Lessons Learned from Tobacco Control:
A Multilevel Analysis of School Characteristics and Adolescent Physical Activity

by

Suzy-Lai Wong Ishibashi

A thesis
presented to the University of Waterloo
in fulfilment of the
thesis requirement for the degree of

Doctor of Philosophy
in
Health Studies and Gerontology

Waterloo, Ontario, Canada, 2007

Author’s Declaration for Electronic Submission of a Thesis

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

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

Abstract

Background: The high prevalence of physical inactivity among children and adolescents (*youth*) and the associated negative health consequences make it critical to increase physical activity levels. Social-ecological models suggest that the school environment may influence youth health behaviour. However, few studies have examined the school environment in relation to youth physical activity. **Purpose:** To 1) examine between-school variability in student physical activity, 2) identify school characteristics that account for between-school variability in student physical activity, and 3) examine the association between senior student participation rates in school physical activities and junior student physical activity. **Methods:** The study consisted of secondary data analysis of the School Health Action, Planning and Evaluation System (SHAPES) Ontario project, which collected self-report data from 69,511 students in 76 secondary schools from seven public health unit districts in Ontario. Multilevel modeling was used to examine between-school variability in student physical activity, as well as school characteristics associated with physical activity. **Results:** There was significant between-school variability in student physical activity, and the relationship between physical activity and age and gender, respectively. School rates of physical education participation were associated with student physical activity levels. Senior student participation in other physical activities at school, such as playing outside, was associated with junior student physical activity levels.
Conclusions: These findings support the social-ecological notion that the school environment can influence adolescent physical activity behaviour. A better understanding of the relationship between the school environment and physical activity will assist in the development of effective school-based policies, programs and interventions to increase physical activity.

Acknowledgements

I would like to thank my supervisor, Dr. Roy Cameron, and committee members, Drs. Steve Manske, Scott Leatherdale and Steve Brown for their assistance in the completion of this thesis, as well as Dr. Guy Faulkner for his insightful review. Data used in this study were drawn from the School Health Action, Planning and Evaluation System (SHAPES) Ontario project, which was funded by the Ontario Ministry of Health and Long-Term Care/Ministry of Health Promotion and Cancer Care Ontario, with in-kind contributions from participating public health units. I would like to acknowledge the SHAPES-ON team for their contributions to the project, as well as the school boards, schools and students for their participation, without which this study would not be possible. Financial support for my doctoral studies was received through a Canadian Institutes of Health Research Canada Graduate Scholarship Doctoral Award, University of Waterloo President's Scholarship and Ontario Graduate Scholarship.

However, my research has consisted of more than this thesis and my time at the University of Waterloo has consisted of more than my research. Thus, on a more personal note, I would like to thank:

- Roy for giving me enough rope to learn and work independently, and enough guidance to not hang myself with it
- Steve for allowing me to truly work as part of a research team. The experience was invaluable and extremely positive. I had no idea it was possible to have so much fun at meetings – and the sticky buns didn't hurt either.
- Scott. As a colleague, mentor and friend, you have supported me in countless ways over the years. I can't thank you enough – but the coffees I owe you might be a good place to start.
- Everyone I've known at PHR for their friendship, support and assistance. You've truly been amazing people to know and work with. Doing my PhD would not have been the great experience it was without you.
- My friends for their continued support. In particular, thanks to Carolyn, for always being there for me. And to Josephine, Kelly, Leanne and Margo for celebrating with me on the good days, seeing me through on the darkest days, and making sure I wasn't stuck at a desk for the ones in between – be it for lunch or an ice capp, or gasping for air on the road, on a bike or in a pool.
- My family for being everything family should be. In particular, thanks to my Mom and Dad who serve as my role models and inspiration. My PhD is a small testament to the opportunities they have given me through their hard work and sacrifices, and it pales by comparison to their accomplishments.
- My husband, Brent, for his patience and the kind of understanding it takes to tell me to just hand this in now rather than continue to struggle to find the right words to thank him, and for the sense of humour to appreciate that I actually did.

Best wishes to all of you in the future.

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

BMI	body mass index
CCHS	Canadian Community Health Survey
CDC	Centers for Disease Control and Prevention
CFLRI	Canadian Fitness & Lifestyle Research Institute
HLM	hierarchical linear modeling
ICC	intraclass correlation
KKD	kilocalories per kilogram per day
MET	metabolic equivalent
MLM	multilevel modeling
MPA	moderate intensity physical activity
MVPA	moderate-to-vigorous physical activity
PE	physical education
PHE	Physical and Health Education
PRECEDE-PROCEED	Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation - Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development
SES	socio-economic status
SHAPES	School Health Action, Planning and Evaluation System
SHAPES-ON	School Health Action, Planning and Evaluation System Ontario Project
VPA	vigorous physical activity

1.0 INTRODUCTION

Non-communicable diseases are a major, global public health issue. In 2001, non-communicable diseases accounted for almost 60% of the 56 million deaths annually and 47% of the global burden of disease [1]. Physical inactivity, unhealthy diets and tobacco use are the leading causes of the major non-communicable diseases, including cardiovascular disease, type 2 diabetes and cancer, and contribute substantially to the global burden of disease, death and disability [1].

The effects of diet and physical activity on health often interact, such as in the case of obesity. However, there are additional health benefits to be gained from physical activity that are independent of diet. According to the World Health Report 2002, physical inactivity is estimated to cause, globally, about 10-16% of cases each of breast cancer, colon and rectal cancers and type 2 diabetes, and about 22% of cardiovascular disease [2]. Overall, 1.9 million deaths are attributable to physical inactivity [2].

Physical activity is of particular importance to children and adolescents (youth), who require regular physical activity for healthy growth and development [3, 4]. In addition, being physically inactive during childhood and adolescence can contribute to the development of chronic ailments, such as type 2 diabetes, heart attack and stroke susceptibility, and joint problems, at an uncharacteristic early age. Further, health habits that are developed during childhood and adolescence tend to carry-over into adulthood[5].

According to the 2004 Canadian Community Health Survey (CCHS), 51% of Canadian youth aged 12-19 were not physically active and as many as 79% may not have been active enough for optimal growth and development [6]. Moreover, older youth were more likely to be inactive than younger youth (48% of youth aged 12-14 were inactive vs. 54% of youth aged 15-19) and girls were more likely to be inactive than boys (59% vs. 44%) [6]. Effective policies, programs and interventions are required to reduce the prevalence of physical inactivity. A better understanding of the influences on youth physical activity behaviour is required to inform the development of effective interventions.

