IS THE ASSOCIATION BETWEEN THE BUILT ENVIRONMENT AT SCHOOL AND STUDENTS' PHYSICAL ACTIVITY MODERATED BY THE SOCIAL ENVIRONMENT?

by

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Abstract

Surveillance data from 105 countries indicates that 80% of 13-15 year-olds do not meet the public health guideline of 60 minutes of moderate-to-vigorous physical activity (MVPA) per day. This is problematic as a lack of physical activity in young people is associated with physical, mental, and social health problems. Schools are a place where children and adolescents spend a large amount of their time and where they have several opportunities to engage in physical activity. The built and social environment of the school can influence the physical activity levels of students. The school built environment consists of the facilities that can encourage physical activity such as gymnasia, fields, and fitness rooms. This thesis looked at two aspects of the social environment: 1) school policies, programs, and practices (PPP) for physical activity, and 2) school social capital. School PPP includes things like having intramural sports. School social capital is based on the relationships formed at school. The purpose of this thesis was to determine whether selected features of the school social environment (social capital, school PPP for physical activity) changes the relationship between the school built environment and physical activity among 11-15 year-old Canadians. Information on the school social environment, school built environment and school time physical activity was gathered using a national representative survey called the Health Behaviour in School-aged Children survey (HBSC). The HBSC consists of a survey completed by grade 6-10 students in their classroom and a second 10 minute long survey completed by the principal of the participating schools.

Results of this thesis indicate that the school built environment and school social capital were positively associated with school time MVPA, while school PPP had a slight negative association. School PPP altered the relationship between the built environment and physical activity. Specifically, the strongest positive association was between the built environment and

MVPA levels in schools with few school PPP. However, school social capital did not alter the relationship between the built environment and MVPA.

The results of this thesis can be useful in creating new school physical activity interventions.

Co-Authorship

This thesis presents the work of Brenton Button in collaboration with his supervisor, Dr. Ian Janssen.

Manuscript 1: *The association between the built environment at school and physical activity among students is moderated by school policies, programs and practices related to physical activity* has been submitted with revisions to the Journal of School Health. I was responsible for doing a literature review on how the built environment affects physical activity and a more in-depth review of potential moderators of the association between the built environment and physical activity. Once the relevant background was assessed, I was responsible for managing the Health Behaviour in School-aged Children dataset, conducting the statistical analysis, interpreting the results, writing the first draft of the manuscript, and revising the manuscript on the feedback received from Dr. Janssen. In addition to providing editorial feedback, Dr. Janssen helped with the study design, statistical analysis, statistical interpretation, and presentation of information.

Manuscript 2: *School social capital does not moderate the association between the built environment at school and physical activity* has been submitted to BMC Public Health.
My contributions and Dr. Janssen's are comparable to what was explained above for manuscript 1. In addition, the method for creating the school social capital was based on previous work by Stephen Trities, a member of the physical activity and epidemiology lab and co-author on this paper.

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Chapter 1

Introduction

1.1 General Overview

According to the 2007-2009 Canadian Health Measures Survey, only 7% of school-aged Canadian children and youth accumulate at least 60 minutes of moderate-to-vigorous physical activity (MVPA) on a daily basis.[1] This low rate of physical activity was also found in a combined analysis of the Global School-Based Student Health Survey (GSHS) and the Health Behaviour in School-aged Children (HBSC) survey, which found that only approximately 20% of 13-15 year-olds reached the recommended 60 minutes of daily MVPA.[2] These low rates of physical activity are a major health concern as high levels of physical activity have been shown to help control blood pressure, reduce the risk factors of the metabolic syndrome, improve bone mineral density, and help lower body weight and fat as well as reduce symptoms of depression and increase academic performance.[3,4] In order to provide all the benefits that physical activity offers, it is necessary that we understand the possible determinants of physical activity.

One determinant that has shown a positive association with physical activity is the built environment. The built environment is defined as "the arrangement of activities or land uses within community settings, and the nature of the physical connections between the places where we live, work, and play."[6] The built environment at school may be particularly important for young people as they spend around 1,400 hours a year in this environment. The school built environment includes indoor and outdoor facilities and equipment for safe, quality physical activity during students' free time. Such facilities and equipment may include running tracks, soccer fields, gymnasiums, and basketball courts.

Research over the past decade has increased our understanding of the association between the built environment and physical activity within schools. This research has shown a weak positive association between the built environment at school and physical activity.[7-10] For example, a playground redesign intervention in England found that when schools divided playgrounds for different types of play (sports area, multi-activity area, and a quiet play zone) and added several built environment features (soccer goal posts, basketball hoops, and fencing around certain areas of the playground), children engaged in 4.5% and 2.3% more MVPA and vigorous physical activity (VPA), respectively, during recess compared to the control school children.[11] Although this amount of activity may seem small, if this is applied to the population level, such as all the school children in Canada, the results are actually quite significant. However, many aspects of this relationship remain unclear. Of particular interest for this thesis is the lack of research that has considered whether the built environment and physical activity relationship is impacted by a third variable, such as the social environment. It is possible that the built environment may be weakly or not at all related to physical activity if there is not a supportive social environment. If this were the case, it would suggest that changing the built environment would be ineffective in the absence of corresponding changes to the social environment.

Two social factors that may affect the relationship between the built environment and physical activity at school are social capital and school policies, programs, and practices (PPP) related to physical activity. The purpose of this thesis was to examine if the school social environment moderated the relationship between the built environment at school and physical activity in students. It was hypothesized that the built environment at school would be more

strongly related to students' physical activity levels in schools with a higher social capital and more physical activity related school PPP.

1.2 Thesis Focus

This thesis aimed to determine how the social environment at schools affects the relationship between the built environment at school and physical activity in Canadian youth. The thesis contains two manuscripts. The first is focused on how school PPP affects the relationship between the built environment and physical activity. The second is focused on how school social capital affects the relationship between the built environment and physical activity. The two manuscripts are tied together conceptually by their investigation of the social environment as a moderator of the relationship between the built environment at school and physical activity among Canadian youth.

1.3 Scientific and Public Health Significance

The vast majority of Canadian youth do not engage in enough physical activity for health benefits.[1,2] In an attempt to better understand the low physical activity levels within the pediatric population, researchers have studied the associations between the built environment and physical activity. As reviewed previously, this research has demonstrated that the built environment has small to modest positive effects on youths' physical activity.[12] This includes the built environment at school, a place where most young people spend about 38% of their waking hours during the school year. Despite the amount of published work, more research is needed in the built environment field. Specifically, there is a lack of information on the interaction between the built and the social environments. It is important to determine if such interactions exist because it is possible that differing levels of social environment may strengthen or weaken the relationship between the built environment and physical activity. It is necessary to understand the influence of the social environment because making changes to the social environment could be easier and

more cost effective than to the built environment. Changes to the social environment may in turn increase the association between the built environment and physical activity.

1.4 Study Purpose and Population

The overall purpose of this thesis was to determine if the relationship between the built environment and MVPA within youth is moderated by the social environment at school. The relationships were explored using the Canadian HBSC. The HBSC is a cross-sectional survey that obtains information on a variety of health behaviours, health determinants, and personal characteristics of students in grades 6-10 (approximate ages of 11-15 years-old). In addition to the student questionnaire, the Canadian HBSC collects information on school characteristics and environment using an administrator survey that is completed by the principal or designate at each of the participating schools. The 2009/10 Canadian HBSC includes data on 26,078 participants who attended 436 schools across the country.

1.5 Thesis Objectives

The purpose of this thesis was addressed by conducting two studies which comprise two distinct manuscripts in this thesis. Manuscript 1 determined if school PPP around physical activity moderated the relationship between the built environment at school and physical activity in students. I hypothesized that school PPP would moderate the relationship between the built environment and physical activity such that schools with higher levels of school PPP would have more active students. The objective of manuscript 2 was to determine if school social capital moderated the relationship between the schools' built environment and physical activity in students. I hypothesized that social capital would moderate the relationship between the built environment and physical activity in students and that schools with higher levels of social capital will have more active students.

1.6 Thesis Organization

This thesis is manuscript-based and conforms to the regulations as outlined in the Queen's School of Graduate Studies and Research "General Forms of Theses" as well as the guidelines of the School of Kinesiology and Health Studies. This thesis consists of five chapters. Chapter 1 is a general introduction to the topic area, rationale for this thesis, and the objectives and hypothesis. Chapter 2 is a summary of the literature that examines the relationship between the school built environment and physical activity, and the moderator effects of the social environment on this relationship. Chapter 3, the first manuscript of the thesis, looks at school PPP as a moderator of the relationship between the built environment at school and physical activity. Chapter 4, the second manuscript of the thesis, looks at social capital at school as a moderator of the relationship between the built environment at school and physical activity. Chapter 5 reviews the key findings and provides a general discussion on the overall thesis topic. Finally, some additional information is included in the Appendixes. The additional information includes: exclusion diagrams, ethics, and relevant questionnaire items from the HBSC student and administrator surveys.

1.7 References

1. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep.* Mar 2011;22(1):15-23.

2. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet.* Jul 21 2012;380(9838):247-257.

3. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act.* 2010;7:40.

4. Strong WB, Malina RM, Blimkie CJ, et al. Evidence based physical activity for school-age youth. *J Pediatr.* Jun 2005;146(6):732-737.

5. Olshansky SJ, Passaro DJ, Hershow RC, et al. A potential decline in life expectancy in the United States in the 21st century. *N Engl J Med.* Mar 17 2005;352(11):1138-1145.

6. Papas MA, Alberg AJ, Ewing R, Helzlsouer KJ, Gary TL, Klassen AC. The built environment and obesity. *Epidemiol Rev.* 2007;29:129-143.

7. Haug E, Torsheim T, Sallis JF, Samdal O. The characteristics of the outdoor school environment associated with physical activity. *Health Educ Res.* Apr 2010;25(2):248-256.

8. Nichol ME, Pickett W, Janssen I. Associations Between School Recreational Environments and Physical Activity. *J School Health.* Jun 2009;79(6):247-254.

9. Fein AJ, Plotnikoff RC, Wild TC, Spence JC. Perceived environment and physical activity in youth. *Int J Behav Med.* 2004;11(3):135-142.

10. Taylor RW, Farmer VL, Cameron SL, Meredith-Jones K, Williams SM, Mann JI. School playgrounds and physical activity policies as predictors of school and home time activity. *Int J Behav Nutr Phy.* Apr 27 2011;8.

11. Ridgers ND, Stratton G, Fairclough SJ, Twisk JW. Long-term effects of a playground markings and physical structures on children's recess physical activity levels. *Prev Med.* May 2007;44(5):393-397.

12. Davison KK, Catherine T. Do attributes in the physical environment influence children's physical activity? A review of the literature. *Int J Behav Nutr Phy.* 2006:1.

Chapter 2

Literature Review

2.1 General Overview

A modeling study using information gathered up to the early 2000's predicted that the current generation of children will be the first generation that will theoretically fail to have the same life expectancy of their parents.[1] One reason for this decline in life expectancy is that only 20% of 13-15 year-olds reach the recommended 60 minutes of daily MVPA.[2] In order to reverse these problems, researchers must find effective ways to increase children's physical activity. The school environment has been thought of as an effective place to increase the physical activity levels of students because children spend a large portion of time at school.[3-6]

This literature review starts by defining the key terms and concepts used in this thesis. This is followed by a section that examines the importance of physical activity for school-aged children and youth, including physical activity that is performed while at school. This is followed by a brief section that describes the individual determinants of physical activity in children and youth. Next, a brief look at the relationship between different built environment features and physical activity is given. This is followed by a more extensive review of the relationship between the school built environment and physical activity. Finally, an overview of the association between the social environment and physical activity is given, as well as a discussion of how the social environment may moderate the effect of the built environment.

2.2 Key Definitions

2.2.1 Pediatric age groups

The term "child" is normally used to designate people under age 12 and "adolescence" people aged 12-19 years. "School-aged children" is often used to describe children and adolescents who attend school (approximately ages 5-17 years). In this thesis, I have used the term "youth" to describe the pre-adolescent and early adolescent age period (approximately ages 10-16 years).

2.2.2 Built Environment

The built environment is "the arrangement of activities or land uses within community settings, and the nature of the physical connections between the places where we live, work and play."[7] Built environment features relevant for physical activity include, but are not limited to, walkability, parks and green space, and recreation facilities. The main exposure (independent) variable in this thesis is the school built environment. The school built environment includes the number of facilities and the makeup of the play area and playground markings.[8-10] Relevant facilities may consist of gymnasiums, sports fields, courts, fitness/exercise rooms, swimming pools, and running tracks.

2.2.3 Physical Activity

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure.[11] This thesis focuses primarily on MVPA; MVPA is activity which significantly increases one's heart rate, breathing, and body temperature.[12] Physical activity intensity can be measured based on metabolic equivalents (METs), which measure the amount of oxygen used by the body during physical activity. One MET is the energy (oxygen) used by the body at rest.[13] For children, sedentary activity ranges from 1-1.5 METs and would include

activities such as playing traditional video games, doing homework, or playing board games. Low to moderate intensity activities range from 1.6-3.9 METs and include light walking, and household chores. MVPA are those activities where the MET values are 4 or greater and include fast walking, rope skipping, soccer, basketball, and running.[13]

2.2.4 Social Capital

Researchers have debated the meaning of social capital. Some researchers have defined social capital as "the material, informational and affective resources to which individuals and, potentially, groups, have access through social connections."[14] Other researchers refer to social capital as "the features of social organization, such as civic participation, norms of reciprocity, and trust in others that facilitate cooperation for mutual benefit."[15] For this thesis, school social capital will encompass the idea that students' lives are improved through social relationships at school.[16,17]

2.2.5 School policies, programs, and practices (PPP)

A policy is "an explicit or implicit single decision or group of decisions which may set out directives for guiding future decisions, initiate or retard action, or guide implementation of previous decisions."[18] A program is simply "a planned series of upcoming events" and practice is the "action or process of performing or doing something."[19] An example of school policy is a school rule that would promote physical activity as part of special events. An example of a practice is giving students a five minute activity break if they need to be seated for longer than 30 minutes. An example of a school program is an intramural basketball league. A program or practice normally helps the school reach the goals of its policies.

2.2.6 Moderator

A moderator variable is a variable that affects the direction and/or strength of the relationship between an independent (exposure) variable and dependent (outcome) variable.[20] For example, the strength of the relationship between social support and depression is considerably stronger in women than it is in men. In this example sex is the moderator variable.

2.3 Physical Inactivity in Children is a Public Health Problem

Canada's Physical Activity Guidelines state that school-aged children and youth (5-17 years of age) should accumulate at least 60 minutes of MVPA on a daily basis to achieve health benefits.[21] Unfortunately, according to the 2007-2009 Canadian Health Measures Survey, a nationally representative survey that assessed physical activity objectively using accelerometers, only 9% of boys and 4% of girls met the 60 minutes/day MVPA guideline.[22]

The poor adherence to the physical activity guidelines is concerning because physical activity declines into adulthood[23] and because physical activity in adulthood is a key determinant of morbidity, mortality, and healthcare spending.[24] Within school-aged children and youth, physical activity is associated with both short- and long- term health benefits. Some short-term benefits of physical activity include higher self-esteem, reduced stress, reduced anxiety, and lower levels of depression, which is important since depression is becoming more prevalent.[25] Some long-term benefits of physical activity include control of blood pressure, reduced risk factors of the metabolic syndrome, improved bone mineral density, and regulation of body weight and fat.[26] In addition, physical activity, levels have been positively linked with cognitive development.[27] Thus, establishment of a healthy active lifestyle early in life has the potential to reduce future risk of developing chronic diseases and dying prematurely.

