexibility activities	<3 days/week	REF	Flexibility activities	<3 days/week	REF	Flexibility activities	<3 days/week	REF
	≥3 days/week	22.87 (2.43)[c]		≥3 days/week	27.75 (1.97)[c]		≥3 days/week	19.05 (3.12)[c]
Strength activities	<3 days/week	REF	Strength activities	<3 days/week	REF	Strength activities	<3 days/week	REF
	≥3 days/week	31.70 (2.62)[c]		≥3 days/week	25.46 (2.11)[c]		≥3 days/week	29.95 (3.32)[c]
Environment-level			Environment-level			Environment-level		
Another room for PA	No	REF	Offer daily PE	No	REF	Offer varsity sports	No	REF
	Yes	17.83 (6.99)[a]		Yes	12.69 (4.47)[b]		Yes	13.35 (7.17)
Fast food outlets	0	*removed to create more parsimonious model	Another room for PA	No	REF	Dance studio	No	*removed to create more parsimonious model
	1			Yes	16.48 (6.16)[a]		Yes	
	≥2		Fast food outlets	0	REF	Paved area for games	No	*removed to create more parsimonious model
				1	21.53 (5.20)[b]		Yes	
Shopping	0	REF		2	7.03 (6.22)	Outdoor hoops	No	*removed to create more parsimonious model
	1	20.48 (7.69)[a]		≥3	3.70 (5.21)		Yes	
	≥2	12.26 (6.57)	Walkability index*		-4.39 (1.27)[b]	Walkability index*		*removed to create more parsimonious model
Walkability index		-5.22 (3.24)						

Note: [a]p<0.05; [b]p<0.01; [c]p<0.001; Controlling for: area-level SES, season of data collection (winter, fall, spring)

APPENDIX GG Table 23. Exploratory Analysis of School Indices.

Descriptives of School PA Facilities Indices

Number of school PA facilities	Schools Overall %(N)	Urban Schools %(N)	Suburban Schools %(N)	Rural Schools %(N)
1-2	3.95% (3)	1.32% (1)	1.32% (1)	1.32% (1)
3-4	28.95% (23)	11.84% (9)	10.53% (8)	6.58% (5)
5-6	39.48% (30)	11.84% (9)	17.11% (13)	10.53% (8)
7-8	23.69% (18)	7.89% (6)	10.53% (8)	5.26% (4)
9-10	3.95% (3)	1.32% (1)	0	2.63% (2)
>7*	27.63% (21)	73.08% (19)	73.33% (22)	70.00% (14)
≤7*	72.37% (55)	26.92% (7)	26.67% (8)	30.00% (6)
Ratio: # of students per school / # of school PA facilities**	0.007 (0.01)	0.005 (0.00)	0.005 (0.00)	0.012 (0.01)

*75th percentile; **mean (SD) for continuous measure

Results of Univariate analyses for Additional School PA Facilities Indices Overall and by Gender

# of school PA facilities	Schools Overall N=76		Female Students n=10781		Male Students n=10973	
	B(SE)	p-value	B(SE)	p-value	B(SE)	p-value
1-2	REF	REF	REF	REF	REF	REF
3-4	2.62 (10.57)	0.8043	4.34 (9.11)	0.6340	-1.96 (11.83)	0.8686
5-6	3.68 (10.40)	0.7238	6.14 (8.97)	0.4934	-1.06 (11.63)	0.9275
7-8	2.71 (10.76)	0.8015	7.21 (9.31)	0.4391	-2.84 (12.06)	0.8139
9-10	-5.61 (14.20)	0.6925	-5.77 (12.34)	0.6397	-5.80 (16.02)	0.7173
>7	REF	REF	REF	REF	REF	REF
≤7	1.54 (4.48)	0.7306	-0.20 (3.98)	0.9597	1.86 (5.10)	0.7153
Ratio: # of students per school / # of school PA facilities	0.00 (0.01)	0.8790	0.01 (0.01)	0.4516	-0.00 (0.01)	0.8294

Results of Univariate analyses for Additional School PA Facilities Indices by School Location

# of school PA facilities	Urban Schools N=26		Suburban Schools N=30		Rural Schools N=20	
	B(SE)	p-value	B(SE)	p-value	B(SE)	p-value
1-2	REF	REF	REF	REF	REF	REF
3-4	27.61 (22.40)	0.2177	-9.14 (15.64)	0.2463	-10.62 (17.67)	0.5477
5-6	27.87 (22.35)	0.2126	-1.41 (15.31)	0.5591	-17.50 (17.26)	0.3106
7-8	26.23 (23.06)	0.2550	-1.46 (15.66)	0.9267	-22.75 (18.49)	0.2186
9-10	18.14 (29.83)	0.5461	NA	0.9258	-19.76 (20.11)	0.3258
>7	REF	REF	REF	REF	REF	REF
≤7	1.27 (9.34)	0.6585	-2.72 (6.14)	0.8922	8.16 (8.12)	0.3153
Ratio: # of students per school / # of school PA facilities	0.02 (0.02)	0.3453	0.02 (0.02)	0.4580	-0.02 (0.02)	0.2411