Social-ecological models provide a framework for understanding physical activity behaviour. A social-ecological perspective of behaviour focuses on the interactions between people and their physical and social environments[7]. The school environment may be particularly important to the health behaviour of Canadian youth since the vast majority of them spend a substantial amount of their waking day at school[8]. The field of tobacco control has already amassed empirical evidence to support the notion that the school environment can influence student smoking behaviour[9-13]. However, the extent to which the school environment influences student physical activity behaviour is largely unknown[14].

Few studies have examined whether schools have an effect on physical activity behaviour[15-18]. Even fewer have examined which characteristics of the school environment may be responsible for such an effect[16, 17]. A better understanding of the relationship between the school environment and physical activity will assist in the design and implementation of effective school-based physical activity interventions.

2.0 LITERATURE REVIEW

2.1 Theoretical Frameworks

2.1.1 Social-ecological Models

A social-ecological approach can provide a framework for studying school environmental influences on youth health behaviour. Unlike traditional theories of health behaviour, a social-ecological approach refers to models, frameworks or perspectives, rather than to specific constructs or variables. Although numerous social-ecological models have been proposed and many different typologies have been used (e.g. Bronfenbrenner[7], Moos[19], Stokols[20]), they all share common features[21]. Each consists of intra-individual (person) and extra-individual (environment) influences that are interdependent, interact and can exert direct effects on each other. The environment consists of both the social and physical environment, and typically multiple levels of environmental influences are posited. Because social-ecological models are very broad, other models and theories can be integrated to provide specific constructs and variables[21].

2.1.2 A Social-ecological Model for Levels of Influence

McLeroy et al.[22] proposed a social-ecological model of health behaviour that identified multiple levels of influence. The model was designed to guide researchers and practitioners to systematically assess and intervene on each of those levels of influence. Indeed, it was the model cited in Active2010, the Province of Ontario's strategy to increase participation in sport and physical activity that was released in 2005[23].

The five levels of influence in the model are intrapersonal factors, interpersonal processes and primary groups, institutional factors, community factors and public policy[22] (see Appendix A). *Intrapersonal factors* are characteristics of the individual, such as knowledge, attitudes, beliefs and skills. *Interpersonal processes and primary groups* are formal and informal social network and social support systems, such as family, friends, peers and work groups. *Institutional factors* are characteristics of organizations such as formal and informal rules, and regulations and policies for operation. Examples of organizations include day care settings, primary and secondary schools, universities and work settings. *Community factors* are social networks and norms or standards, which exist formally or informally among individuals, groups and organizations. *Public policy* includes local, provincial and federal policies and laws. Factors at each level may constrain or promote physical activity.

2.1.3 The PRECEDE-PROCEED Planning Model

Although social-ecological models provide a framework for understanding the multilevel nature of influences on behaviour, the models do not specify how they can be applied to develop intervention strategies. However, the development of effective interventions is required to increase physical activity levels. A planning model, such as PRECEDE-PROCEED (*P*redisposing, *R*einforcing, and *E*nabling *C*onstructs in *E*ducational *D*iagnosis and *E*valuation) - (*P*olicy, *R*egulatory, and *O*rganizational *C*onstructs in *E*ducational and *E*nvironmental *D*evelopment)[24], can provide a structure for applying theories so that the most appropriate intervention strategies can be identified and implemented.

Within this model, the concept of predisposing, reinforcing and enabling factors are prominent. These domains are used to organize theoretical constructs and variables that have the ability to cause the behaviours to occur or to inhibit their occurrence. *Predisposing factors* are factors that exert their effects prior to a behaviour occurring, by increasing or decreasing a person or population's motivation to undertake that particular behaviour (e.g. individuals' knowledge, attitudes, beliefs, personal preferences, skills and self-efficacy beliefs). *Reinforcing factors* are factors following a behaviour that provide continuing reward or incentive for the persistence or repetition of the behaviour (e.g. social support, peer influence, significant others and vicarious reinforcement). *Enabling factors* are factors that make it possible (or easier) for individuals or populations to change their behavior or their environment (e.g. programs, services and resources necessary for behavioural outcomes to be realized, new skills to be acquired)[24].

2.1.4 Social Cognitive Theory

Social Cognitive Theory is often integrated with social-ecological models to provide specific constructs and variables to explain the mechanisms by which one factor influences another. Within Social Cognitive Theory, behaviour is explained in terms of a triadic, dynamic and reciprocal model in which behaviour, personal factors (including cognitions), and environmental influences all interact[25]. Social Cognitive Theory includes many intrapersonal factors, such as self-efficacy, expectations, expectancies and self-control, as well as interpersonal factors, such as observational learning. The interpersonal constructs are more relevant to the current study compared to intrapersonal factors, since they may aid in understanding the mechanism by which the school environment influences adolescent physical activity behaviour.

One interpersonal construct is observational learning, or vicarious experience, whereby learning occurs when a person watches the actions of another person and the reinforcements that the person receives[25]. By observing another person's actions and the ensuing consequences, the observer forms rules of behaviour which serve as a guide for their own action in future situations. The direction and strength of the impact depends on the observer's ability to execute the behaviour, the observer's perceptions of the modeled action as producing rewards or punishments, and the inference that similar or unlike consequences would result if the observer were to perform the modeled behaviour[25].

2.1.5 Summary of Theoretical Frameworks

Social-ecological models suggest that institutional-level factors, such as the school environment, can influence behaviour. Combining the PRECEDE-PROCEED planning model with Social Cognitive Theory may provide insight into the mechanisms by which the school environment could predispose, enable and reinforce student physical activity behaviour. Within the school environment, social modeling may predispose students to performing physical activity by influencing their attitudes, beliefs and expectations. Reinforcing factors may include vicarious reinforcement, as well as social support from peers, teachers and coaches. Enabling factors within the school environment may include indoor and outdoor facilities, as well as school programs and policies that provide access to facilities and opportunities for structured and unstructured physical activities. In addition, physical education (PE) may provide skills that enable students to participate in sports and other physical activities.

2.2 Multilevel Modeling

2.2.1 Overview

Multilevel modeling (MLM), also known as hierarchical linear modeling (HLM), is a statistical technique that has long been utilized in the field of education, but only more recently has been applied to public health and health promotion. Studying students from multiple schools results in a clustered design, with students from each school forming a group or cluster (see Figure 1).