2.4 Determinants of Physical Activity in Children

In order to understand why school-aged children are not meeting the Canadian physical activity guidelines of 60 minutes of daily MVPA it is important to understand the determinants of physical activity levels. Research has indicated that factors beyond the individual may determine levels of physical activity. Social, physical and policy environments impact the ability or likelihood of individuals participating in physical activity. Because of this, researchers are increasingly considering ecological models.[28] Ecological models provide a framework which shapes the concept that individual behaviours and characteristics interact with the environment within which that individual is situated.[28] Thus in order to improve individual health behaviour, determinants outside the individual must be considered. Depending on the model, usually 4 or 5 layers are considered. These layers include: individual environment, social environment, physical environment and policy environment. Each of these layers consists of various determinants of physical activity. The individual layer can consist of: age, sex, level of education, and socioeconomic status (SES).[29] The social environment can consist of: family support, friends, schools, community norms and background.[29] The physical environment can consist of: availability of parks, playgrounds, and sports fields, as well as street connectivity.[29] Finally, the policy environment can consist of: education policies, health policies and active transport policies.[30] Considering this type of model allows for the possibility of integrated interventions.

2.4.1 Importance of the School on Physical Activity

The vast majority of 5-17 year-olds in Canada spend about six hours a day, five days a week, 37 weeks a year at school (approximately 195 days).[31] Students have several opportunities to engage in physical activity during their free time at school: before classes begin, during breaks

(lunch and recess), and after classes end. During class time, children can be active during their physical education classes or, in some provinces, during the daily physical activity (DPA) portion of the curriculum. Health and physical education (PE) classes refer to a specific time of the day or week when the physical education curriculum is taught. The goal of PE is to have students acquire the skills that will allow them to lead healthy and active lifestyles. DPA refers to a time in each school day where students are provided with opportunities to participate in a certain amount of sustained MVPA each school day during instructional time. The goal of DPA is to enable all elementary students to improve or maintain their physical fitness and their overall health and wellness, and to enhance their learning opportunities.[32]

Physical activity may also be accumulated at school during extra-curricular activities such as intramural sports, varsity sports, or activity clubs. Given the opportunities that schools present for physical activity, it is not surprising that, after the home environment, the school is the geographic location where high school students accumulate the most physical activity.[33] In fact, a study of 12-16 year-old Nova Scotia students that used accelerometers and global position satellite (GPS) units to measure the amount of physical activity occurring in different locations found (depending on gender and urban/rural location) that between 20%-40% of students' total physical activity is obtained at their school.[33]

Since students accumulate a significant proportion of physical activity at school, it is necessary to understand how well schools are currently doing in respect to getting students active. Active Healthy Kids Canada, a non-governmental organization dedicated to improving the physical activity levels of children and adolescents, generates an annual Report Card that grades Canada as a nation in several areas of physical activity, including the amount of physical activity accumulated at school and the school setting itself (e.g., how well are schools doing at

getting kids to be active). In the 2013 edition of the Report Card, Canadian schools received a C in the area of school policies and programs for physical activity. The C grade is based on the finding that only 41%-60% of schools meeting the benchmarks for a variety of physical activity policies (e.g., daily physical education, DPA, and safety precautions), having physical education classes taught by physical education specialists, having students offered at least 150 minutes of health and physical education per week, and offering physical activity opportunities outside of PE to the majority of their students.

The Report Card highlighted that even with all the research in this area some research gaps still exist. For example, research is required on how governments, school boards, and the community can work together to better support the creation and operation of school physical activity PPP. Furthermore, the divide between school PPP and student physical activity levels needs to be researched.

Canada also received a C in PE and physical activity participation at school. This result was based on the finding that only 41%-60% of students meet the benchmark of at least 150 minutes of PE per week and are physically active at school outside of PE (e.g., intramurals, varsity sports, teams/clubs, and recess). With such a low grade on the physical activity Report Card at schools, it is important we study the entire school environment to try and increase this grade.[34]

2.5 Influence of the Built Environment on Physical Activity in the Home Neighbourhood

The built environment is recognized as an important determinant of health[35] and physical activity.[36] Different aspects of the built environment can be relevant for physical activity, including walkability, parks and green space, and recreational facilities. The following three

paragraphs focus on these different aspects within the youth's home neighbourhood. Note that the key limitations of the studies in these areas are summarized collectively in section 2.6.4 rather that within each subsection.

2.5.1 Walkability in the Home Neighborhood

In simple terms, walkability is how friendly a neighborhood is to walking. Researchers have measured walkability using individual measures and/or a combination of measures. These measures have included street connectivity (how well streets connect to one another and the density of intersections[37]), land-use mix (distribution of residential, commercial, and office development[38]), and safety (cycling and walking infrastructure, road speed, or other things that may cause personal injury).[39]

The results of the studies on the association between walkability and physical activity have produced mixed results. A cross-sectional study on street connectivity conducted on 8,535 Canadian young people aged 11-15 years using subjective physical activity measures and geographic computer software to measure street connectivity found that students living in areas with lower street connectivity were more likely to be physically active outside of school.[37] Unfortunately, this study used a five kilometer buffer around the school as a measure for the home neighbourhood. This may have resulted in area level data being given to a student who may not live in their school neighbourhood.

A quasi-experimental study of safety and active transport on 1,244 American parents of students in grades 3-5 found 15.4% of students walked more following completion of the safety changes, compared to only a 4.3% increase of children who did not pass the area with safety changes.[40] These safety changes included: increasing sidewalks, traffic lights, improving pedestrian crossings, and creating bicycle paths. However, it is possible that the parents became

more educated on the importance of physical activity and encouraged their children to walk. Conversely, a cross-sectional study of neighborhood land use of 1,124 Portuguese teens aged from 12-18 years-old using subjective physical activity and neighbourhood land-use measures found no association between land-use mix and physical activity. Land-use mix was judged by asking if there were interesting things to look at while walking in the neighbourhood and if there were many places to go within walking distance of the participants' homes.[41] It is possible that this study found no association because the study used a convenience sample of Portuguese teens and the data came from only five schools in an urban area.

2.5.2 Parks and Green Space in the Home Neighbourhood

Parks and green space are essentially pieces of land in or near a city or town kept for recreation.[19] Research on the areas of park and green space has generally shown a positive relationship with availability and physical activity. A study of 5,558 teenagers aged 13-17 years-old from New Zealand using self-reported data on physical activity and perceived opportunity for physical activity found that adolescents living within walking distance to a park were 17% more likely to participate in regular physical activity as compared to adolescents not living within walking distance of a park.[42] However, walking distance was measured by student perception in this study. Therefore, the more active students might have been willing to walk further and considered themselves within walking distance of a park. A second study of 177 seventh grade students who were primarily Mexican-American found similar results. Using a map and a draft compass to determine the distance to nearest parks and self-reported data on physical activity, the study found that distance to the nearest open play area was inversely related to outdoor physical activity for boys. This model accounted for 8.8% of the variance in the physical activity outcome.[43] However, with only 177 participants from just one school in a low

SES neighborhood from Texas these results are difficult to generalize to other populations. Conversely, a cross-sectional study of 52 African-American girls (8-10 years-old) that measured physical activity using an accelerometer and a survey to measure access to parks and green space found no association.[44] This study may have found no association because it had a very small sample size, only included African-American girls, and only measured physical activity from 12-6 p.m.

2.5.3 Recreation Facilities in the Home Neighbourhood

Recreational facilities are structures or places that people use for recreation, they include such facilities as: gyms, swimming pools, baseball diamonds, and multi-use recreation fields.[45] Most studies findings show that physical activity is positively association with living in a close proximity of a recreational facility. A cross-sectional study of 2,874 14-19 years-old from Northeastern Brazil that measured self-rated physical activity and perception of the environment found that males with greater access were 2 times more likely to be physically active, and females were 1.3 times more likely to be physically active as compared to children with less access to facilities.[46] Similarly, a study of 610 female children aged 10-15 years in six American cities found that the girls having ten or more facilities near their homes were 2.3 times more likely to be physically active as compared to those having fewer than seven facilities near the home.[47] Finally, a study of 811 grade 7-8 students from London, Ontario that using subjective physical activity measures and a geographical information system software to assess facilities found that children with more than two recreation facilities nearby engaged in 16 more minutes of physical activity per day than those with fewer than two.[48]

2.5.4 Limitation of Research on Built Environments and Physical Activity in the Home Neighbourhood

Collectively, these studies suffer from similar limitations. First, they are mostly of a cross-sectional design, which does not allow us to infer temporality. Second, most of the studies assessed physical activity by self-reports; this is problematic as self-reported physical activity data are prone to reporter bias and self-reported measures of MVPA are only modestly correlated with objective measures.[49] Third, there is a lack of consistency in the way the built environment is measured among researchers. This is problematic because it is hard to show a consistency in results. In self-reported built environment data, one of the aforementioned studies used self-reported perceptions of a neighbourhood. A more active person in the neighbourhood might be more aware of things that are present in the neighbourhood as compared to someone in the same neighbourhood who is active only at work or at home. The fourth problem is the buffer zone; a buffer zone is a distance from a participant's house that researchers consider to be accessible. This can be measured using census tracts for neighbourhoods, circular distances around homes, or distance using walkable areas. For example, the study from London, Ontario used a 1.6 km radius buffer instead of street-network buffer. Since no standard exists for size; it is hard to make comparisons across studies. Finally, all the studies had fewer than 10,000 participants and only three had more than 2,000, which would make it difficult to find an association if a stratified analysis needed to be performed.

2.6 Influence of the Built Environment at School on Physical Activity

A cross-sectional study of 22,117 students in grades 9-12 from 76 Ontario schools using self-reported physical activity measures and a survey completed by a school administrator on school facilities found a positive association between school facilities and MVPA. This study

used hierarchical linear regression, and found an alternate room for physical activity within the school was associated with an increase of 8 minutes per day in MVPA. None of the other features of the built environment in that study were found to be significant predictors of MVPA; they included dance studios, swimming pool, baseball diamond, outdoor hoops court, tennis court, paved area for games, bicycle racks, skating rink, and a running/walking track.[50] A second similarly designed study by the same group of researchers of 21,754 students in grades 9-12 from 76 secondary schools in Ontario found that the school environment accounted for 2.1% of the variability in female physical activity and 2.8% of the variability in male physical activity. This means that about 2.5% of physical activity can be explained by the school built environment.[51] These studies both used census information to determine SES, which is an area level predictor of SES, and these measures have been found to be weaker predictor of inactivity as compared to individual measures[52] and the study used the administrator's perception of rural, urban, and suburban. These measures may have resulted in misclassification of students and changed the strength of the results. Finally, a cross-sectional study of 610 grades 9-12 students from four rural Albertan high schools found that an index of student perceived availability of school facilities was weakly positively correlated (Pearson $r=0.15$, $p<0.01$) with adolescents' self-reported physical activity in a sample.[8] The results remained significant after correcting for traditional predictors (i.e., self-efficacy, and peer and family influences). However, this study had access only to a convenience sample of rural Albertan students which makes the results hard to generalize to the rest of Canada, and this study did not control for SES.

At the national level, a cross-sectional study of 7,638 grade 6-10 students from across Canada found a moderate positive gradient between the number of recreational facilities within a school and the likelihood that students engaged in at least two hours/week of MVPA, with the

odds ratio increasing from 1.00 in school with 0-1 facilities to 1.37 in schools with 5 or more facilities.[9] This study used a student questionnaire to gather information on physical activity and an administrator survey to gather information on the facilities available to students. A cross-sectional study of 16,471 Norwegian students in grades 4-10 found that students at the secondary level (grades 8-10) with a larger number of outdoor facilities had a 2.80 times higher odds of being physically active compared with students in schools with fewer facilities. Physical activity was measured using a student survey, and school facilities were measured using an administrator survey. Finally, a cross-sectional study of 441 grade1-8 students from 16 schools in New Zealand found that each additional 10-unit increase in facilities was associated with 3.2% more total activity and 8.3% more during recess.[53] Facilities included things such as fields, nets, slides, playground markings and things of that nature. This study measured physical activity using accelerometers, and school playground equipment was measured using a standardized protocol on three occasions by three researchers. These final two studies contained facilities that may not be relevant in a Canadian climate such as a boarding/skating area and an obstacle course. Therefore, these results may not be generalizable to the Canadian population.

The results from the aforementioned studies suggest that the school built environment is associated with physical activity, but this relationship is weak to modest in strength. Nonetheless, even weak relationships can be important from a public health standpoint if the proportion of people exposed to the risk factor, in this case a poorly built environment at school, is high.[9] However, these studies all suffer from similar limitations. All studies were cross-sectional in design; this does not allow us to infer temporality of the given relationship. In some cases the studies had small sample sizes. If these studies used stratified analyses, they may not have had adequate power to detect a significant association. This is important because the strength of a

relationship may differ when comparing stratas and an overall measure may weaken a stronger association. Only one study assessed physical activity objectively (using accelerometers), and this study had the smallest sample size. None of the studies measured the school built environment in the same way: some studies used administrator data, one used student data, and one used observations of trained researchers. This lack of consistency makes the studies difficult to compare against one another. Finally, none of these studies looked at whether the association between the built environment and physical activity at school was moderated by the social environment. This thesis research attempts to address that gap in knowledge.

2.7 Moderating Effects of the Social Environment between the Built Environment and Physical Activity

Detecting a moderator variable is important as it may influence the strength and/or direction of a given relationship.[54] The research above has shown that the built environment has a relationship with physical activity, but this relationship is stronger in some studies as compared to others. It is possible that the social environment acts as a moderator of the relationship between the built environment and physical activity which could account for the different strengths of the association. The following sections look at different aspects of the social environment and how they change the relationship between the built environment and physical activity.

2.7.1 *Moderating Effects of Safety on the Relationship between the Built Environment and Physical Activity*

There is considerable and consistent evidence that the safety of the environment impacts physical activity within children. The Canadian Health Behaviour in School-aged Children (HBSC) survey asked 9,114 students in grades 6-10 questions about neighbourhood safety and

physical activity. An individual's perceptions of safety were based on feeling safe, thinking the area they live in is safe, and assessing if it was safe for younger children to play outside. A multi-level logistic regression illustrated that an individual's perception of safety was associated with physical activity. This study found that the relative risk of participating in physical activity increased by 31% in males and 45% in females when moving from the lowest to highest perception of safety.[55] This study also found the relationship between recreations facilities and physical activity was not moderated by students' individual perceptions of safety.

While the study mentioned immediately above showed safety was not a significant moderator, a different study found that safety had an interactive effect on obesity, a health outcome that was influenced by physical activity.[56] A cross-sectional modeling study in Indiana predicted that the relationship between trails and body mass index (BMI) is modified by crime rates. Specifically, the parameters from the regression model indicated that in areas with 800 m of trails, there would be a 2.2 kg/m^2 difference in the BMI of children living in low crime areas compared to children living in high crime areas. This was much greater than the association between crime and BMI in areas with 100 m of trails, where there was only an estimated 0.4 kg/m^2 difference the BMI in children in low and high crime areas.[57]

2.7.2 *Moderating Effects of Socioeconomic Status on the Relationship Between the Built Environment and Physical Activity*

As reviewed in detail elsewhere, considerable research indicates SES at the neighbourhood- and individual-level is related to physical activity and other health-related behaviours within young people.[58,59] For example, 2,411 Italian youth between the ages of 11-17 years were questioned about their physical activity and participation in extra-curricular sports and parents were asked about educational levels and work activities, in order to estimate SES.

The study found students who had fathers who were mangers/professionals or office-workers/skilled workers had a significantly higher level of extra-curricular physical activity than students with fathers who were non-skilled workers.[60]

There is some evidence, albeit mixed, that the influence of the built environment on physical activity may be moderated by SES. A cross-sectional study of 13-15 year-old Belgian youth investigated whether the association between neighbourhood walkability and physical activity was moderated by neighbourhood SES. A neighbourhood walkability index was calculated using three objective geographic information system based measures: residential density, intersection density, and land use mix. Residential density is the units of the land area devoted to residential use per statistical sector. Intersection density is the ratio between the number of true intersections (three or more legs) to the land area of each statistical sector. Land use mix is an indication of the degree to which a diversity of land use types was present in each statistical sector. Physical activity was measured using an accelerometer. SES was measured using information on median house hold income from Belgium's national institute of statistics. The study found that neighbourhood walkability was associated with MVPA, and that this association was moderated by SES. In low-SES neighbourhoods, a high walkability score was associated with a 7.4 min/day greater MVPA than a low walkability score. Conversely, in high-SES neighbourhoods, a high walkability score was associated with a 0.4 min/day lower MVPA level than low walkability scores.[61] In contrast to these findings, cross-sectional studies of Belgian[62] and Swedish[63] adults reported that the relationship between neighbourhood walkability and physical activity was not moderated by neighbourhood SES.

2.7.3 Moderating Effects of Policies on the Relationship Between the Built Environment and Physical Activity

There is evidence that physical activity at school is influenced by school policies around physical activity. A study of 1,347 students from Norway using the HBSC survey found that 49% of students attending a school with a written policy were physically active during recess compared to 34% of students attending a school without a written physical activity policy.[64] In addition, 43% of students attending a school that offered organized physical activity in non-curricular time at least three times a week were physically active as compared to 34% of students attending a school without physical activity in non-curricular times under the same exposure conditions.[64]

Although information on whether policies moderate the relationship between the built environment and physical activity is absent, analogies can be drawn from the smoking literature. In the state of California, a cross-sectional study found that local clean air policies moderated the relationship between cigarette outlet density and youth smoking. Youth who lived in a low tobacco outlet density and high policy area had a 4% *higher* prevalence of ever smoking. Contrarily, youth who lived in a high tobacco outlet density and high policy level had a 4% *lower* prevalence of ever smoking.[65] This shows that the association between tobacco outlet density and smoking prevalence was moderated by smoking policies.

A major gap in the literature exists, in that there are currently no studies looking at school programs and policies as a moderator of the relationship between the built environment and physical activity. Future research in this area is warranted.

2.7.4 *Moderating Effects of Social Capital on the Relationship Between the Built Environment and Physical Activity*

As children grow older, contexts beyond the family become increasingly important. Their well-being is affected not only by the physical environment at the school, but also by the social relationships within the school.[66] These social relationships form the bases of social capital. A recent study, which used a resource-based definition of social capital, found that the neighbourhood social capital was significantly associated with sports participation (Odds Ratio= 3.51) in adolescents in the Netherlands.[67] In a study out of Chicago, children from neighbourhoods with high social cohesion (based on social bonds and conflict) were only 0.43 times as likely to be inactive compared to children from neighbourhoods with low social cohesion.[68]

To my knowledge, only one study has examined whether the association between the built environment and physical activity is moderated by social capital. The study found that park density was associated with leisure time sports participation, and that this association was moderated by neighbourhood social capital (NSC). In low-NSC neighbourhoods, high park density was associated with an approximately 20% decrease in the odds of leisure time sports participation, compared to an area of low park density. Conversely, in high-NSC neighbourhoods, a high park density was associated with an approximately 55% increase in leisure time sports participation, compared to an area with a low park density.[69]

2.7.5 *Summary of the Moderating Effects of the Social Environment on the Relationship Between the Built Environment and Physical Activity*

The research mentioned above provides evidence that the social environment may interact with the built environment to strengthen an association between the built environment

and physical activity on health-related outcomes. If this interactive effect holds true for the school built environment and school time physical activity, it might be possible to increase school time physical activity by changing the social environment in the appropriate school built environment. Even if the change is small, a small effect on the relationship between the school built environment and school time physical activity can have significant public health importance, as it could result in a large improvement in overall population health.

2.8 Summary

The physical activity of school-aged children in Canada is in a sad state. The built environment and social environments at school are both related to the physical activity levels of children and youth. However, a large gap concerning interactions between the built environment and social environment exists. This thesis will try to address some of these gaps.

2.9 References

1. Olshansky SJ, Passaro DJ, Hershow RC, et al. A potential decline in life expectancy in the United States in the 21st century. *N Engl J Med.* Mar 17 2005;352(11):1138-1145.

2. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet.* Jul 21 2012;380(9838):247-257.

3. Wyatt KM, Lloyd JJ, Abraham C, et al. The Healthy Lifestyles Programme (HeLP), a novel school-based intervention to prevent obesity in school children: study protocol for a randomised controlled trial. *Trials.* 2013;14:95.

4. Stratton G, Mullan E. The effect of multicolor playground markings on children's physical activity level during recess. *Prev Med.* Nov-Dec 2005;41(5-6):828-833.

5. Ridgers ND, Stratton G, Fairclough SJ, Twisk JW. Long-term effects of a playground markings and physical structures on children's recess physical activity levels. *Prev Med.* May 2007;44(5):393-397.

6. Verstraete SJ, Cardon GM, De Clercq DL, De Bourdeaudhuij IM. Increasing children's physical activity levels during recess periods in elementary schools: the effects of providing game equipment. *Eur J Public Health.* Aug 2006;16(4):415-419.

7. Papas MA, Alberg AJ, Ewing R, Helzlsouer KJ, Gary TL, Klassen AC. The built environment and obesity. *Epidemiol Rev.* 2007;29:129-143.

8. Fein AJ, Plotnikoff RC, Wild TC, Spence JC. Perceived environment and physical activity in youth. *Int J Behav Med.* 2004;11(3):135-142.

9. Nichol ME, Pickett W, Janssen I. Associations Between School Recreational Environments and Physical Activity. *J School Health.* Jun 2009;79(6):247-254.

10. Haug E, Torsheim T, Sallis JF, Samdal O. The characteristics of the outdoor school environment associated with physical activity. *Health Educ Res.* Apr 2010;25(2):248-256.

11. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep.* Mar-Apr 1985;100(2):126-131.

12. Physiology CSoE. Canadian Physical Activity Guidelines for Children 5-11 years2012.

13. Harrell JS, McMurray RG, Baggett CD, Pennell ML, Pearce PF, Bangdiwala SI. Energy costs of physical activities in children and adolescents. *Med Sci Sport Exer.* Feb 2005;37(2):329-336.

14. Moore S, Daniel M, Paquet C, Dube L, Gauvin L. Association of individual network social capital with abdominal adiposity, overweight and obesity. *J Public Health-Uk.* Mar 2009;31(1):175-183.

15. Kawachi I, Kennedy BP, Lochner K, Prothrow-Stith D. Social capital, income inequality, and mortality. *Am J Public Health.* Sep 1997;87(9):1491-1498.

16. Coleman JS. Social Capital in the Creation of Human-Capital. *Am J Sociol.* 1988;94:S95-S120.

17. Putnam RD. *Bowling alone : the collapse and revival of American community*. New York: Simon & Schuster; 2000.

18. Haddad W, Demsky T. *Education policy-planning process : an applied framework*. Paris: UNESCO, International Institute for Educational Planning; 1995.

19. Merriam-Webster Inc. *Merriam-Webster's concise dictionary*. Large print ed. Springfield, Mass.: Merriam-Webster; 1998.

20. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol.* Dec 1986;51(6):1173-1182.

21. Tremblay MS, Leblanc AG, Carson V, et al. Canadian Physical Activity Guidelines for the Early Years (aged 0-4 years). *Appl Physiol Nutr Metab.* Apr 2012;37(2):345-369.

22. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep.* Mar 2011;22(1):15-23.

23. Williams PG, Holmbeck GN, Greenley RN. Adolescent health psychology. *J Consult Clin Psychol.* Jun 2002;70(3):828-842.

24. Janssen I. Health care costs of physical inactivity in Canadian adults. *Appl Physiol Nutr Metab.* Aug 2012;37(4):803-806.

25. Biddle SJ, Asare M. Physical activity and mental health in children and adolescents: a review of reviews. *Brit J Sport Med.* Sep 2011;45(11):886-895.

26. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act.* 2010;7:40.

27. Davis CL, Tomporowski PD, Boyle CA, et al. Effects of aerobic exercise on overweight children's cognitive functioning: a randomized controlled trial. *Res Q Exerc Sport.* Dec 2007;78(5):510-519.

28. McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. *Health Educ Q.* Winter 1988;15(4):351-377.

29. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sport Exer.* May 2000;32(5):963-975.

30. Katzmarzyk PT, Baur LA, Blair SN, Lambert EV, Oppert JM, Riddoch C. International conference on physical activity and obesity in children: summary statement and recommendations. *Int J Pediatr Obes.* 2008;3(1):3-21.

31. Education OMo. School Year Calendar. In: Education Mo, ed. Ottawa: Queen's Printer 2013.

32. Education OMo. Policy/Program Memorandum No. 138. In: Education Mo, ed: Queen's Printer for Ontario; 2005.

33. Rainham DG, Bates CJ, Blanchard CM, Dummer TJ, Kirk SF, Shearer CL. Spatial Classification of Youth Physical Activity Patterns. *Am J Prev Med.* May 2012;42(5):E87-E96.

34. Canada AHK. Are We Driving Our Kids to Unhealthy Habits? The 2013 Active Healthy Kids Canada Report Card on Physical Activity for Children and Youth. Toronto Active Healthy Kids Canada.; 2013.

35. Frank LD, Andresen MA, Schmid TL. Obesity relationships with community design, physical activity, and time spent in cars. *Am J Prev Med.* Aug 2004;27(2):87-96.

36. McCormack GR, Shiell A. In search of causality: a systematic review of the relationship between the built environment and physical activity among adults. *Int J Behav Nutr Phys Act.* 2011;8:125.

37. Mecredy G, Pickett W, Janssen I. Street Connectivity is Negatively Associated with Physical Activity in Canadian Youth. *Int J Env Res Pub He.* Aug 2011;8(8):3333-3350.

38. Frank LD, Schmid TL, Sallis JF, Chapman J, Saelens BE. Linking objectively measured physical activity with objectively measured urban form - Findings from SMARTRAQ. *Am J Prev Med.* Feb 2005;28(2):117-125.

39. Carver A, Timperio A, Crawford D. Playing it safe: The influence of neighbourhood safety on children's physical activity - A review. *Health Place.* Jun 2008;14(2):217-227.

40. Boarnet MG, Anderson CL, Day K, McMillan T, Alfonzo M. Evaluation of the California Safe Routes to School legislation: urban form changes and children's active transportation to school. *Am J Prev Med.* Feb 2005;28(2 Suppl 2):134-140.

41. Santos MP, Page AS, Cooper AR, Ribeiro JC, Mota J. Perceptions of the built environment in relation to physical activity in Portuguese adolescents. *Health Place.* Jun 2009;15(2):548-552.

42. Utter J, Denny S, Robinson EM, Ameratunga S, Watson P. Perceived access to community facilities, social motivation, and physical activity among New Zealand youth. *J Adolesc Health.* Nov 2006;39(5):770-773.

43. Gomez JE, Johnson BA, Selva M, Sallis JF. Violent crime and outdoor physical activity among inner-city youth. *Prev Med.* Nov 2004;39(5):876-881.

44. Adkins S, Sherwood NE, Story M, Davis M. Physical activity among African-American girls: the role of parents and the home environment. *Obes Res.* Sep 2004;12 Suppl:38S-45S.

45. Norman G, Nutter, S. K., Ryan, S. Sallis, J.F.,Calfas, K. & Patrick K. Community Design and Access to Recreational Facilities as Correlates of Adolescent Physical Activity and Body-Mass Index. *Journal of Physical Activity and Health.* 2006:10.

46. de Farias JC, Lopes AD, Mota J, Santos MP, Ribeiro JC, Hallal PC. Perception of the social and built environment and physical activity among Northeastern Brazil adolescents. *Prev Med.* Feb 2011;52(2):114-119.

47. Evenson KR, Birnbaum AS, Bedimo-Rung AL, et al. Girls' perception of physical environmental factors and transportation: reliability and association with physical activity and active transport to school. *Int J Behav Nutr Phys Act.* 2006;3:28.

48. Tucker P, Irwin JD, Gilliland J, He M, Larsen K, Hess P. Environmental influences on physical activity levels in youth. *Health Place.* Mar 2009;15(1):357-363.

49. Adamo KB, Prince SA, Tricco AC, Connor-Gorber S, Tremblay M. A comparison of indirect versus direct measures for assessing physical activity in the pediatric population: a systematic review. *Int J Pediatr Obes.* 2009;4(1):2-27.

50. 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 9-12 in Ontario, Canada. *Int J Public Health.* Feb 10 2012.

51. Hobin EP, Leatherdale ST, Manske S, Dubin JA, Elliott S, Veugelers P. A multilevel examination of gender differences in the association between features of the school environment and physical activity among a sample of grades 9 to 12 students in Ontario, Canada. *BMC Public Health.* Jan 24 2012;12.

52. Janssen I, Boyce WF, Simpson K, Pickett W. Influence of individual- and area-level measures of socioeconomic status on obesity, unhealthy eating, and physical inactivity in Canadian adolescents. *Am J Clin Nutr.* Jan 2006;83(1):139-145.

53. Taylor RW, Farmer VL, Cameron SL, Meredith-Jones K, Williams SM, Mann JI. School playgrounds and physical activity policies as predictors of school and home time activity. *Int J Behav Nutr Phy.* Apr 27 2011;8.

54. Baron RM, Kenny DA. The Moderator Mediator Variable Distinction in Social Psychological-Research - Conceptual, Strategic, and Statistical Considerations. *J Pers Soc Psychol.* Dec 1986;51(6):1173-1182.

55. Nichol M, Janssen I, Pickett W. Associations Between Neighborhood Safety, Availability of Recreational Facilities, and Adolescent Physical Activity Among Canadian Youth. *J Phys Act Health.* Jul 2010;7(4):442-450.

56. Wilding J. Are the causes of obesity primarily environmental? Yes. *Bmj.* 2012;345:e5843.

57. Sandy R, Tchernis R, Wilson J, Liu G, Zhou X. Effects of the built environment on childhood obesity: The case of urban recreational trails and crime. *Econ Hum Biol.* Mar 6 2012.

58. Voorhees CC, Catellier DJ, Ashwood JS, et al. Neighborhood socioeconomic status and non school physical activity and body mass index in adolescent girls. *J Phys Act Health.* Nov 2009;6(6):731-740.

59. Giles-Corti B, Donovan RJ. Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. *Prev Med.* Dec 2002;35(6):601-611.

60. La Torre G, Masala D, De Vito E, Langiano E, Capelli G, Ricciardi W. Extra-curricular physical activity and socioeconomic status in Italian adolescents. *BMC Public Health.* 2006;6:22.

61. De Meester F, Van Dyck D, De Bourdeaudhuij I, Deforche B, Sallis JF, Cardon G. Active living neighborhoods: is neighborhood walkability a key element for Belgian adolescents? *BMC Public Health.* 2012;12:7.

62. Van Dyck D, Cardon G, Deforche B, Sallis JF, Owen N, De Bourdeaudhuij I. Neighborhood SES and walkability are related to physical activity behavior in Belgian adults. *Prev Med.* Jan 2010;50:S74-S79.

63. Sundquist K, Eriksson U, Kawakami N, Skog L, Ohlsson H, Arvidsson D. Neighborhood walkability, physical activity, and walking behavior: The Swedish Neighborhood and Physical Activity (SNAP) study. *Soc Sci Med.* Apr 2011;72(8):1266-1273.

64. Haug E, Torsheim T, Samdal O. Local school policies increase physical activity in Norwegian secondary schools. *Health Promot Int.* Mar 2010;25(1):63-72.

65. Lipperman-Kreda S, Grube JW, Friend KB. Local tobacco policy and tobacco outlet density: associations with youth smoking. *J Adolesc Health.* Jun 2012;50(6):547-552.

66. Eriksson U, Hochwalder J, Carlsund A, Sellstrom E. Health outcomes among Swedish children: the role of social capital in the family, school and neighbourhood. *Acta Paediatr.* May 2012;101(5):513-517.

67. Richard Prins SM, Frank van Lenthe, Johannes Brug, Anke Oenema. Are neighbourhood social capital and availability of sports facilities related to sports participation among Dutch adolescents? *International Journal of Behavioral Nutrition and Physical Activity.* 2012.