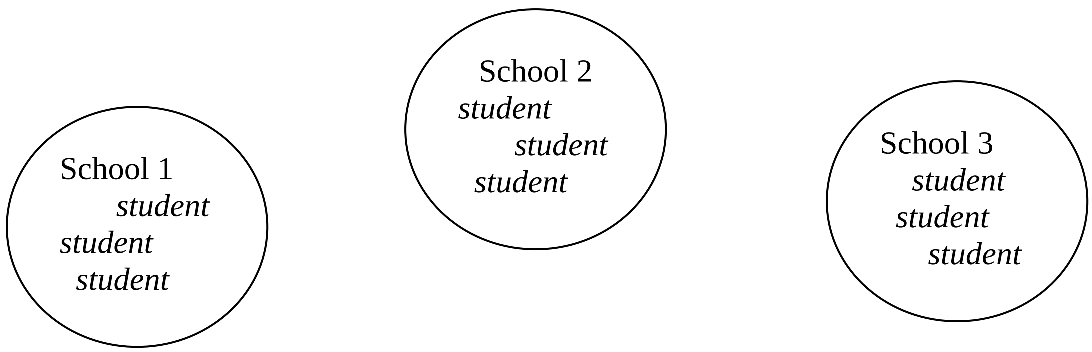


Figure 1. Diagram of students from multiple schools forming clusters

Alternatively, this can be viewed as a nested, multilevel structure, with students at one level being nested within schools at a second level (see Figure 2).

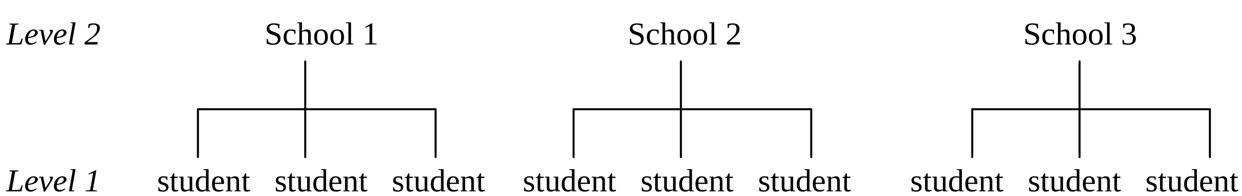


Figure 2. Diagram of students from multiple schools forming a nested, multilevel structure

Standard regression techniques assume that all observations are independent. However, a clustered design violates this assumption since observations within one cluster may be more similar to each other than observations within a different cluster. Violating the assumption of independence may result in making incorrect inferences. However, MLM does not rely on an assumption of independent observations and thus, is appropriate for use with clustered data[26].

2.2.2 Between-School Variation

MLM, as its name suggests, is also useful for studying multiple levels of influence or effects. Thus, MLM is particularly useful when using a social-ecological approach, which posits multiple levels of influence. In the study of the physical activity behaviour of students within multiple schools, behaviour may be influenced by factors at the student level (individual factors, such as age, gender, knowledge and beliefs) and at the school level (institutional factors, such as school policies and programs). MLM is able to estimate the amount of variance in the outcome of interest at the student level, as well as at the school level[26]. For example, a significant amount of variation at the student level would indicate that physical activity differs from student to student and that there are factors at the individual level that are associated with student physical activity. Similarly, a significant amount of variation at the school level would indicate that the average physical activity of students differs from school to school and that there are factors at the school level that are associated with student physical activity. A lack of between-school variation would indicate that student physical activity does not cluster within schools and that standard regression techniques would be appropriate for further statistical analyses. However, significant between-school variation would indicate that MLM would be the appropriate statistical technique for further analyses.

2.2.3 Intraclass Correlation

Estimates of the variance at the individual and school levels can be used to calculate the intraclass correlation (ICC), which is the proportion of the total variance that is between schools [26]. The ICC can have important implications for group-randomized trials in which classrooms, schools or school boards are assigned to treatment conditions while observations are made on individual students[27]. In group-randomized trials, the treatment effect must be assessed against the between-group variance. The factor $(1 + (n – 1)\ \rho)$ defines the extra variation that results from the ICC between members of the same group, where n = group size and ρ = ICC. This factor has been called the design effect by Kish[28] and the variance inflation factor by Donner et al[29]. The inflation factor is 1 when $\rho = 0$, but when $\rho \neq 0$, the inflation factor increases both with increasing ICC and with increasing group size. Thus, even for small ρ, the inflation factor is large when n is large. Consequently, this extra variation can substantially reduce power in group-randomized trials.

Although statistical strategies have been suggested to address the issue of between-group variance in group-randomized trials, none of the strategies are completely effective. Thus, it is recommended that between-group variance be taken into account during the planning stages by planning a study that is large enough to allow for the extra variation inherent in the group-randomized trial[27]. To do so, good estimates of ρ for the outcomes of interest are needed, which, together with the number of observations per unit, determine the magnitude of the extra variation in nested designs[27].

2.2.4 Individual and School-Level Predictors

In addition to calculating the proportion of variance at the individual and school levels, respectively, MLM can also be used to determine which variables are significant predictors of student physical activity[26]. Individual-level predictors are characteristics of individual students that may account for some, or all, of the variance between students. Similarly, school-level predictors are characteristics of schools that may account for some, or all, of the variance between schools. MLM can also be used to examine the interactions between individual- and school-level variables.

2.2.5 Controlling for Student Composition

One of the challenges in trying to identify school-level predictors of student health behaviour is controlling for student composition[30]. If the health behaviour is influenced by one or more individual-level variables, then differences in this health behaviour between schools may be due to the fact that some schools have a greater proportion of students with these individual-level characteristics rather than due to something that is different between schools. By allowing individual- and school-level variables to be simultaneously considered in a statistical model, MLM can examine school-level predictors while controlling for student composition[26]. Two individual-level variables have been consistently associated with physical activity levels: age[15, 31] and sex (*gender*)[15]. This suggests that student composition should be controlled for in terms of both age and gender when examining school-level predictors of student physical activity.

2.3 Tobacco Control Research

The dramatic reduction in tobacco consumption over the past 40 years is a major public health achievement. In 1965, when the Government of Canada began regular monitoring of tobacco use, more than 50% of Canadian adults smoked tobacco[32]. Recently, it was estimated that less than 21% of the Canadian population smokes. Other countries, including the United States, Australia, New Zealand, Singapore and some northern European countries, have achieved similar reductions[32].

It has been suggested that insights from the field of tobacco control may increase the effectiveness, and rate of progress, in addressing other behavioural risk factors, such as physical inactivity[32-34]. It is acknowledged that there are some significant differences between smoking and physical activity[32]. The most obvious is that tobacco use is a behaviour that public health aims to prevent, whereas physical activity is a behaviour that is encouraged. Further, prior to tobacco control efforts, tobacco was a widely promoted, easily purchasable product. It was a normative behaviour that could be carried out at any time of the day, several times a day, in almost any location. By contrast, physical activity does not revolve around a particular product, the conditions under which physical activity is performed are more varied and limited in the degree to which they can be regulated or taxed, and performing physical activity can be inconvenient; requiring time, showering and changes in clothing. Further, physical activity requires physical exertion and may be accompanied by physical discomfort during and after physical activity, particularly for those who are not regularly physically active. Despite these differences, if parallels and points of generalizability can be identified, then physical activity promotion may be able to benefit from the experiences of tobacco control[32].