68. Cradock AL, Kawachi I, Colditz GA, Gortmaker SL, Buka SL. Neighborhood social cohesion and youth participation in physical activity in Chicago. *Soc Sci Med.* Feb 2009;68(3):427-435.

69. Prins RG, Mohnen SM, van Lenthe FJ, Brug J, Oenema A. Are neighbourhood social capital and availability of sports facilities related to sports participation among Dutch adolescents? *Int J Behav Nutr Phys Act.* Jul 31 2012;9(1):90.

Chapter 3

The association between the built environment at school and physical activity among students is moderated by school policies, programs, and practices related to physical activity

3.1 Abstract

Background: The school built environment may interact with school policies, programs, and practices (PPP) to promote or hinder student participation in moderate-to-vigorous physical activity (MVPA). The objective of this study was to explore the interactive effects of the school built environment and physical activity PPP on the MVPA of students while at school.

Methods: Data from 17,917 grade 6-10 students from 316 schools who participated in the 2009/10 Canadian Health Behavior in School-aged Children survey were analyzed using multi-level regression. Students answered questions on the amount of time they spend in MVPA at school. Administrator reports were used to create physical-activity-related built environment and PPP scores for each school.

Results: The school built environment score was positively associated with student MVPA ($p <$ .001). This association was moderated by the PPP on MVPA such that the association existed in schools with low PPP scores but not in schools with moderate or high PPP scores.

Conclusion: The findings suggest that the association between the built environment at school and student MVPA levels is moderated by school PPP on physical activity. These results set the stage for future intervention research addressing the role of the school built environment on students' health.

KEY WORDS: adolescent health; physical activity; school environment

3.2 Background

Canada's physical activity guidelines state that school-aged children and youth should accumulate at least 60 minutes of moderate-to-vigorous physical activity (MVPA) on a daily basis.[1] Unfortunately, only 7% of Canadian children and youth meet those guidelines.[2] This is concerning because a lack of physical activity may continue into adulthood[3] and because physical activity in school aged-children and youth can help control body weight, blood pressure and other cardiovascular risk factors; increase bone mineral density; reduce symptoms of depression; and increase academic performance.[4,5]

Most 5-17 year-olds spend about six hours a day on almost 200 days of the year at school.[6] Students have opportunities to engage in physical activity at school before classes begin, during breaks (lunch and recess), and after classes end. During class time children can be active in physical education class and physical activity can occasionally be integrated into other parts of the curriculum.[7] While the basic structure of the school day is similar at most schools, the physical activity levels of students vary from one school to the next.[8,9] This variation could potentially be explained by differences in the built environments at school and/or the policies, programs, and practices (PPP) the schools have in place to promote physical activity.

Research examining the associations between school built environments and PPP with student physical activity levels suggests that school built environments[10-14] and physical activity PPP[15,16] are associated with physical activity, but that these associations are weak to modest in strength and not consistent for all groups of students. Consider, for instance, a study of 16,471 students from Norway.[14] In that study, grade 8-10 students who attended schools with all eight of the assessed built environment features were approximately 2.5 times more likely to engage in physical activity during recess on a daily basis compared to grade 8-10 students who attended

schools with none of the built environment features. Conversely, no association between the built environment and physical activity during recess was observed in grade 4-10 students.

The inconsistency of the associations between the school built environment and student physical activity levels in different studies and across different groups of students suggests that a third variable may be moderating these associations.[17] Although not yet addressed in the published literature, it is possible that the association between the school built environment and student physical activity levels is being moderated by the school PPP on physical activity. It is also possible that the association between the school PPP and student physical activity levels is moderated by the built environment.

The objective of this study was to explore the interactive effects of the school built environment and school PPP on the physical activity levels of students during the school day. We had the opportunity to examine such relationships in a large and representative sample of Canadian youth in grades 6-10. The knowledge gained from this research could help guide the development of future strategies aimed at increasing physical activity within school-aged youth.

3.3 Methods

Participants

This research involved analyses of cross-sectional data from the 2009/10 Canadian Health Behaviour in School-aged Children Survey (HBSC). The Canadian HBSC was conducted in collaboration with the World Health Organization and followed an established international protocol.[18] HBSC participants consisted of students in grades 6-10 in publicly funded schools across Canada. Youth attending private, special needs, or home schools were ineligible, as were institutionalized, incarcerated, and homeless youth.[18] The survey used a cluster sampling design, with classrooms reflecting the distributions of schools according to size, location, language, and

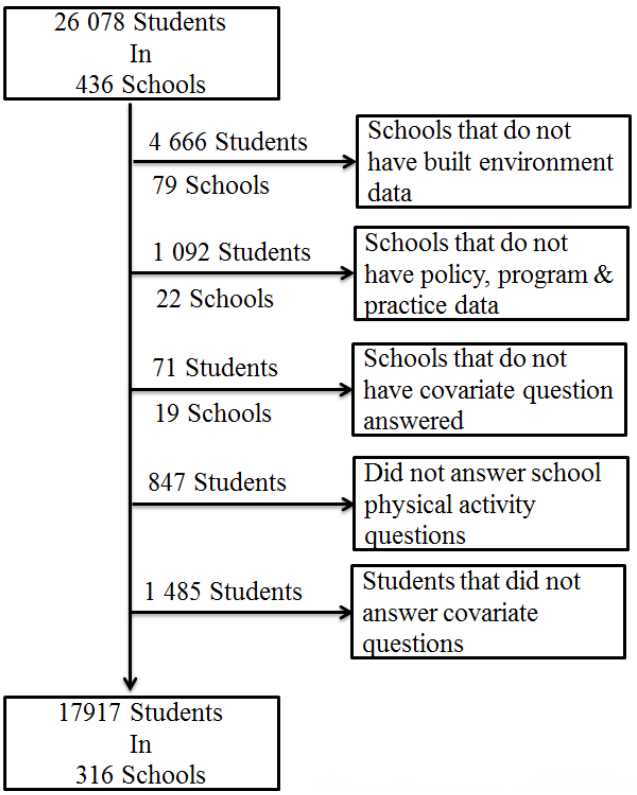
religion.[18] The survey gathered information on 26,078 students from 436 schools. Seventy-seven percent of eligible students participated.

Procedures

The main component of the HBSC was a student questionnaire that collected information on students' demographics, health behaviours, health determinants, and health outcomes. In addition, the school principal or designate completed an administrator questionnaire, which inquired about the characteristics of the school including the size and demographic distribution of the students, PPP and facilities. The administrator questionnaire was created by education researchers in Canada with expertise in school health. Information from the administrator survey was linked to information from the student participants.

For the present study, we excluded 5,829 students from 120 schools because the administrator questionnaire was either not completed or was missing data for one or more of the relevant study variables. An additional 2,332 students were excluded because of missing physical activity or covariate information. Thus, the final sample consisted of 17,917 students from 316 schools. Compared to the 8,161 students who were excluded, the final sample had a similar age (0.02 years younger), gender (1.3% less boys), and socioeconomic status. Figure 1 displays the reasons why HBSC students were excluded from this study.

Figure 1: Flow chart of the inclusion criteria for both students and schools.



Instruments

Physical Activity at School

The outcome of interest was participation in MVPA at school. Students were asked: "*About how many hours a week do you usually take part in physical activity that makes you out of breath or warmer than usual in your class time at school?*" and "*About how many hours a week do you usually take part in physical activity that makes you out of breath or warmer than usual in your free time (for example, lunch) at school?*" There were nine response options for each question that ranged from "*none at all*" through "*7 or more hours*". Responses from the two questions were combined to create a continuous score that ranged from 0-14 hours/week. A panel of physical activity experts in the international HBSC assembly developed these physical activity questions based on face validity with the intent that they be universally interpretable by

11-15 year-old students.[18] A previous validation study on physical activity questions similar to the questions used in the HBSC reported that questionnaire responses were modestly correlated with objective measures of physical activity obtained by accelerometry (r=0.39),[19,20] although it is important to recognize that questionnaires and accelerometers measure different aspects of physical activity (e.g., questionnaires measure time spent doing bouts of activity, including sedentary and light intensity activity, while accelerometers measure all movement at a defined intensity, including bouts and sporadic activity).

School Built Environment

The HBSC administrator survey asked if students had access to the following physical activity facilities on school grounds: (1) gymnasium, (2) other large room suitable for physical activity, (3) fitness room for aerobic or strength training, (4) running track, (5) outdoor field, (6) outdoor paved area, (7) skating rink/arena, or (8) indoor swimming pool. Positive responses were given a score of 1 and negative responses a score of 0. Scores from all 8 items were summed to create a built environment score ranging from 0-8. The use of a summary score was used because a previous Canadian HBSC study had found that no single specific facility was of particular importance, but that there was a linear relationship between the cumulative number of facilities and student physical activity levels.[21]

School Policies, Programs, and Practices for Physical Activity

The HBSC administrator survey included 6 questions about school PPP relevant for physical activity. Responses were used to create a summary school PPP score that ranged from 0-6. Table 1 lists the questions that were used, their response options, and how the responses were combined to create the summary score. Low, medium and high tertiles were created based

on the summary score. Because a large proportion of schools had summary PPP scores in the middle of the range, the tertiles were not of equal size.

Table 1: Physical activity policies, programs and practices questions from the administrator questionnaire.

Policy or Program Question	**Response Options (points allocated for creation of summary score)**
Does your school have a committee that oversees policies and practices concerning physical activity and healthy eating at your school (e.g., health action team)?	- Yes (1 points) - No (0 points)
Does your school's improvement plan for the current school year contain any items related to physical activity and healthy eating?	- Yes (1 point) - No (0 points)
We promote physical activity during or as part of special events.	- A lot (1 point) - Some (1 point) - Very little (0 points) - Not at all (0 points)
We integrate physical activity into other curriculum areas.	- A lot (1 point) - Some (1 point) - Very little (0 points) - Not at all (0 points)
Which of the following 18 sports are offered in your varsity or intramural athletics programs: Basketball, Volleyball, Soccer, Football, Baseball/ Softball, Rugby, Ice Hockey, Lacrosse, Gymnastics, Wrestling, Track & Field, Badminton, Swimming, Skiing, Ultimate Frisbee, Other.	A summary score was created by assigned each sport a value of 0 (no) or 1 (yes), and summing all values. Schools were divided into "low" (0 points) and "high" (1 point) groups based on the median summary score.
Does your school offer late bus/transportation service to students who participate in extra-curricular activities?	- Yes (1 point) - No (0 points)

Potential Covariates

Both student- and school-level confounders were considered. Student-level confounders included socioeconomic status, grade, and gender. Socioeconomic status is determined in the

HBSC using the three point (low, medium, high) Family Affluence Scale (FAS), which is comprised of four items: vehicle ownership by family, having a bedroom for yourself, family vacations during past year, and computer ownership.[22] The FAS has good criterion validity and is less affected by non-response bias than other socioeconomic measures.[23] School-level confounders included urban-rural school location and school size; previous research has shown that urban-rural location is associated with physical activity[24] and school size is associated with student well-being.[25] Based on the population of the municipality where the schools were located, the schools were classified as being in a rural area (0-999 people), small city (1,000-29,999 people), medium city (30,000-99,999 people), or metropolitan area (≥100,000 people). Principals reported the number of students attending their school, and schools were divided into small, medium, and large populations using tertiles.

Data Analysis

Analyses were performed in SPSS version 20.[26] Descriptive statistics, including frequencies, means, and standard deviations, were conducted. Relationships between study variables were examined using multi-level linear regression models to account for the clustered and hierarchical nature of the data. Backwards deletion was used to build a model for the main exposure variables (built environment score and policies, programs and practices score) that included only the relevant covariates. The model building started with all candidate covariates. If deletion of the variable caused less than a 10% change in the effect estimate for either of the main exposure variables, the potential covariate was not included in the model.[27] This process was repeated with all potential covariates. A second model included the variables that were included in model 1 and an interaction term between the built environment score and the PPP score. Finally, two stratified analyses were performed. The first stratified analysis examined the

association between the built environment score and physical activity within low, medium, and high PPP score groups. The second stratified analysis examined the association between the built environment score and school PPP within low, medium and high built environment groups. In order to prevent multi-collinearity in the model, school built environment and PPP scores were centred.[28]

3.4 Results

The distribution of the student participants according to demographic characteristics is shown in Table 2. The sample was evenly split across the two genders and five grade groups. On average, students reported participating in 4.4 ± 3.5 hours/week of MVPA at school. All participating schools had at least one of the built environment features that were assessed, and 55% had at least five of the eight features (Table 3). A small percentage (2%) of schools had none of the six physical activity PPP and 54% had at least three of the six shown in Table 3.

Table 2. Distribution of the student sample according to student-level variables (N=17 917)

	N	**%**
Gender		
Male	8615	48
Female	9302	52
Grade		
≤6	3513	20
7	3388	19
8	3632	20
9	3793	21
≥10	3591	20
Family Affluence Scale		
Low	467	3
Moderate	9371	52
High	8079	45
Physical Activity at School		
Low (<2 hours/week)	5075	28
Medium (2-5 hours/week)	7046	39
High (≥6 hours/week)	5796	32

Table 3. Distribution of the school sample according to school-level variables (N=316)

	N	%
Built Environment Feature (% yes)		
Gymnasium	304	96
Other large room suitable for physical activity	191	60
Fitness room for aerobic or strength training	138	44
Running track	92	29
Outdoor field	263	83
Outdoor paved area	195	68
Skating rink/arena	36	11
Indoor swimming pool	18	6
Built Environment Score		
0 (low)	0	0
1	1	0
2	11	4
3	40	13
4	57	18
5	64	20
6	61	19
7	47	15
8 (High)	35	11
Physical Activity Policies, programs and practices (% yes)	170	54
Committee to increase physical activity	167	53
School improvement plan for physical activity	289	92
Promotes physical activity during special events	214	68
Integrates physical activity into curriculum	139	44
Offers more than 9 intramural and varsity sports	37	12
Offers late bus transportation		
Physical Activity Policies, programs and practices Score		
0 (low)	7	2
1	24	8
2	58	18
3	82	26
4	101	32
5	38	12
6 (High)	6	2

The association between the school built environment, school policies, programs and practices around physical activity, and student physical activity levels is shown in Table 4. As

shown in model 1, each one unit increase in the built environment score was associated with a .073 hour per week increase in MVPA performed at school ($p < .001$). Conversely, each one unit increase in the physical activity policies, programs and practices score was associated with a .080 hour per week decrease in MVPA performed at school ($p < .001$).

An interaction term between the built environment score and the PPP scores was added to model 2 (Table 4). There was a minimal change in the parameter estimates for the built environment score and PPP score from those observed in model 1, and the interaction term contributed significantly to the model ($p = .031$). This indicated that the association between the built environment at school and student MVPA was moderated by the PPP on physical activity.