It is generally agreed that comprehensive interventions ranging from individual-based, downstream approaches to institution-based, midstream approaches to population-based, upstream strategies were required for the significant reductions in tobacco consumption[35]. Indeed, a review of progress in population health promotion concluded that the field of tobacco control has had the greatest combined effectiveness and reach of downstream, midstream and upstream interventions compared to five other lifestyle health behaviours; alcohol abuse, drug abuse, unhealthy diet, physical inactivity and risky sexual practices[36]. Of these, physical inactivity and unhealthy diet were ranked last, and were considered particularly lacking in midstream and upstream approaches.

Social-ecological models are well suited to providing a framework for understanding the interactions between the individual and the individual's social and physical environment, which is required for informing midstream and upstream interventions. One area in which tobacco control has amassed empirical evidence to support the use of social-ecological models is the influence of schools on student smoking behaviour[9-13]. A recent review concluded that smoking prevalence varied significantly between schools[9], which suggested that there may be school-level factors that influence student smoking.

Indeed, school characteristics that were associated with student smoking behaviour have been identified[10-13]. The enforcement of school smoking bans[37-39], perceptions of enforcement[40] and staff smoking policies[41] have been associated with student smoking behaviour.

Further, school-level social modeling characteristics appeared to be related to experimental and regular smoking behaviour[10-13, 18, 38, 42-44]. Smoking onset was more likely to occur in elementary schools[10, 13] and secondary schools [11, 12] with higher smoking rates among senior students. For example, low-risk students (i.e. students who do not have smoking friends or family members) were more than twice as likely to try smoking if they attended a high-risk elementary school (i.e. a school with a relatively high prevalence of senior students who smoke) than if they attended a low-risk school[42].

School characteristics have also been shown to moderate the effectiveness of school-based smoking interventions. Cameron et al. examined the effect of provider (nurse or teacher) and training method (workshop or self preparation) on outcomes of a social influences smoking prevention program[13]. All four treatment conditions produced smoking rates that were less than the control group rate, but when examined together, differences between intervention and control schools were not significant. However, there was a significant interaction between condition and senior student smoking rate. In low- and medium-risk schools (i.e. schools with a low or medium prevalence of senior students who smoke), no significant differences were found between treatment and control schools. However, in high-risk schools, students in the treatment conditions smoked significantly less than students in the control schools; students in the control schools were approximately 1.5 times as likely to be smokers[13].

2.4 Between-School Variation in Physical Activity

Although evidence from tobacco control research supports the social-ecological hypothesis that the school environment can influence smoking behaviour, few studies have examined the notion that schools can also influence physical activity behaviour.

2.4.1 Review of Studies

Three studies have examined between-school variability in the physical activity behaviour of students[17, 18, 45]. Between-school variation in each study was significant, with ICCs ranging from 0.021 to 0.290. The study with the lowest ICC was conducted in the United States and involved 12 schools and 436 female students in grade 8 (mean age 14.1 yr)[45]. Physical activity was measured by accelerometers that participants wore for seven days. The study with the next lowest ICC (0.040) was conducted in Belgium and involved 29 schools and 3225 students in Year 2 (mean age 13.6 yr) and Year 5 (mean age 16.9 yr)[18]. Physical activity was defined as the number of hours of vigorous exercise per week (exercise causing breathlessness or sweating) and was measured using a validated self-report questionnaire. The study with the highest ICC (0.290) was conducted in New Brunswick and involved 6883 students in grade 6 from 147 schools[17]. Physical activity was derived from four self-report questionnaire items that asked about the number of days of participation in sports, walking or biking for at least 20 minutes at a time, doing stretching exercises and doing strengthening exercises in the last week[17].

A fourth study examined the between-school variation in student physical fitness (defined as 1-mile run/walk performance) rather than physical activity[16]. The sample consisted of 2372 students in grades 3 and 4 from 54 schools in the United States. There was significant between-school variation in children's fitness; the ICC was 0.224. It was also observed that the relationship between age and physical fitness varied significantly between schools[16]. In other words, in some schools, age was more strongly related to physical fitness compared to other schools. However, the relationship between gender and physical fitness did not vary significantly between schools[16].

2.4.2 Discussion

Overall, results from the four studies indicated that there was significant between-school variation in physical activity/fitness[16-18, 45]. However, the range of ICCs was relatively large (0.021-0.290), which indicated that the proportion of variation in student physical activity/fitness that was accounted for at the school-level was quite variable. Due to the limited number of studies, it remains unclear if the observed differences in ICCs were due to differences in methodology (questionnaire vs. accelerometer, physical activity vs. physical fitness), sample population (age, female only vs. male and female combined, single grade vs. multiple grades), sample size (e.g. number of schools, number of students), school level (elementary vs. secondary vs. elementary and secondary combined) or country (Canada vs. USA vs. Belgium).

One study observed that the relationship between age and physical fitness varied significantly between schools, but that the relationship between gender and physical fitness did not[16]. Since the study was conducted in younger children (grades 3 and 4), it is not known if this significant between-school variability exists at the secondary school level. Moreover, the study examined physical fitness rather than physical activity, so it is not known if similar between-school variability exists in the relationship between age and physical activity. However, since physical fitness is moderately correlated with physical activity[46], these findings raise the possibility that schools may be able to attenuate the decline in physical activity that is associated with increasing age.

2.5 School-Level Predictors of Student Physical Activity

2.5.1 Review of Studies

Of the four studies that used multilevel modeling to examine between-school variability, only two examined school characteristics that may have accounted for the variation[16, 17]. The school characteristics that were considered in one study included school size, school mean socio-economic status (SES), disciplinary climate, academic expectation of teachers and parental academic involvement[17]. Student-level characteristics that were controlled for included gender, SES, native status, number of parents, number of siblings, mathematics/science achievement, reading/writing achievement and self-esteem. School size was the only school-level variable associated with physical activity; students in large schools reported doing significantly less physical activity than did students in small schools[17]. School size accounted for 8% of the variance in physical activity at the school level[17].

The other study examined 10 school-level variables that were more specific to physical activity/fitness[16]. These included the percentage of classes taught by PE specialists, minutes in PE per week, minutes in recess per day, percentage of PE class spent in vigorous physical activity (VPA), minutes of PE class spent in administrative matters, minutes of activity in average PE class, usually take PE on school grounds, warm climate, fitness tests administered, and percentage of students typically recognized for test participation. Controlling for student age and gender, the only school-level variable that was a significant predictor of children's fitness was the percentage of classes taught by a PE specialist[16].