Table 4. Multi-level regression analyses of the association between the built environment at school and school physical activity policies, programs, and practices with student physical activity levels at school

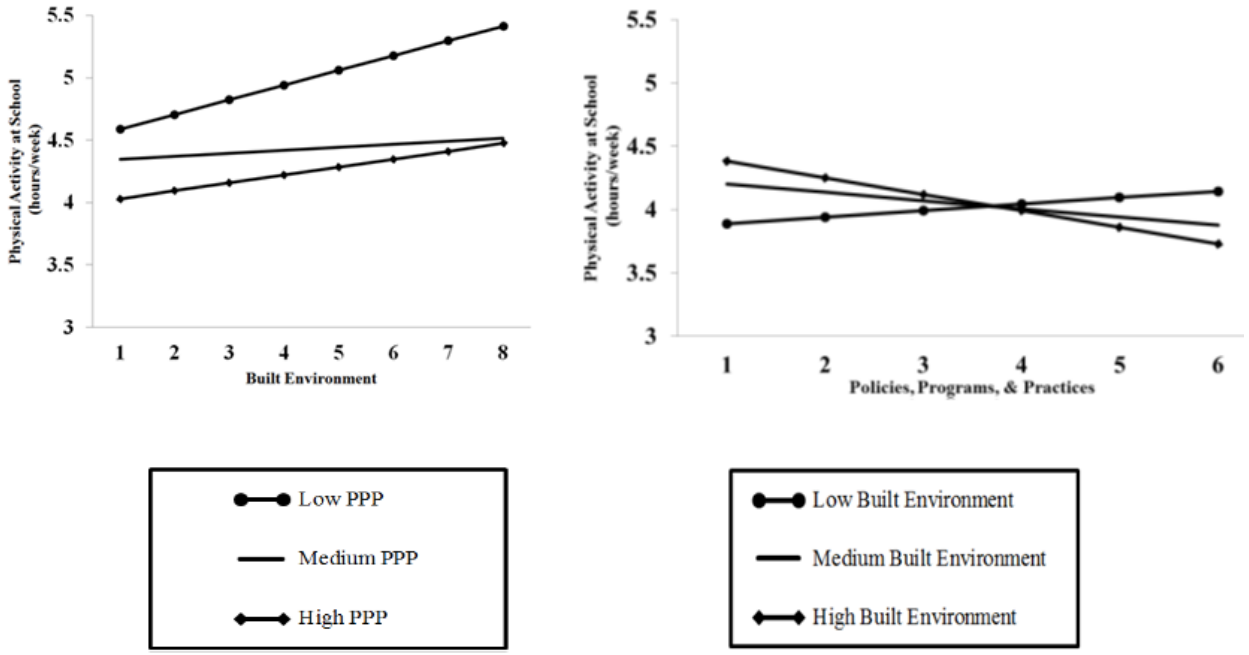
	Model 1			**Model 2**		
	β	SE	*P* value	B	SE	*P* value
Built Environment Score	.073	.017	<.001	.070	.017	<.001
Policies, programs and practices Score	-.080	.021	<.001	-.072	.021	.001
School Size						
Large (ref.)						
Medium	.307	.061	<.001	.375	.072	<.001
Small	.376	.072	<.001	.375	.061	<.001
Built Environment Score X Policies, programs and practices Score	N/A	N/A	N/A	-.027	.013	.031

Note: β coefficient represent the change in the physical activity outcome (e.g., hours per week of moderate-to-vigorous activity at school) per each one unit change in the built environment score, one unit change in the policies, programs, and practices scores, or the schools with a medium or small population relative to the schools with a large population.

To help interpret this interaction, a stratified analysis was performed in which the association between the built environment and MVPA was examined separately within schools

with low, medium, and high PPP scores. As shown in the left panel of Figure 2, there was a significant positive association between the built environment score and student MVPA levels for schools with low PPP scores but not for schools with medium or high PPP scores. A second stratified analysis was performed in which the association between the school PPP score and MVPA was examined separately within students attending schools with low, medium, and high built environment scores. As shown in the right panel of Figure 2, there was a negative association between the school PPP score with student MVPA levels for schools with medium and high built environment scores but not for schools with low built environment scores.

Figure 1. *Left Panel*: The association between the school built environment score with student physical activity levels within schools with low, medium, and high physical activity PPP scores. *Right Panel:* The association between the school physical activity PPP score with student physical activity levels within schools with low, medium, and high built environment scores.



3.5 Discussion

The key finding of this study is that the school built environment was positively associated with students MVPA levels, but that this association was only significant and meaningful within the schools that had the fewest physical activity related PPP. This suggests that the relationship between the built environment and physical activity is complicated and varies according to the social environment.

Our observation that students' MVPA at school was associated with their school's built environment is consistent with previous research that found moderate gradients in physical activity according to the number of school recreational features.[12-14,21] The findings of our regression analyses suggest that the average weekly volume of MVPA performed by students attending schools with the most built environment features (8 features) is about 30 minutes/week higher than the volume of MVPA for students attending schools with only one built environment feature. Thirty minutes/week represents a modest amount of MVPA for an individual student; however, this volume of activity is quite meaningful at the population level as it would apply to all students attending such schools.

Previous research on the association between school physical activity PPP with student physical activity levels has produced mixed results. A cross-sectional study of high schools in Norway observed that students were more active if they attended schools with a written policy for physical activity,[15] whereas a randomized trial of 24 middle schools in the U.S. found that a two-year school-based policy and social media intervention had an influence on the physical activity level in boys but not in girls.[29] Surprisingly, we observed a negative association between the school PPP score and student MVPA levels. We can only speculate as to why such as association existed. It may be that schools with a larger number of PPP do not implement them

properly and/or the quality of these programs was lower. It is also possible that schools with the lowest physical activity levels developed PPP to try and increase physical activity, which may have contributed to the counterintuitive cross-sectional association observed in our study. Another possible explanation is that the schools with the fewest PPP had more 15-29 minute curriculum breaks (data not shown), which would have allowed the students more time to access the built environment and accumulate MVPA in their free time.

To our knowledge, this is the first study to simultaneously consider the influence of the school built environment and school PPP on MVPA. Consistent with previous research on smoking behaviours, we found that the association between the built environment and physical activity was moderated by PPP.[30] Specifically, the strongest positive association was between the schools built environment and student MVPA levels in schools with few PPP.

Limitations

This study examined a large and representative sample of Canadian youth. The findings may also be generalizable to other northern industrialized countries with similar physical activity levels, educational systems, and social demographics. The current study is limited by its cross-sectional design, and we cannot infer temporality around the observed associations. In addition, the MVPA outcome was self-reported; self-reported measures of MVPA are only modestly correlated with objective measures.[31] This likely led to non-differential misclassification of the MVPA variable and biased our results towards the null.

Conclusions

The findings of this study suggest that the associated between the built environment at school and student physical activity levels is moderated by school PPP. These results set the

stage for future intervention research addressing the role of the school built environment on students' health.

IMPLICATIONS FOR SCHOOL HEALTH

The key observation of this study is that students' MVPA at school is dependent upon built environment at their school, but only for students who attend schools with a limited number of PPP aimed at addressing physical activity. This study suggests that making improvements to a school's built environment may not be useful in all situations, particularly if the school has already developed several PPP around physical activity. These cross-sectional findings need to be confirmed with prospective and intervention research.

Human Subjects Approval Statement

The General Research Ethics Board of Queen's University granted ethics approval for the study. Individual schools and their school boards, parents/guardians, and the student participants provided consent.

3.6 References

1. Tremblay MS, Leblanc AG, Carson V, et al. Canadian Physical Activity Guidelines for the Early Years (aged 0-4 years). *Appl Physiol Nutr Metab.* Apr 2012;37(2):345-369.

2. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep.* Mar 2011;22(1):15-23.

3. Williams PG, Holmbeck GN, Greenley RN. Adolescent health psychology. *J Consult Clin Psychol.* Jun 2002;70(3):828-842.

4. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act.* 2010;7:40.

5. Strong WB, Malina RM, Blimkie CJR, et al. Evidence based physical activity for school-age youth. *J Pediatr.* Jun 2005;146(6):732-737.

6. Education OMoE. School Year Calendar. In: Education OMoE, ed2013.

7. Association OPaHE. Daily Physical Activity in Schools. In: Education Mo, ed. Ontario: Ontario Government 2005.

8. McKenzie TL, Marshall SJ, Sallis JF, Conway TL. Student activity levels, lesson context, and teacher behavior during middle school physical education. *Res Q Exerc Sport.* Sep 2000;71(3):249-259.

9. Pellegrini AD, Huberty PD, Jones I. The effects of recess timing on children's playground and classroom behaviors. *Am Educ Res J.* Win 1995;32(4):845-864.

10. Nichol M, Janssen I, Pickett W. Associations Between Neighborhood Safety, Availability of Recreational Facilities, and Adolescent Physical Activity Among Canadian Youth. *J Phys Act Health.* Jul 2010;7(4):442-450.

11. 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 9-12 in Ontario, Canada. *Int J Public Health.* Feb 10 2012.

12. Fein AJ, Plotnikoff RC, Wild TC, Spence JC. Perceived environment and physical activity in youth. *Int J Behav Med.* 2004;11(3):135-142.

13. Taylor RW, Farmer VL, Cameron SL, Meredith-Jones K, Williams SM, Mann JI. School playgrounds and physical activity policies as predictors of school and home time activity. *Int J Behav Nutr Phy.* Apr 27 2011;8.

14. Haug E, Torsheim T, Sallis JF, Samdal O. The characteristics of the outdoor school environment associated with physical activity. *Health Educ Res.* Apr 2010;25(2):248-256.

15. Haug E, Torsheim T, Samdal O. Local school policies increase physical activity in Norwegian secondary schools. *Health Promot Int.* Mar 2010;25(1):63-72.

16. Sallis JF, McKenzie TL, Conway TL, et al. Environmental interventions for eating and physical activity: a randomized controlled trial in middle schools. *Am J Prev Med.* Apr 2003;24(3):209-217.

17. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol.* Dec 1986;51(6):1173-1182.

18. Health Behaviour in School-Aged Children: A World Health Organization Cross-National Study. University of Edinburgh1998.

19. Prochaska JJ, Sallis JF, Long B. A physical activity screening measure for use with adolescents in primary care. *Arch Pediat Adol Med.* May 2001;155(5):554-559.

20. Booth ML, Okely AD, Chey T, Bauman A. The reliability and validity of the physical activity questions in the WHO health behaviour in schoolchildren (HBSC) survey: a population study. *Brit J Sport Med.* Aug 2001;35(4):263-267.

21. Nichol ME, Pickett W, Janssen I. Associations Between School Recreational Environments and Physical Activity. *J School Health.* Jun 2009;79(6):247-254.

22. Currie C, Molcho M, Boyce W, Holstein B, Torsheim T, Richter M. Researching health inequalities in adolescents: the development of the Health Behaviour in School-Aged Children (HBSC) family affluence scale. *Soc Sci Med.* Mar 2008;66(6):1429-1436.

23. Boyce W, Torsheim T, Currie C, Zambon A. The family affluence scale as a measure of national wealth: Validation of an adolescent self-report measure. *Soc Indic Res.* Sep 2006;78(3):473-487.

24. Plotnikoff RC, Bercovitz M, Loucaides CA. Physical activity, smoking, and obesity among Canadian school youth - Comparison between urban and rural schools. *Canadian Journal of Public Health-Revue Canadienne De Sante Publique.* Nov-Dec 2004;95(6):413-418.

25. McNeely CA, Nonnemaker JM, Blum RW. Promoting school connectedness: Evidence from the national longitudinal study of adolescent health. *J School Health.* Apr 2002;72(4):138-146.

26. *SPSS student version 20.0 for Windows 95, Windows 98 or Windows NT 4.0* [computer program]. Upper Saddle River, N.J.: Prentice Hall,; 2012.

27. Rothman KJ. *Modern epidemiology*. 1st ed. Boston: Little, Brown; 1986.

28. Aiken LS, West SG, Reno RR. *Multiple regression : testing and interpreting interactions*. Newbury Park, Calif.: Sage Publications; 1991.

29. Sallis JF, McKenzie TL, Conway TL, et al. Environmental interventions for eating and physical activity - A randomized controlled trial in middle schools. *Am J Prev Med.* Apr 2003;24(3):209-217.

30. Lipperman-Kreda S, Paschall MJ, Grube JW. Perceived enforcement of school tobacco policy and adolescents' cigarette smoking. *Prev Med.* Jun 2009;48(6):562-566.

31. Adamo KB, Prince SA, Tricco AC, Connor-Gorber S, Tremblay M. A comparison of indirect versus direct measures for assessing physical activity in the pediatric population: a systematic review. *Int J Pediatr Obes.* 2009;4(1):2-27.

Chapter 4

School social capital does not moderate the association between the built environment at school and physical activity

4.1 Abstract

Background: The built and social environments at schools are related to students' moderate-to-vigorous physical activity (MVPA) levels. The objective of this study was to explore the interactive effects of the school built environment and school social capital on the MVPA of students while at school.

Methods: Data from 18,875 grade 6-10 students from 331 schools who participated in the 2009/10 Canadian Health Behaviour in School-aged Children survey were analyzed using multi-level regression. Students answered questions on the amount of time they spend in MVPA at school and on their school's social capital. Administrator reports were used to create a physical-activity-related built environment score.

Results: The school built environment score was positively associated with student MVPA at school ($\beta = 0.040$, $p < .005$). The association between the school social capital and MVPA was also positive ($\beta = 0.074$, $p < .001$). No significant interaction was found between the built environment and school social capital.

Conclusion: The findings suggest that school social capital may be a more important factor in increasing students MVPA than the built environment. The results of this study provide useful information for future intervention research on school social capital on student physical activity.

KEY WORDS: adolescent health; physical activity; school environment; social capital

4.2 Introduction

Surveillance data from 105 countries indicate that 80% of 13-15 year-olds do not meet the public health guideline of 60 minutes of moderate-to-vigorous physical activity (MVPA) per day.[1] Increasing the rates of MVPA amongst young people is important because MVPA in this age group is linked to a decrease in chronic disease risk factors such as obesity, the metabolic syndrome, and high blood pressure.[2] Furthermore, MVPA improves academic performance, increases self-esteem, and decreases the likelihood of experiencing mental health problems.[3,4]

Schools are an important setting for MVPA because youth spend large amounts of time there and because school-based physical activity opportunities are accessible to all students.[5] There are numerous opportunities for MVPA at school; including physical education classes and several non-curricular options (e.g., active play at recess, intramural sports, and varsity sports). While the course load is similar at most schools, the MVPA levels of students vary from school to school.[5] This difference could potentially be explained by differences in the built environments at school and/or the level of school social capital.

There are several features of the school built environment that are relevant for MVPA such as gymnasiums, sports fields, and fitness rooms. Previous research has shown that the school built environment is associated with student MVPA levels, although such associations are modest in strength and not consistent in all population groups.[6-8] For instance, a cross-sectional study of 7,638 grade 6-10 students found that girls attending high schools with 5 or 6 physical-activity-related built environment features were 62% more likely to participate in MVPA than girls attending schools with one or no features; this difference was only 10% in boys.[9]

In its most basic terms social capital refers to the social connections that we have.[10] It has been hypothesized that social capital impacts physical activity participation through enhanced communication.[11] For instance, if a school has enhanced communication it could be easier for students to find out about the available physical activity opportunities. A number of studies have shown a positive, albeit weak, association between social capital and physical activity.[11-14] For example, a cross-sectional study of 680 American adolescents reported that adolescents living in neighbourhoods with a high social cohesion were only half as likely to be inactive as adolescents living in neighbourhoods with a low social cohesion.[11]

Previous research based on the neighbourhood environment suggests that social capital may moderate the influence of the built environment on physical activity. Specifically, a study of 12-13 year-olds from the Netherlands found that each one standard deviation increase in a neighbourhood social capital score was associated with a 50% increased odds of leisure-time sports participation within neighbourhoods with lots of park space; this association was not observed in neighbourhoods with a limited amount of park space.[12] To our knowledge, previous research has not simultaneously considered the associations of the built environment and social capital at school with student physical activity levels.

The objective of this study was to examine the interactive associations between the school built environment and school social capital with the MVPA levels of students during the school day. These findings could help direct intervention efforts. We had the opportunity to examine such relationships in a large and representative sample of Canadian youth in grades 6-10.

4.3 Methods

Participants

This research involved analyses of cross-sectional data from the 2009/10 Canadian Health Behaviour in School-aged Children Survey (HBSC). The Canadian HBSC was conducted in collaboration with the World Health Organization and followed an established international protocol.[15] HBSC participants consisted of students in grades 6-10 in publicly funded schools across Canada. Youth attending private, special needs, and home schools were ineligible, as were institutionalized, incarcerated, and homeless youth.[15] The survey used a cluster sampling design, with classrooms reflecting the distributions of schools according to size, location, language, and religion.[15] The survey gathered information on 26,078 students from 436 schools. The General Research Ethics Board of Queen's University granted ethics approval for the study. Individual schools and their school boards, parents and guardians, and the student participants all provided consent. Seventy-seven percent of eligible students participated.