2.5.2 Discussion

Few studies have examined the association between school characteristics and student physical activity levels. Indeed, only one study has done so to date. This study was conducted in elementary schools with a large sample of both schools and students[17]. Although one school characteristic (school size) was significantly associated with student physical activity levels, the study failed to control for the age of the students and did not examine school characteristics that were specific to physical activity. A similar study found one school characteristic, the percentage of classes taught by PE specialists, was significantly associated with physical fitness[16]. However, it is unknown if this school characteristic is also significantly associated with physical activity.

2.6 Summary

Evidence from tobacco control supports the use of social-ecological models for understanding health behaviour. For example, research has shown that institutional factors, such as schools, are associated with the smoking behaviour of students. Social-ecological models are well-suited to informing the midstream and upstream interventions that have been necessary to substantially reduce the prevalence of smoking at a population level.

Physical activity research lags behind tobacco control research in terms of examining social-ecological influences on health behaviour, as well as the development and implementation of midstream and upstream interventions. Few studies have examined between-school variation in physical activity[17, 18, 45]. Of these, only one has examined school characteristics and physical activity[17]. Nonetheless, these studies are in agreement that significant between-school variation in physical activity exists, which subsequently suggests that there are school characteristics associated with physical activity. However, the scarcity of research in this area precludes drawing conclusions about what these school characteristics are.

Further research is required to characterize the between-school variability in the physical activity of students. In addition, further research is required to identify school characteristics that are associated with this variability in student physical activity. A better understanding of the relationship between the school environment and student physical activity behaviour will assist in the development of effective school-based policies, programs and interventions to increase physical activity.

3.0 PURPOSE AND RESEARCH QUESTIONS

3.1 Purpose

The purpose of this study was to examine between-school variability in the physical activity of students in grades 9-12, identify school characteristics that account for between-school variability in student physical activity, and examine the association between senior student participation rates in school physical activities and junior student physical activity.

3.2 Research Questions

1. Is there between-school variability in student physical activity?

2. Is there an association between student physical activity and age? If so, does the relationship between physical activity and age vary across schools?

3. Is there an association between student physical activity and gender? If so, does the relationship between physical activity and gender vary across schools?

4. Do school characteristics (e.g., participation rate in physical education, intramural activities, interscholastic sports) account for a significant amount of the between-school variability in student physical activity, controlling for student composition (age, gender) and school demographic characteristics (e.g. size, urban/rural)?

5. Is there an association between senior student participation in school-related physical activities and junior student physical activity levels?

3.3 Potential Implications

In addition to improving our understanding of the association between school characteristics and adolescent physical activity, this study:

1. Will provide empirical evidence to support or refute the use of a social-ecological approach for physical activity behaviour
2. May identify school characteristics that could contribute to the development of effective school-based policies, programs and interventions to increase physical activity
3. May assist in determining the sample size required for future group-randomized school-based physical activity studies
4. May identify school characteristics which could potentially moderate the effectiveness of school-based interventions
5. Will increase awareness of the use, and usefulness, of multilevel analyses in the field of physical activity research
6. Will provide direction for future research examining the school environment and physical activity

4.0 METHODS

4.1 The School Health Action, Planning and Evaluation System

The School Health Action, Planning and Evaluation System (SHAPES) is a modular local data collection and feedback system designed for schools. SHAPES was designed to 1) engage local public health and education systems in the development, planning, and evaluation of interventions and policies related to health behaviours within schools, 2) enable high quality research to be conducted in real world settings, 3) minimize burden on school personnel and students, and 4) maximize value to schools and stakeholders[47]. Each SHAPES module consists of three components: 1) a low cost, machine-readable questionnaire designed to collect data about a health behaviour from all grade 6-12 students in a school, 2) a school administrator questionnaire designed to collect data about school programs and policies related to the behaviour, and 3) feedback reports with school-specific results from the student and administrator questionnaires, respectively. There are currently four SHAPES modules: Tobacco, Physical Activity, Healthy Eating and Mental Fitness. The author's contributions to the SHAPES program of research are described in Appendix B.

4.2 The SHAPES Ontario Project

The School Health Action, Planning and Evaluation System Ontario Project (SHAPES-ON) used SHAPES to collect data from Ontario secondary schools. The project was funded by the Ontario Ministry of Health and Long-Term Care / Ministry of Health Promotion and by Cancer Care Ontario, with in-kind contributions from participating public health units. The co-principal investigators were Dr. Steve Manske (University of Waterloo) and Dr. Scott Leatherdale (Cancer Care Ontario), and the co-investigators were Ms. Suzy Wong, Dr. Steve

Brown, Dr. Roy Cameron and Dr. Mary Thompson (all University of Waterloo), as well as Ms. Cora Craig (Canadian Fitness & Lifestyle Research Institute [CFLRI]). The Population Health Research Group at the University of Waterloo conducted the project. The author's contributions to SHAPES-ON are described in Appendix B.

Funding for SHAPES-ON was granted as part of the Ontario Ministry of Health and Long-Term Care / Ministry of Health Promotion's Smoke-Free Ontario Strategy, a provincial government strategy to reduce tobacco consumption. The primary purpose of SHAPES-ON was to collect data on tobacco-related behaviours, programs and policies. However, the design was modified to enable the collection of physical activity data in order to increase potential value to stakeholders, including school boards and schools. The University of Waterloo collaborated with CFLRI to use their School Capacity Survey as the administrator level physical activity questionnaire for SHAPES-ON. Since CFLRI was planning to collect data using the School Capacity Survey at the same time as data collection for SHAPES-ON, this collaboration enabled researchers to reduce the response burden on schools and school boards.

The current report describes a cross-sectional study based on the secondary data analysis of data collected using the student questionnaires of the SHAPES Physical Activity Module and Tobacco Module as part of SHAPES-ON. Although the School Capacity Survey has been used previously[48], the reliability and validity of the questionnaire has not been established. Further, preliminary examination of the first 12 questionnaires returned suggested that some questions of interest may have had inadequate validity or a lack of variability. Thus, the current study does not include data collected using the School Capacity Survey.

4.3 Recruitment and Consent

4.3.1 Public Health Unit Recruitment

Public health involvement in the Smoke-Free Ontario Campaign is led by seven public health units who coordinate activities within their respective Tobacco Control Area Network. The Ontario Ministry of Health and Long-Term Care / Ministry of Health Promotion selected these seven public health units for SHAPES-ON. One additional public health unit was added due to their involvement in previous projects and their innovativeness in tobacco control. All agreed to participate, though with different levels of involvement.