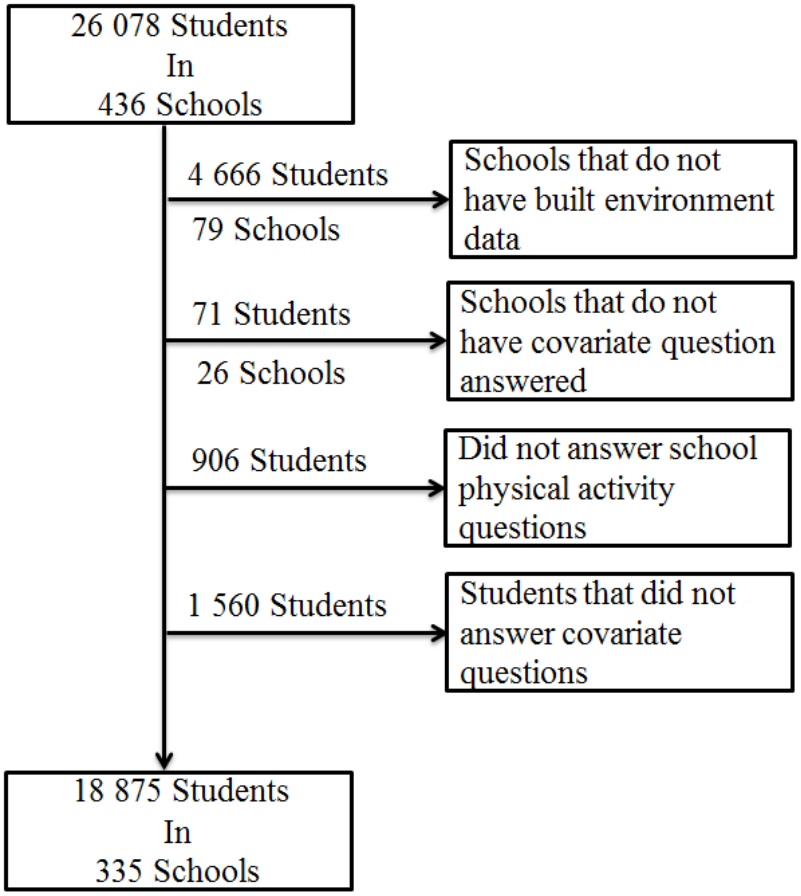
Procedures

The main component of the HBSC was a student questionnaire that collected information on students' demographics, health behaviours, health determinants, and health outcomes. In addition, the school principal or designate completed an administrator questionnaire that inquired about the school's characteristics, including the size and demographic distribution of the students, policies, programs, and availability of facilities. Information from the administrator survey was linked to the individual–level information from the student participants.

For the present study, we excluded 4,737 students from 105 schools because the administrator questionnaire was either not completed or was missing data for one or more of the relevant study variables. An additional 2,466 students were excluded because of missing physical

activity or covariate information. Thus, the final sample consisted of 18,875 students from 331 schools. Compared to the 7,203 students who were excluded, the final sample was similar in age (0.02 years younger), gender distribution (49.4% vs. 48.0 % male), and socioeconomic status. Figure 1 displays the loss of participants due to missing study variables.

Figure 1: Flow chart of the inclusion criteria for both students and schools.



Instruments

Physical Activity at School

The outcome of interest was participation in MVPA at school. The student questionnaire asked: "*About how many hours a week do you usually take part in physical activity that makes you out of breath or warmer than usual in your class time at school?*" and "*About how many*

hours a week do you usually take part in physical activity that makes you out of breath or warmer than usual in your free time (for example, lunch) at school?" There were nine response options for each question that ranged from "*none at all*" through "*7 or more hours.*" Responses from the two questions were combined to create a continuous score that ranged from 0-14 hours/week. A panel of physical activity experts in the international HBSC assembly developed these physical activity questions based on face validity with the intent that they be universally interpretable by 11-15 year-olds.[15] A previous validation study on a physical activity questionnaire similar to the one used in the HBSC reported that questionnaire responses were modestly correlated with objective measures of physical activity obtained by accelerometry (r=0.39),[16,17] although it is important to recognize that questionnaires and accelerometers measure different aspects of physical activity (e.g., questionnaires measure time spent doing bouts of activity, including sedentary and light intensity activity, while accelerometers measure all movement at a defined intensity, including bouts and sporadic activity).

School Built Environment

The HBSC administrator survey asked if students had access to the following physical activity facilities on school grounds: (1) gymnasium, (2) other large room suitable for physical activity, (3) fitness room for aerobic or strength training, (4) running track, (5) outdoor field, (6) outdoor paved area, (7) skating rink/arena, and (8) indoor swimming pool. Positive responses were given a score of 1 and negative responses a score of 0. Scores from all 8 items were summed to create a built environment score ranging from 0-8. The use of a summary score was used because a previous Canadian HBSC study had found that no single specific facility was of particular importance, but that there was a linear relationship between the cumulative number of facilities and student physical activity levels.[9]

School Social Capital

The HBSC student survey asked students to rate their level of agreement (strongly agree, agree, neither agree nor disagree, disagree, strongly disagree) to the following 4 statements: **"***Our school is a nice place to be", "I feel a lot of trust in my teachers", "Our teachers treat us fairly",* and *"I feel I belong at this school*". Responses to individual statements were scored from 0 (strongly disagree) to 4 (strongly agree). Students were also asked "*How do you feel about school at present?*" and responses to this question were scored from 0 (I don't like it at all) to 3 (I like it a lot). The responses for all 5 questions were summed to create a 0-19 point score, with higher values reflecting higher degrees of school social capital.

The statements *"I feel I belong at this school"*[18] and *"I feel a lot of trust in my teachers"*[19] is also based on previous social capital research. The questions *"Our school is a nice place to be"* and *"Our teachers treat us fairly"* have been used to assess school climate in previous HBSC studies.[20] The question *"How do you feel about school at present?"* has been used as an indicator of a student's perception of school.[21] A factor analysis revealed that these questions represent one factor, which we have called school social capital.[22] The Cronbach's alpha for this factor-derived scale is .81.[22] All questions had a factor loading ranging from .64 to .83 except the question *"How do you feel about school at present?",* which had a factor loading of .57. A school-level social capital score was subsequently derived for each school by calculating the mean of the factor scores from all of the participating students from that school.

Potential Covariates

Both student- and school-level confounders were considered. Student-level confounders included socioeconomic status, grade, and gender. Socioeconomic status is determined in the HBSC using the three point (low, moderate, high) Family Affluence Scale (FAS), which is

comprised of four items: vehicle ownership by family, having a bedroom for yourself, family vacations during past year, and computer ownership.[23] The FAS has good criterion validity and is less affected by non-response bias than other socioeconomic measures.[24] School-level confounders included urban-rural school location and school size; previous research has shown that urban-rural location is associated with physical activity[25] and school size is associated with student well-being.[26] Based on the population of the municipality where the schools were located, they were classified as being in a rural area (0–999 people), small city (1,000-29,999 people), medium city (30,000-99,999 people), or metropolitan area (≥100,000 people). Principals reported the number of students attending their school, and schools were divided small, medium, and large populations using tertiles.

Statistical Analysis

Analyses were performed in SPSS version 20.[27] Descriptive statistics including frequencies, means, and standard deviations, were conducted. The bivariate relationship between school built environment and school social capital was determined using a Pearson correlation. Relationships between the exposure variables and the MVPA outcome were examined using multi-level linear regression models that accounted for the clustered and hierarchical nature of the data. The method of estimation was a restricted maximum likelihood procedure. In order to prevent multi-collinearity in the model, school built environment and school social capital scores were centered.[28] Backwards deletion was used to build a model for the main exposure variables (built environment score and school social capital score) that only included the relevant covariates. The model building started with all candidate covariates. If deletion of the covariate caused less than a 10 percent change in the effect estimate for either of the main exposure variables, the potential covariate was not included in the model.[29] This process was repeated with

all potential covariates. A second model included the variables that were included in model 1 and an interaction term between the school built environment score and the school social capital score. Next, two stratified analyses were performed. The first stratified analysis examined the association between the built environment score and physical activity within low, medium, and high school social capital groups. The second stratified analysis examined the association between the school social capital score and physical activity within low, moderate and high built environment groups. Low, moderate/medium and high tertiles were created for these stratified analyses. Finally, the combined influence of the built environment and school social capital on MVPA was performed by creating 4 groups: low built environment/low social capital, low built environment/high social capital, high built environment/low school social capital, and high built environment/high social capital. For these groups, low and high were defined based on the median scores. To determine if there was a difference between these 4 groups, a one way ANOVA with a Bonferroni post-hoc was conducted.

4.4 Results

The distribution of the student participants according to demographic characteristics are shown in Table 1. The sample was fairly evenly split across the two genders and five grade groups. On average, students reported participating in 4.4 ± 3.5 hours/week of MVPA at school. All participating schools had at least one of the built environment features that were assessed, and 62% had at least four of the eight features (Table 2). The average school social capital score was 12.6 ± 1.3, with a minimum score of 7.5 and a maximum score of 17.0 (Table 2).

Table 1. Distribution of the student sample according to individual-level variables (N=18,875)

	N	%
Gender		
Male	9051	48
Female	9824	52
Grade		
≤6	3697	20
7	3576	19
8	3854	20
9	3960	21
≥10	3788	20
Family Affluence		
Low	494	3
Moderate	5889	36
High	12492	61
Physical Activity at School		
Low (<2 hours/week)	5329	28
Medium (2-5 hours/week)	6076	32
High (≥6 hours/week)	7470	40

Table 2. Distribution of the schools according to school-level variables (N=331)

	N	%
School Built Environment Features Present		
Gymnasium	321	96
Other large room suitable for physical activity	202	60
Fitness room for aerobic or strength training	146	44
Running track	99	30
Outdoor field	280	84
Outdoor paved area	206	62
Skating rink/arena	39	12
Indoor swimming pool	19	6
School Built Environment Score		
0 (low)	0	0
1	2	0.6
2	11	3.3
3	42	12.5
4	62	18.5
5	68	20.3
6	65	19.4
7	50	14.9
8 (High)	35	10.4
School Social Capital Score		
Low (≤11.93)	6388	34
Moderate (11.94 – 13.11)	6520	35
High (≥13.12)	5967	31

The school built environment and school social capital scores were weakly, negatively correlated with each other (r = -.19, $p < .001$). The association between the school built environment, school social capital, and student physical activity levels is shown in Table 3. As shown in model 1, after controlling for relevant covariates, each one unit increase in the built environment score was associated with a .040 hour per week increase in MVPA performed at school ($p = .005$) and each one unit increase in the school social capital score was associated with a .074 hour per week increase in MVPA performed at school ($p = .001$).

An interaction term between the built environment score and the school social capital scores was added to model 2 (Table 3). There was a minimal change in the parameter estimates

for the built environment score and the school social capital score versus those observed in model 1. The interaction term did not contribute significantly to the model ($p = 0.192$). This suggested that the association between the schools built environment and student MVPA was not moderated by the school social capital.

Table 3. Multi-level regression analyses of the association between the school built environment, school social capital, and moderate-to-vigorous physical activity at school

	Model 1			Model 2		
	β	SE	*P* value	β	SE	P value
Built Environment Score	.040	.015	.005	.044	.015	.003
School Social Capital Score	.074	.021	.001	.077	.022	001
School Size						
Large (ref.)						
Medium	.190	.063	.003	.190	.063	.002
Small	.344	.071	<.001	.346	.071	<.001
Grade	-.018	.020	.395	-.020	.021	.356
Built Environment Score X School Social Capital Score	N/A	N/A	N/A	.015	.011	.192

Note: β coefficient represent the change in hours per week of moderate-to-vigorous physical activity at school per each one unit change in the built environment score, one unit change in the school social capital scores, one grade level change, or the schools with a medium or small population relative to the schools with a large population.

To further investigate interaction, a stratified analysis was performed in which the association between the built environment and MVPA was examined separately within schools with low, medium, and high school social capital scores. As shown in the left panel of Figure 2, there was a positive association between the built environment score and student MVPA levels for schools with low (β = .038, p = .085) , medium (β =.045, p = .086) and high (β = .047, p = .121) school social capital scores, although these did not reach statistical significance. A second stratified analysis was performed in which the association between school social capital and

MVPA was examined within schools with low, moderate, and high built environment scores. As shown in the right panel of Figure 2, there was no association (β = -.005, *p* = .924) between the school social capital score with student MVPA levels for schools with low built environment scores. Conversely, there was a positive association between the school social capital score with student MVPA levels for schools with moderate (β =.073, *p* = .031) and high (β =.090, *p* = .007) built environment scores.

Figure 2. *Left Panel*: The association between the school built environment score with student MVPA levels within schools with low, medium, and high school social capital scores. Data are plotted to represent a grade 8 student from a medium sized school. *Right Panel*: The association between the school social capital score with student MVPA levels within schools with low, moderate, and high built environment scores. Data are plotted to represent a grade 8 student from a medium sized school.

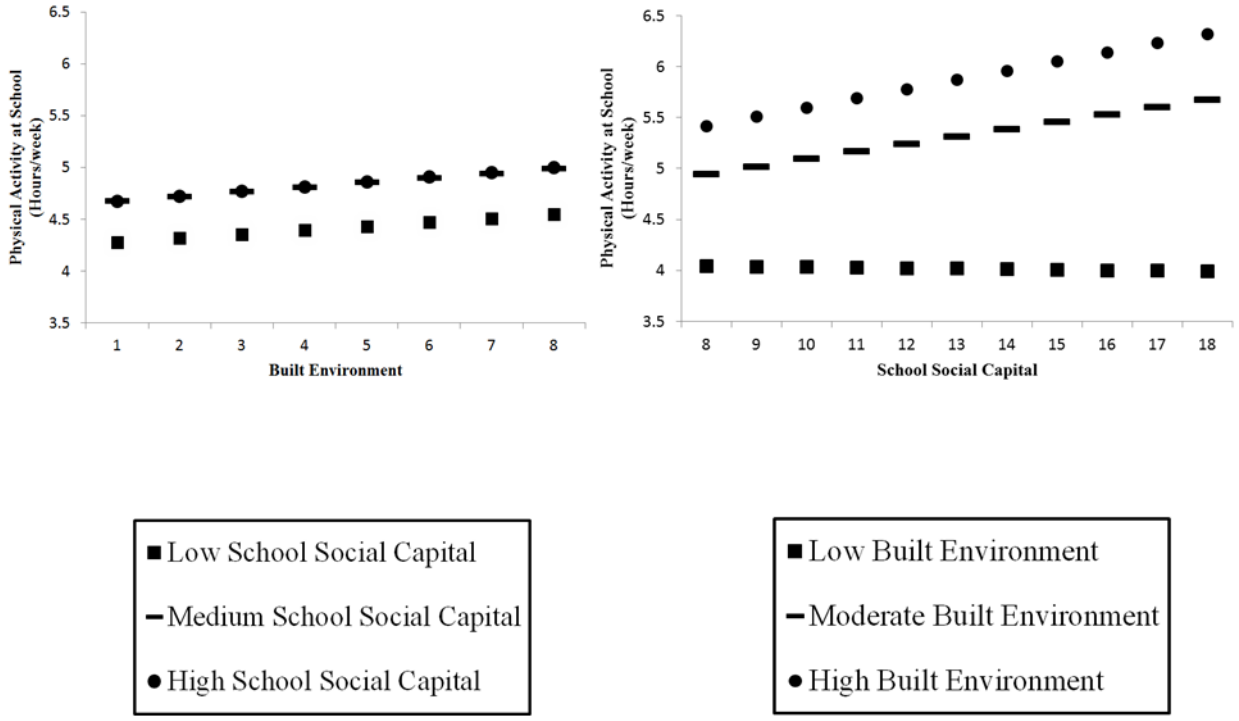
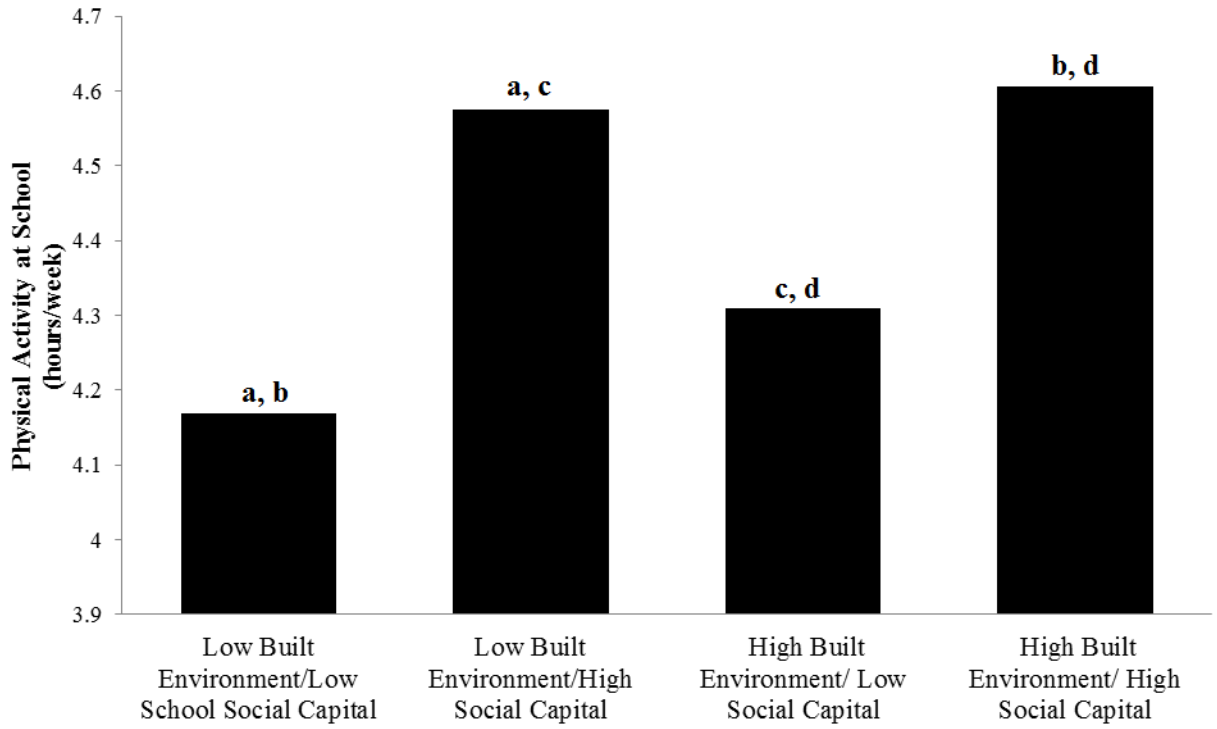


Figure 3 shows the average MVPA for schools with low built environment/low social capital scores (4.17 hours/week), low built environment/high social capital scores (4.57

hours/week), high built environment/low social capital scores (4.34 hours/week), and high built environment/high social capital scores (4.58 hours/week). MVPA was significantly ($p < .05$) different across the four groups with two exceptions: the low built environment/high social capital group was not different from the high built environment/high social capital group, and the low built environment/low school social capital group was not different from the high built environment/low social capital group.

Figure 3. MVPA levels for students based on low and high built environment and school social capital scores. The letters on the bars indicate significant group differences; groups with the same letter are significantly ($p < 0.05$) different from each other. For example, the letter "a" indicates that the low built environment/low social capital group is different than the low built environment/high social capital group.



4.5 Discussion

The school built environment and school social capital were both positively associated with students' MVPA levels at school. The relationship between the built environment and MVPA was not moderated by school social capital.

Our observation that students' MVPA at school was associated with the built environment at their school is consistent with previous research which has found a positive association with the number of school facilities and student MVPA.[8-9,30] The findings of our regression analyses suggest that the difference in built environments equate to about 20 minutes per week of MVPA for students attending schools with the lowest number of built environment features (N=1) versus students attending schools with the highest number of built environment features (N=8). Twenty minutes/week represents a modest amount of MVPA for an individual student; however, if this volume of activity is applied to all students attending schools with few built environment features, the volume is quite meaningful.

The results from this study support a growing body of literature that has linked social capital and physical activity of children and youth.[12,14,31] Our study extends this earlier finding as we examined a large and representative group of youth and studied the social capital of schools. The findings of our regression analyses suggest that the average weekly volume of MVPA performed by students attending schools with the highest school social capital score is about 40 minutes/week higher than the weekly volume of MVPA for students attending schools with the lowest school social capital score. Forty minutes/week represents a large amount of MVPA when applied to a large group of students. The findings of our analyses also suggest that school social capital is more strongly associated with MVPA at school than is the built environment. This could possibly be explained by the notion that areas with higher school social capital are

friendlier and are more willing to let all students play in games rather than excluding students based on sex[32] or age.[33] It is also possible that students in high social capital areas have better communication amongst one another and this may increase the awareness of opportunities to be active.[11]

To our knowledge, this is the first study to simultaneously consider the influence of the school built environment and school social capital on MVPA. Our result is consistent with some previous research on leisure time physical activity outside of school, as we found that the association between the built environment and physical activity was not moderated by school social capital.[12] Conversely, the right panel of figure 2 shows that school social capital is related to physical activity in schools with moderate and high built environment scores but not in schools with low built environment scores. This suggests that a high school social capital may not support physical activity in the absence of a decent built environment.

A notable strength of this study was the large and representative sample of Canadian youth. The results of this study may also be generalizable to other northern industrialized countries with similar physical activity levels, school systems, and social demographics. A key limitation of this study is its cross-sectional design. With this design type, we cannot infer temporality of the observed association. Another important limitation is that the MVPA measure was reported by students and this self-reported measure is only modestly correlated with objective measures.[34] This likely lead to a non-differential misclassification and associations that were biased towards the null.[35]

Conclusions

In summary, the findings of this study suggest that the association between the school built environment and MVPA is not moderated by school social capital. This study also suggests

that school social capital has a stronger influence on school time MVPA than does the school built environment. These results could help inform school-based interventions aimed at increasing student physical activity levels.

4.6 References

1. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet.* 2012;380(9838):247-257.

2. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act.* 2010;7:40.

3. Biddle SJ, Asare M. Physical activity and mental health in children and adolescents: a review of reviews. *Brit J Sport Med.* 2011;45(11):886-895.

4. Davis CL, Tomporowski PD, Boyle CA, Waller JL, Miller PH, Naglieri JA, et al. Effects of aerobic exercise on overweight children's cognitive functioning: a randomized controlled trial. *Res Q Exerc Sport.* 2007;78(5):510-519.

5. Fuller D, Sabiston C, Karp I, Barnett T, O'Loughlin J. School sports opportunities influence physical activity in secondary school and beyond. *J Sch Health.* 2011;81(8):449-454.

6. 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 9-12 in Ontario, Canada. *Int J Public Health.* 2012;57(4):699-709.

7. Hobin EP, Leatherdale ST, Manske S, Dubin JA, Elliott S, Veugelers P. A multilevel examination of gender differences in the association between features of the school environment and physical activity among a sample of grades 9 to 12 students in Ontario, Canada. *BMC Public Health.* 2012;12.

8. Fein AJ, Plotnikoff RC, Wild TC, Spence JC. Perceived environment and physical activity in youth. *Int J Behav Med.* 2004;11(3):135-142.

9. Nichol ME, Pickett W, Janssen I. Associations Between School Recreational Environments and Physical Activity. *J School Health.* 2009;79(6):247-254.

10. Putnam RD. *Bowling alone : the collapse and revival of American community*. New York: Simon & Schuster; 2000.

11. Cradock AL, Kawachi I, Colditz GA, Gortmaker SL, Buka SL. Neighborhood social cohesion and youth participation in physical activity in Chicago. *Soc Sci Med.* 2009;68(3):427-435.

12. Prins RG, Mohnen SM, van Lenthe FJ, Brug J, Oenema A. Are neighbourhood social capital and availability of sports facilities related to sports participation among Dutch adolescents? *Int J Behav Nutr Phys Act.* 2012;9:90.

13. Ueshima K, Fujiwara T, Takao S, Suzuki E, Iwase T, Doi H, et al. Does Social Capital Promote Physical Activity? A Population-Based Study in Japan. *Plos One.* 2010;5(8).

14. Franzini L, Elliott MN, Cuccaro P, Schuster M, Gilliland MJ, Grunbaum JA, et al. Influences of physical and social neighborhood environments on children's physical activity and obesity. *Am J Public Health.* 2009;99(2):271-278.

15. Health Behaviour in School-Aged Children: A World Health Organization Cross-National Study. University of Edinburgh1998.

16. Prochaska JJ, Sallis JF, Long B. A physical activity screening measure for use with adolescents in primary care. *Arch Pediat Adol Med.* 2001;155(5):554-559.

17. Booth ML, Okely AD, Chey T, Bauman A. The reliability and validity of the physical activity questions in the WHO health behaviour in school children (HBSC) survey: a population study. *Brit J Sport Med.* 2001;35(4):263-267.

18. Libbey, H. Measuring Student Relationships to School: Attach ment, Bonding, Connected ness, and Engagement . *J School Health.* 2004;74(7):274-283.

19. Kennedy BP, Kawachi I, Prothrow-Stith D, Lochner K, Gupta V. Social capital, income inequality, and firearm violent crime. *Soc Sci Med.* 1998;47(1):7-17.

20. Freeman JG, Samdal O, Klinger DA, Dur W, Griebler R, Currie D, et al. The relationship of schools to emotional health and bullying. *Int J Public Health.* 2009;54 Suppl 2:251-259.

21. Inchley J, Todd J, Currie D, Levin K, Smith R. and Currie C. *HBSC Briefing Paper 13.* Edinburgh: The University of Edinburgh; 2007.

22. Trites S. Development of an adolescent social capital scale. Ottawa ON: University of Ottawa:20.

23. Currie C, Molcho M, Boyce W, Holstein B, Torsheim T, Richter M. Researching health inequalities in adolescents: the development of the Health Behaviour in School-Aged Children (HBSC) family affluence scale. *Soc Sci Med.* 2008;66(6):1429-1436.

24. Boyce W, Torsheim T, Currie C, Zambon A. The family affluence scale as a measure of national wealth: Validation of an adolescent self-report measure. *Soc Indic Res.* 2006;78(3):473-487.

25. Plotnikoff RC, Bercovitz M, Loucaides CA. Physical activity, smoking, and obesity among Canadian school youth - Comparison between urban and rural schools. *Canadian Journal of Public Health-Revue Canadienne De Sante Publique.* 2004;95(6):413-418.

26. McNeely CA, Nonnemaker JM, Blum RW. Promoting school connectedness: Evidence from the national longitudinal study of adolescent health. *J School Health.* 2002;72(4):138-146.

27. *SPSS student version 20.0 for Windows 95, Windows 98 or Windows NT 4.0* [computer program]. Upper Saddle River, N.J.: Prentice Hall,; 2012.

28. Aiken LS, West SG, Reno RR. *Multiple regression : testing and interpreting interactions*. Newbury Park, Calif.: Sage Publications; 1991.

29. Rothman KJ. *Modern epidemiology*. 1st ed. Boston: Little, Brown; 1986.

30. Haug E, Torsheim T, Sallis JF, Samdal O. The characteristics of the outdoor school environment associated with physical activity. *Health Educ Res.* 2010;25(2):248-256.

31. Cradock AL, Kawachi I, Colditz GA, Gortmaker SL, Buka SL. Neighborhood social cohesion and youth participation in physical activity in Chicago. *Soc Sci Med.* 2009;68(3):427-435.

32. Wrigley J. *Education and gender equality*. London ; Washington, D.C.: Falmer Press; 1992.

33. Ridgers ND, Stratton G, Fairclough SJ, Twisk JWR. Children's physical activity levels during school recess: a quasi-experimental intervention study. *Int J Behav Nutr Phy.* 2007;4.

34. Adamo KB, Prince SA, Tricco AC, Connor-Gorber S, Tremblay M. A comparison of indirect versus direct measures for assessing physical activity in the pediatric population: a systematic review. *Int J Pediatr Obes.* 2009;4(1):2-27.

35. Webb P, Bain C. *Essential epidemiology : an introduction for students and health professionals*. 2nd ed. Cambridge, UK ; New York: Cambridge University Press; 2011.

Chapter 5

General Discussion

5.1 Summary of Key Findings

The purpose of this thesis was to determine if the school built environment physical activity relationship was moderated by the school social environment within grades 6-10 Canadian youth. In the first manuscript, it was observed that students' MVPA at school was positively associated with the built environment at their school and, surprisingly, negatively associated with the PPP at the school. Furthermore, school PPP moderated the association between the built environment and physical activity such that the association was the strongest in schools with the fewest PPP. These findings suggest that the built environment and PPP must be looked at collectively in order to determine the best way to increase students' school time physical activity.

Results from the second manuscript showed that students' MVPA at school was associated with the built environment and social capital of their school. However, social capital did not moderate the relationship between the built environment and students' MVPA. Moreover, social capital was more strongly associated with students' MVPA than was the built environment.

5.2 Limitations

Both manuscripts were subject to some common limitations. A key limitation is that both manuscripts used a cross-sectional study design. Thus, the temporal nature of the observed relationships is unknown. However, a temporal relationship is not the only criterion that determines whether a relationship is causal. Epidemiologist Sir Austin Bradford Hill

recommended that several criteria be used to determine if a relationship is causal.[1] Some of these other criteria include consistency, specificity, plausibility, and evidence of a dose response-relationship. This thesis adds consistency to the literature as the results of this study on the association between the built environment at school and students' physical activity are similar to other studies performed in different locations, with different students, and with different study designs. This study also adds specificity as this study found a positive association between the built environment and physical activity in a very specific group of adolescents (11-15 years-olds) in the school environment while controlling for confounding variables. The findings are also plausible as it makes sense that if a school has more facilities for physical activity students are more likely to be physically active. Finally, a dose-response relationship was observed as the higher the built environment score, the higher the MVPA levels of students.

The analyses were limited to some degree by methodological challenges. In order to be included in the analyses, students and principals had to complete the questions that were used to derive the exposure variables, the physical activity outcomes, and the covariates. Approximately 30% of the original HBSC sample was excluded for not completing these questions. The loss of these participants likely did not influence the generalizability of the findings as the 30% who were excluded were comparable in age, gender, and SES to the 70% who were included. However, this loss of participants may have influenced the statistical power to detect subtle associations. In both manuscripts, a stratified analyses based on 1/3 of the sample was performed. These subgroup analyses may have been underpowered. For example, in the manuscript titled "School social capital does not moderate the association between the built environment at school and physical activity," a positive relationship between built environment and physical activity is seen in the entire sample, but when that analysis was stratified to

participants from schools with low, medium and high social capital scores, the associations remained positive and of a similar order of magnitude, but none of these associations reached statistical significance. This suggests that the stratified analysis was underpowered.

No standard method exists for assessment of school PPP and of school social capital. Therefore, it is unclear what the most accurate and best way is to capture these variables. The lack of standard measurement protocol may bring the validity and reliability of the exposure measures into question. In regards to school PPP, since the administrators complete the survey and because they should have a strong knowledge of the school, the reliability should be acceptable. However, the validity of school PPP questions may have been weaker as the questions are very general and could be interpreted in different ways by different people. This may cause schools to score higher than they should, resulting in an over-estimation of the true result. In regards to the school social capital variable, since school social capital is a measurement of an individuals' perceptions, it can be considered valid, and studies on other parts of the HBSC have shown strong reliability of the social capital measure in this age group.[2]

Finally, the outcome measures and individual-level covariates for the two manuscripts were based on student self-reported survey data. Evidence suggests that physical activity is over-reported due to its social desirability.[3] If misreporting of these behaviours was non-differential, the relationships observed would have been underestimates, suggesting that the built environment may exert a greater impact on health behaviours than what was found in this research.