4.3.2 School Board Recruitment

All public and separate school boards within the selected public health unit jurisdictions were sampled for the project. French language boards were not included unless a public health unit specially requested it and was able to fully support the survey implementation (including materials translation, co-ordination with schools, data collection, etc.). A total of 22 school boards were approached to participate, of which 19 (86%) agreed. School boards (N=18) from seven of the eight public health units approved active information with passive consent procedures, whereas the school board (N=1) from one public health unit required active consent procedures. Due to the differences in consent procedures and their subsequent impact on participation rates and data collection[49], schools using active consent procedures were considered a separate sub-project and were not included in this study.

4.3.3 School and Student Recruitment

In public health jurisdictions with less than 15 secondary schools, all were approached for participation. In areas with larger numbers of schools, either a random sample was chosen or the health unit selected a convenience sample (i.e., a sample that would be meaningful to them, for example, schools where programming had been implemented or grants given). Some health units requested additional schools and provided additional support to enable this expansion. A total of 118 schools from the 19 school boards approving passive consent were approached to participate, of which 76 (64%) agreed (see Table 1). Data were not available for schools that declined to participate, so it is unclear if or how schools that agreed to participate differed from schools that declined to participate. All participating secondary schools consisted of students in grades 9-12. All students in participating secondary schools were eligible to participate.

Table 1. School recruitment rates by public health region

	Schools in Region (n)	Approached (n)	Agreed (n)	Response Rate (%)
Region 1	28	15	10	67%
Region 2	14	13	8	62%
Region 3	27	22	7	32%
Region 4	56	19	19	100%
Region 5	26	28	26	93%
Region 6	22	9	1	11%
Region 7	15	12	5	42%
Total	188	118	76	64%

4.4 Data Collection, Processing and Management

School board and school recruitment began in February 2005. Data collection was conducted in partnership with public health staff over two waves; Wave 1 (April to May 2005 [6 schools]) and Wave 2 (September 2005 to May 2006 [70 schools]). All surveys were completed in class time and participants were not provided compensation.

The informed consent procedure involved active information with passive consent. This approach was used to reduce demands on schools and to increase student participation rates. The process involved researchers informing the parents of the students about the study via mailed letter (see Appendix C), and asking them to call a toll-free number (accessible 24 hours a day) if they refused their child's participation. Students could decline participation at any time. The final decision to participate was made by individual students during data collection. The University of Waterloo Office of Research Ethics and appropriate school board and public health ethics committees approved all procedures, including passive consent.

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

4.5 Student Response Rate

A total of 63,362 students were approached to participate and 51,739 students (81.7%) completed questionnaires. Of these, 26,596 (51.4%) were Tobacco Module questionnaires and 25,143 (48.6%) were Physical Activity Module questionnaires. Non-response at the student level can be attributed to several factors: parents/guardians refusal to allow their child to take part in the survey, student refusal to participate, absenteeism on the day of the survey, not enrolled in a class that was administering the survey (e.g. spare/study period, co-operative education work placement, peer tutoring), or enrolled in a class that elected not to complete the survey (e.g. field trip, special needs, other activities scheduled, etc.).

Complete data regarding the number of students on spare, co-op and absent at the day and time of data collection were provided by 62 of the 76 participating schools (82%). Of the eligible students in these 62 schools, 2,963 (4.7%) were in a class designated as a spare at the time of data collection, 1,488 (2.3%) were on co-operative education work placements and 6,526 (10.3%) were absent. Of the 76 schools, parent/guardian refusal accounted for 1,031 students not completing questionnaires (1.6% of all eligible students). Of the remaining 298 (0.5%) eligible students that did not complete a questionnaire, it is unknown how many refused participation at the time of data collection, or were on spare, co-op or absent in one of the 14 schools that did not provide this information. The distribution of students completing questionnaires, parent/student refusal, and student non-response was consistent with previous SHAPES data collections[11].

4.6 Measures

4.6.1 SHAPES Physical Activity Module – Student Questionnaire

The Physical Activity Module student questionnaire consisted of 45 multiple choice questions presented in a four-page machine-readable booklet (see Appendix E). Two items requested 7-day recall of vigorous physical activity (VPA) and moderate physical activity (MPA), respectively. Additional items asked about participation in physical activities, sedentary activities, social influences, school environment, self-perceptions, height, weight, smoking behaviour and demographics. In addition, the questionnaire included smoking behaviour and school connectedness items, which were identical to those on the SHAPES Tobacco Module questionnaire.

The questionnaire has demonstrated satisfactory readability, comprehension, reliability and validity[50, 51]. Pilot testing with students in grades 6 and 7 indicated adequate readability and comprehension of the questionnaire[50]. Further, the questionnaire demonstrated satisfactory one-week test-retest reliability with students in grades 9-12[51]. The overall kappa/weighted kappa coefficient for the one-week test-retest reliability of the questionnaire items indicated moderate agreement (mean 0.57 ± 0.24). The questionnaire also demonstrated satisfactory criterion validity of the core physical activity, height and weight items with students in grades 6-12[51]. Students wore an accelerometer for seven consecutive days to objectively measure physical activity, and then completed the questionnaire and had their height and weight measured. Prior to data collection, students were informed that their height and weight would be measured after completing the questionnaire. Self-reported and accelerometer-measured average daily time spent performing moderate-to-vigorous physical activity (MVPA) were significantly correlated (Spearman $r = 0.44$, $p < 0.01$), however students tended to over-report physical activity. Height and weight were not consistently over- or under-reported. Self-reported and measured body mass index (BMI) were significantly correlated (Spearman $r = 0.90$, $p < 0.001$). Classification of weight status by body mass index was similar using self-reported values compared to measured values.

4.6.2 SHAPES Tobacco Module – Student Questionnaire

The SHAPES Tobacco Module student questionnaire consisted of 49 multiple choice questions presented in a four-page machine-readable booklet (see Appendix F). Items asked about demographics, smoking behaviours, attitudes, and the social and physical environment. In addition, the questionnaire included the core physical activity, height and weight items, as well as an item about the physical activity of their five closest friends that were identical to those on the SHAPES Physical Activity Module student questionnaire. An earlier version of the questionnaire, which did not include the physical activity, height and weight items, demonstrated satisfactory test-retest reliability and validity of self-reported non-smoking status as determined by carbon monoxide testing[52].

4.6.3 E-STAT

E-STAT is a Statistics Canada web-based interactive teaching and learning tool that students, faculty and staff of the University of Waterloo are registered to use and can access through the University of Waterloo library website. By entering the postal code of the school, the average income (based on the 2001 Canadian Population Census) for the census tracts containing all or a portion of the area represented by the postal code was retrieved and displayed in a table. This function was available only for postal codes located within 46 large urban centres in Canada. Thus, average income was only available for 59 (78%) of the 76 schools in the study.