5.3 Strengths of the Thesis

To my knowledge, manuscript one is the first study to explore the interactive effects of the built environment and school PPP on school time physical activity, and manuscript two is the

first study to explore the interactive effects of the built environment and school social capital on school time physical activity. Thus, the results from this thesis provide novel findings.

The large and diverse sample size of youth that were studied makes the results of the thesis generalizable to Canadian students in grades 6-10. The large sample size allowed detection of reasonably small effects.

The use of multi-level modeling in the statistical analyses was an additional strength of this study, as it has a number of advantages. The HBSC survey uses a clustered sampling frame to select participants and students within schools who are more similar compared to students attending different schools. Unlike traditional regression approaches, this multi-level modeling approach does not ignore the assumption of independence for clustered samples.[4] Multi-level modeling also allowed for the simultaneous consideration of individual- and area-level exposures and covariates.

5.4 Future Research Directions

Future research is required to build upon the findings of this thesis. Temporality of the relationships between the school built environment, the school social environment, and students' physical activity should be explored using a prospective cohort. Other studies are also needed to discover if other aspects of the social environment moderate the relationship between the built environment and physical activity.

For all studies pertaining to the built environment, more standardized research methods would be beneficial as some studies use student-level scores and others use administrator-level scores to create a built environment score.[5,6] The same problem is relevant with the moderator variables as no consistent method has been developed to test school PPP and school social capital. In order to develop a consistent measure for these variables, expert researchers in each

specific field would need to join together, review the literature, and collectively decide the most valid and reliable way to measure these variables. However, this would be very difficult as researchers may not agree on the best methods.

Finally, this thesis showed that school social capital had a stronger effect than the built environment on physical activity. However, this was not a direct comparison of this thesis and warrants future research. A direct comparison of the two would be beneficial as it would provide school officials with information on what would be the most effective way to increase school time physical activity.

5.5 Public Health and Education Policy Implications

The 2013 Active Healthy Kids Canada Report Card on Physical Activity for Children and Youth graded School Infrastructure and Equipment a B+. This means that 61%–80% of schools provide students with regular access to facilities and equipment that support physical activity (e.g., gymnasiums, outdoor playgrounds, sporting fields, multipurpose-rooms).[7] The grade of B+ is relatively high in comparison to other grades on the report card.

While the School Infrastructure and Equipment grade is quite good, Canada scored a C in physical education and physical activity participation at school, and therefore there is a disconnect between the built environment and participation grades. These different grades show that even if the built environment is accessible, students may not be using it. This thesis looked at this gap by trying to identify if a particular social environment was needed to increase students' MVPA in different built environments. Although the relationships observed in this thesis between features of the built environment, social environment, and physical activity are modest, potential implications are important given the vast number of children and adolescents who attend school and the amount of time students spend in the school environment.

The results from the first manuscript revealed that the built environment was moderated by school PPP. Based on these results, the best place to increase school built environment features would be in a school with low PPP. This information could help school board officials and school administrators as this research gives guidelines regarding where PPP intervention would be most successful in impacting students' MVPA in regards to the built environment.

The results from the second manuscript revealed that the built environment was not moderated by school social capital. However, this study showed that school social capital may be more important in increasing student physical activity as compared to the school built environment. Based on this finding, interventions should focus on ways to increase social capital as compared to enhancing the built environment. This knowledge is critical for school boards and school administrators as built environment interventions might be very costly. Unfortunately, school social capital interventions may be complicated to implement as some authors argue that social capital is based on history and cannot be enhanced in the short term[8], however, other theorists disagree. For example, the school system is a prime place to develop a child's knowledge about social capital. Educators can build social capital by creating lessons about events that involve social capital.[9] If children are taught these types of lessons, it may inspire them to make changes in their own school. Another way to build social capital is by using a stepwise process.[9] First, awareness of the essential role both students and teachers play in creating a supportive and fun environment must be created. Second is the creation of opportunities for students and teachers to become engaged in the school environment. Finally, students and teachers need to be trained on how to make the most of these opportunities so they feel they are being successful.[9] A practical example of a program like this is "peer helpers". "Peer helpers" is a program that includes training where students help other students with

guidance given by more experienced peers or teachers. Programs like this may help improve school social capital. Increasing social capital might be a cheaper option and it might also help improve other aspects of the school environment.

5.6 Conclusion

In conclusion, this study provided insight into how the social environment affects the relationship between the built environment and physical activity at school. School PPP significantly moderated the association between the school built environment and physical activity, but school social capital did not. In order to fully understand this relationship, more research is needed. By understanding the conditions that moderate the built environment physical activity relationship, we can create a foundation to base new school policy to effectively improve the health behaviours of Canadian youth

5.7 References

1. Hill AB. The Environment and Disease: Association or Causation? *Proc R Soc Med.* May 1965;58:295-300.

2. Vereecken CA, Maes L. A Belgian study on the reliability and relative validity of the Health Behaviour in School-Aged Children food-frequency questionnaire. *Public Health Nutr.* Sep 2003;6(6):581-588.

3. Klesges LM, Baranowski T, Beech B, et al. Social desirability bias in self-reported dietary, physical activity and weight concerns measures in 8- to 10-year-old African-American girls: results from the Girls Health Enrichment Multisite Studies (GEMS). *Prev Med.* May 2004;38 Suppl:S78-87.

4. Hox JJ. *Applied multilevel analysis*. 2nd ed. Amsterdam: TT-Publikaties; 1995.

5. Fein AJ, Plotnikoff RC, Wild TC, Spence JC. Perceived environment and physical activity in youth. *Int J Behav Med.* 2004;11(3):135-142.

6. Nichol ME, Pickett W, Janssen I. Associations Between School Recreational Environments and Physical Activity. *J School Health.* Jun 2009;79(6):247-254.

7. Canada AHK. Are We Driving Our Kids to Unhealthy Habits? The 2013 Active Healthy Kids Canada Report Card on Physical Activity for Children and Youth. Toronto Active Healthy Kids Canada.; 2013.

8. Ville S. Social capital formation in Australian rural communities: The role of the stock and station agent. *J Interdiscipl Hist.* Fal 2005;36(2):185-208.

9. Lappe FMDB, P.M. . Building Social Capital Without Looking Backward. *National Civic Review.* 1993;86(2).

Appendix A

Ethics Document Approval

February 21, 2009

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GREB Ref # GEDUC-430-09
Title: "Health Behaviour in School-Aged Children (HBSC) Study: 2009 - 2010"

Dear Professor Freeman:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled **"Health Behaviour in School-Aged Children (HBSC) Study: 2009 - 2010"** for ethical compliance with the Tri-Council Guidelines (TCPS) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (article D.1.6) and Senate Terms of Reference (article G), your project has been cleared for one year. At the end of each year, the GREB will ask if your project has been completed and if not, what changes have occurred or will occur in the next year.

You are reminded of your obligation to advise the GREB, with a copy to the E-REB; of any adverse event(s) that occur during this one year period (details available on webpage www.queensu.ca/vpr/greb/addforms.htm#Adverse). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that any adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example you must report changes in study procedures or implementations of new aspects into the study procedures on the Ethics Change Form that can be found at http://www.queensu.ca/vpr/greb/addforms.htm#Change. These changes must be sent to Linda Frid at the Office of Research Services or FRIDL@queensu.ca prior to implementation. Ms. Frid will forward your request for protocol changes to the appropriate GREB reviewers and / or the GREB Chair.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Yours sincerely,

Joan Stevenson

Joan Stevenson, PhD
Professor and Chair
General Research Ethics Board

/SJF

Appendix B

Health Behaviour and School-aged Children (HBSC) Study Design

Background

The Health Behaviour in School-aged Children (HBSC) is a cross-sectional survey that was completed in 43 countries across Europe and North America in its last cycle in 2009/10. [1] The survey began in 1982 when researchers from 3 countries agreed to implement a shared research protocol to survey school children. Currently the HBSC survey is conducted under the World Health Organization. The HBSC collects data every four years on 11, 13 and 15 year-old boys and girls. This age range was chosen as it is a time that can influence health related behaviours. The survey gathers information on a wide range of health behaviours including: body image, bullying, eating behaviours, injuries, physical activity, school environment and other topics.[2] Canada's first survey was conducted in 1989/90 and the most recent cycle was 2009/2010. In Canada, the HBSC student survey is accompanied with an administrator survey that is filled out by the principal or designate. This thesis uses a combination of both the student and administrator survey.

Student Survey

For all surveys a standard international protocol is used that provides a theoretical framework for research topics, student sampling, and data collection to ensure that each countries survey covers similar areas so meaningful comparisons can be made.[2] Each survey consists of three levels of questions which create the survey instrument. Each survey has core questions that each country must have, optional question on specific topic areas which countries can chose from and country-specific questions related to issues of national importance.[2] Once the survey is created a cluster sampling design is used to select participants. As per international protocol, the Canadian sample uses a cluster sampling design from provinces and the territories (Prince Edward Island and New Brunswick chose not to participate in the 2009/10 survey). The

total Canadian sample included 26,078 students, with an overall response rate of approximately 75%. Canadian surveys systematically sampled from a list of grade 6 through 10 classes that were grouped according to the regional geography, urban-rural geography, school board type (e.g., public or separate), and language of instruction. This list excluded youth in private or special need schools as well as street and incarcerated youth. The survey is a classroom based survey and is designed to take about 45 minutes to complete. Permission was obtained from participating school boards, individual schools, parents/guardians (active or passive consent, depending on jurisdictional requirements and preferences), and students. The study was approved by the Queen's University General Research Ethics Board and the Health Canada research ethics board.

Administrator Survey

This survey is Canadian specific. It was eight pages long and collected basic information on the school and its student population, and other areas that were deemed important including: physical activity, school facilities, healthy eating, the school (social) climate, and neighbourhood factors. The administrator survey was done in 411 of the 436 schools (90% response rate) and is linked to the student level survey.

References

1. CHILDREN HBIS-A. Health Behaviour in School-aged Children: A World Health Organization Collaborative Cross-national Study. http://www.hbsc.org/index.html. Accessed July 2013.

2. Currie C, Nic Gabhainn S, Godeau E. The Health Behaviour in School-aged Children: WHO Collaborative Cross-National (HBSC) study: origins, concept, history and development 1982-2008. *Int J Public Health.* Sep 2009;54 Suppl 2:131-139.

Appendix C

Health Behaviour in School-aged Children (HBSC)

Relevant Student Questionnaire Items 2010/2011

Are you male or female?

1☐ Male

2☐ Female

What month were you born?

1☐	2☐	3☐	4☐	5☐	6☐	7☐	8☐	9☐	10☐	11☐	12☐
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec

What year were you born?

1☐	2☐	3☐	4☐	5☐	6☐	7☐	8☐
1991	1992	1993	1994	1995	1996	1997	1998

What grade are you in?

1☐	2☐	3☐	4☐
Grade 8	Grade 9	Grade 10	Grade 11

Do you have your own bedroom for yourself?

1☐ No 2☐ Yes

Does your family own a car, van or truck?

1☐ No 2☐ Yes, one 3☐ Yes, two or more

During the past 12 months, how many times did you travel away on holiday (vacation) with your family?

1☐ Not at all

2☐ Once

3☐ Twice

4☐ More than twice

How many computers does your family own?

1☐ None

2☐ One

3☐ Two

4☐ More than two

Both manuscripts - Questions used for outcome variable

Physical activity is any activity that increases your heart rate and makes you get out of breath some of the time. Physical activity can be done in sports, school activities, playing with friends, or walking to school.

Some examples of physical activity are running, brisk walking, inline skating, biking, dancing, skateboarding, swimming, soccer, basketball, and football.

For these next two questions, add up all the time you spend in physical activity each day.

About how many hours a week do you usually take part in physical activity that makes you out of breath or warmer than usual in your <u>class time</u> at school?

1☐	2☐	3☐	4☐	5☐	6☐	7☐	8☐	9☐
none at all	about ½ hour	about 1 hour	about 2 hours	about 3 hours	about 4 hours	about 5 hours	about 6 hours	about 7 or more hours

About how many hours a week do you usually take part in physical activity that makes you out of breath or warmer than usual in your <u>free time</u> (for example, lunch) at school?

1☐	2☐	3☐	4☐	5☐	6☐	7☐	8☐	9☐
none at all	about ½ hour	about 1 hour	about 2 hours	about 3 hours	about 4 hours	about 5 hours	about 6 hours	about 7 or more hours

Manuscript 2 – Questions used for social capital variable

How do you feel about school at present?

1☐ I like it a lot.
2☐ I like it a bit.
3☐ I don't like it very much.
4☐ I don't like it at all.

Please show how much you agree or disagree with each statement. *(Please mark one box for each line)*

		Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
	I feel a lot of trust in my teachers.	1☐	2☐	3☐	4☐	5☐
	Our school is a nice place to be.	1☐	2☐	3☐	4☐	5☐
	I feel I belong at this school.	1☐	2☐	3☐	4☐	5☐
	Our teachers treat us fairly.	1☐	2☐	3☐	4☐	5☐

Appendix D

Health Behaviour in School-aged Children (HBSC)

Relevant Administrator Questionnaire Items 2010/2011

Both manuscripts - Questions used for covariate information

What is the total number of students in your school? (Please estimate) _____ students

Both manuscripts - Questions used for school built environment (exposure) variable

Do the majority of students at your school have regular access to any of the following during school hours? (During school hours means from the first bell to the last bell, including both instructional and non-instructional time, e.g., lunch).

	Yes, on grounds only	*Yes, off grounds only*	*Yes, both on and off grounds*	*No*	*Don't know*
Gymnasium	1☐	2☐	3☐	4☐	5☐
Other large room suitable for physical activity (e.g., auditorium, cafeteria, dance studio)	☐	☐	☐	☐	☐
Fitness room for aerobic and/or strength training	☐	☐	☐	☐	☐
Running track	☐	☐	☐	☐	☐
Outdoor field	☐	☐	☐	☐	☐
Outdoor paved area (e.g., tennis courts, basketball courts)	☐	☐	☐	☐	☐
Skating rink/arena	☐	☐	☐	☐	☐
Indoor swimming pool	☐	☐	☐	☐	☐

Manuscript 1 - Questions used for School Policy and Program variable

Does your school have a committee that oversees policies and practices concerning physical activity and healthy eating at your school (e.g., health action team)

1☐ **Yes**, both physical activity and healthy eating

2☐ **Yes**, physical activity only

3☐ **Yes,** healthy eating only

4☐ No

Does your school's improvement plan for the current school year contain any items related to physical activity and healthy eating?

1☐ **Yes**, both physical activity and healthy eating

2☐ **Yes**, physical activity only

3☐ **Yes,** healthy eating only

4☐ No

Does your school offer late bus/transportation service to students who participate in extra-curricular activities?

Yes [1] ☐ No [2] ☐

To the best of your knowledge, how well do each of the following statements characterize your school?

We promote physical activity during or as part of special events.	☐	☐	☐	☐	☐
We integrate physical activity into other curriculum areas.	☐	☐	☐	☐	☐

From the following list, please indicate which sports are offered in your varsity or intramural athletics programs:

	Varsity/ Interschool	*Intramural*		*Varsity/ Interschool*	*Intramural*
Basketball	☐	☐	Gymnastics	☐	☐
Volleyball	☐	☐	Wrestling	☐	☐
Soccer	☐	☐	Track & Field	☐	☐
Football	☐	☐	Badminton	☐	☐
Baseball/softball	☐	☐	Swimming	☐	☐
Rugby	☐	☐	Skiing	☐	☐
Ice Hockey	☐	☐	Ultimate Frisbee	☐	☐
Lacrosse	☐	☐	Other	☐	☐