4.7 Response and Explanatory Variables

4.7.1 Response Variable

The response variable, physical activity, was defined as student weekly time spent performing MVPA. To calculate physical activity, each student's responses to the questions "Mark how many minutes of hard physical activity you did on each of the last 7 days" (see Appendix E, question 20; Appendix F, question 48) and "Mark how many minutes of moderate physical activity you did on each of the last 7 days" (see Appendix E , question 22; Appendix F, question 49) were summed.

4.7.2 School Characteristic Variables

School characteristic variables were derived from student responses to the Physical Activity Module student questionnaire items, which were aggregated to the school level.

Three school-level variables related to participation rates for extracurricular physical activities. The school intramural participation rate was derived from the item “Do you participate in intramurals/house league sports at school?” (yes/no [see Appendix E, question 24]). The intramural participation rate was calculated by dividing the number of students who responded “yes” by the number of students who responded to the item. Similarly, the school interscholastic sports participation rate and the participation rate for other physical activities at school were derived from the items “Do you participate in school team/varsity sports?” (yes/no [see Appendix E, question 25]) and “Do you participate in other physical activities at school (e.g. play in gym, play outside)?” (yes/no [see Appendix E, question 26]), respectively.

One school-level variable related to participation rates for curricular physical activity. The item “In a typical Physical Education class, how much time are you actually active?” was used to derive the rate of students not taking physical education by dividing the number of students who responded “I am not taking a physical education class” by the total number of students who responded to the item (see Appendix E, question 30). The other response options were “Less than 15 minutes”, “15 to 30 minutes”, “31 to 45 minutes”, “46 to 60 minutes”, and “More than 1 hour”.

Two school-level variables related to commuting to school. The item “In the last 7 days, how did you usually get to and from school?” was used to derive two commuting to school variables (see Appendix E, question 8). The active commuting rate was derived by dividing the number of students who responded “Actively (e.g. walk, bike, skateboard)” was divided by the total number of students who responded to the item. The inactive commuting rate was derived by dividing the number of students who responded “Inactively (e.g. car, bus, public transit)” by the total number of students who responded to the item. The other response option was “Mixed (actively and inactively)”.

Three school-level explanatory variables related to physical activity facilities. Students were asked “How strongly do you agree or disagree with each of the following statements? d) the indoor facilities at this school meet my needs; e) the outdoor facilities at this school meet my needs; and f) the facilities at this school accommodate physical activity even when the weather is extreme (e.g. raining or snowing)” (see Appendix E, question 34). Response options were “Strongly agree”, “Agree”, “Disagree”, and “Strongly disagree”. The adequacy of indoor and outdoor facilities, and the adequacy of the facilities to accommodate extreme weather, was derived by dividing the number of students who responded “Strongly agree” and “Agree” by the total number of students who responded to the items, respectively.

Students with missing data for an item were excluded from the calculation of the corresponding school characteristic variable. All school characteristic variables were ratio variables that ranged from 0-1.

4.7.3 Senior Student Participation Rate Variables

Six senior student participation rate variables were examined: senior student rate of participation in intramurals, interscholastic sports, other physical activities at school, active commuting and inactive commuting, as well as the senior student rate of non-participation in PE. These variables were derived in the same manner as the corresponding school characteristic variable, except that the aggregate variables were derived from the responses of students in grades 11 and 12 only, rather than all respondents in the school.

Students with missing data for an item were excluded from the calculation of the corresponding senior student participation rate variable. All senior student participation rate variables were ratio variables that ranged from 0-1.

4.7.4 School Demographic Variables

School demographic variables were based on information collected from the schools during recruitment. These variables included school size (the number of students enrolled in each school [coded per 100 students]), school board (coded public=0, separate=1) and school setting (coded urban=0, rural=1). The classification of school setting was derived from the postal codes of the schools. The second character of a postal code indicated a rural postal code if it was a 0, whereas an urban postal code was indicated by the numerals 1 to 9.[53] The average income (coded in $1000) of the census tract in which the school was located was used as a proxy measure of school SES. In the cases where more than one census tract contained a portion of the area represented by the postal code of the school, the mean of the average income values retrieved was used.

4.7.5 Student-Level Explanatory Variables

Student-level explanatory variables included self-reported age, grade and gender (sex). Age was derived from the item “How old are you?” (11 years or younger/12 years/13 years/14 years/15 years/16 years/17 years/18 years or older). Students reporting “11 years or younger” were coded as 11 years old, and students reporting “18 years or older” were coded as 18 years old. Grade was derived from the item “What grade are you in?” (response options listed each grade from 5-12). Gender was derived from the item “Are you male or female?” (male/female; coded male=0, female=1).

Additional student-level explanatory variables were not included in the multilevel analyses since accounting for student-level variability was not the focus of this study. In addition, little was known about which school-level variables were associated with physical activity, much less the mechanisms by which these school-level variables may be associated with physical activity. Including too many student-level variables in the model may result in controlling for a student-level variable that was the mechanism by which a school-level variable influences physical activity[9].

4.7.6 SHAPES Module

The physical activity response items have been tested for reliability and validity as part of the Physical Activity Module, but not as part of the Tobacco Module. To examine whether completing the Physical Activity Module or Tobacco Module influenced the results, a variable to indicate which module the students completed was created (SHAPES Tobacco Module = 1, SHAPES Physical Activity Module = 2). This variable was used to examine whether there were mode effects (i.e. differences due to the module used to collect the data).

4.7.7 Derived Variables

Additional variables were derived to enable description of the sample population by weight status and physical activity level. Age and gender adjusted BMI cut-points derived from the U.S. Centers for Disease Control and Prevention (CDC) growth charts were used to classify weight status[54, 55]. Students were classified as underweight (BMI for gender by age below the 5th percentile), normal weight (BMI for gender by age between the 6th-84th percentile), at risk of overweight (BMI for gender by age above the 85th percentile) and overweight (BMI for gender by age above the 95th percentile)[54]. BMI was derived from self-reported height and weight (see Appendix E, questions 12 and 13; Appendix F, questions 45 and 46).

Estimated energy expenditure (kcal/kg/day [KKD]) was used to classify students as inactive (<3KKD), moderately active (3-7.9KKD) and active (≥8KKD)[56]. The average KKD expended in VPA and MPA were calculated as:

KKD=[(Hours of VPA*6MET)+(Hours of MPA*3MET)]/7 days

This calculation was based on the assumption that the standard metabolic equivalent (MET, a unit used to estimate the amount of oxygen used by the body during physical activy) for VPA was six and MPA was three[57]. Time spent performing VPA and MPA was based on self-reported time spent performing VPA and MPA in the last week (see Appendix E, questions 20 and 22; Appendix F, questions 48 and 49).

4.8 Statistical Analyses

4.8.1 Descriptive Statistics

As an indication of potential response bias, the response rate by school mean physical activity was examined. Descriptive statistics were calculated for the students and the schools included in the study. In addition, the range of school mean physical activity levels was calculated. T-tests were used to examine differences between groups and generalized linear models were used to examine relationships with age and gender.

4.8.2 Research Question 1

Multilevel linear regression was used to address each of the research questions. A fully unconditional model was used to determine the between-school variability in physical activity (Research Question 1). A fully unconditional model does not contain any student-level or school-level explanatory variables (see Appendix G). Fully unconditional models were examined overall, by module, by gender and by grade. The ICC (see Appendix G) was calculated for each model to determine the proportion of the variance in a single observation that was due to the variation between schools.

4.8.3 Research Questions 2 and 3

A random coefficient model was used to determine if the relationship between physical activity and age differed between schools (Research Question 2). Similarly, a random coefficient model was also used to determine if the relationship between physical activity and gender differed between schools (Research Question 3). Each of these random coefficient models contained one student-level explanatory variable whose coefficients were allowed to vary at random (see Appendix H). The age variable was group mean centred (i.e. school mean age was subtracted from the age of each student in that school) to aid interpretation.

Figures 3 and 4 present graphical representations of potential results from the random coefficient models. Figure 3 presents a graphical representation of relationship between student age and MVPA, where there is 1) significant negative association between age and MVPA, 2) significant between-school variation in the relationship between age and MVPA (i.e. significant variation in the slopes), and 3) no significant correlation between the intercepts and slopes for age. Figure 4 presents a graphical representation between student gender and MVPA, where there is 1) significant negative association between gender and MVPA, 2) significant between-school variation in the relationship between age and MVPA, and 3) significant correlation between the intercepts and slopes for gender (i.e. the higher the intercepts, the lower the slopes).

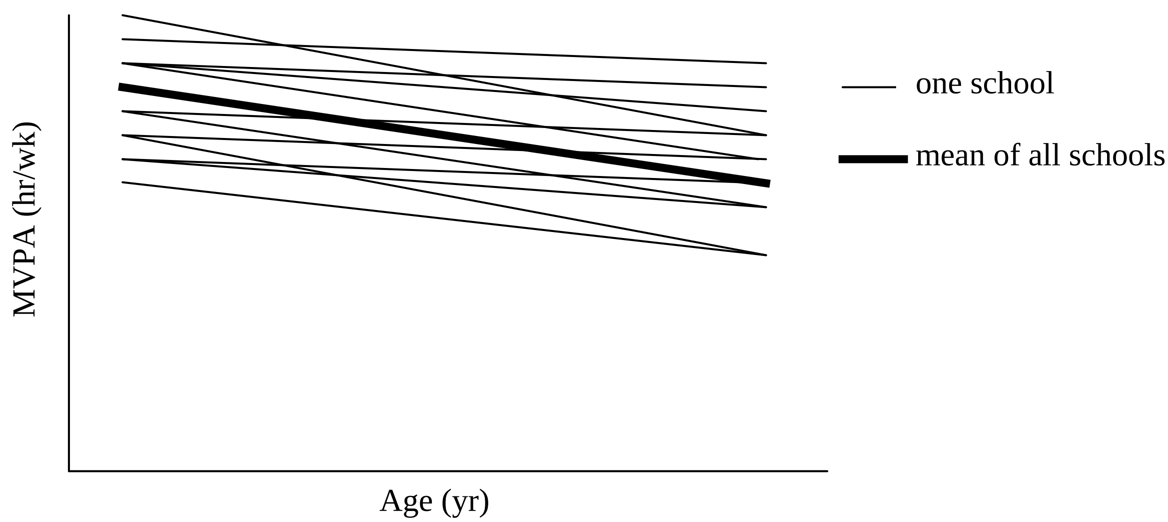


Figure 3. Graphical representation of the relationship between student age and moderate-to-vigorous physical activity (MVPA)

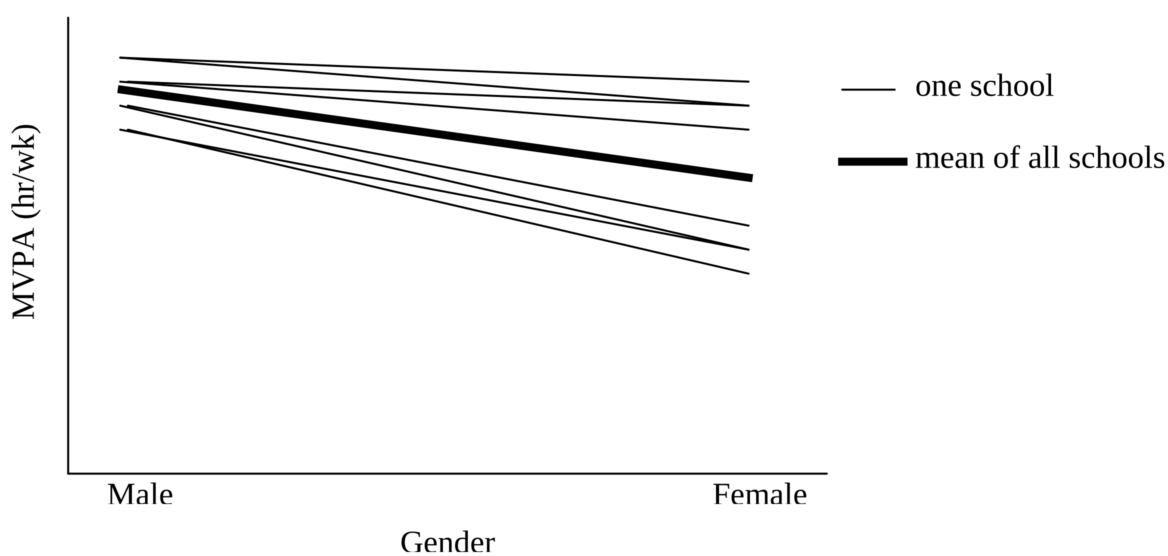


Figure 4. Graphical representation of the relationship between student gender and moderate-to-vigorous physical activity (MVPA)

An additional random coefficient model containing both student-level explanatory variables, age and gender, was used to determine if the relationship between physical activity and age differed between schools when controlled for gender and if the relationship between physical activity and gender differed between schools when controlled for age (Research Questions 2b and 3b; see Appendix H).

4.8.4 Research Question 4

A slopes-and-intercepts-as-outcomes model was used to examine the relationship between physical activity and school characteristics (Research Question 4). A slopes-and-intercepts-as-outcomes model contains both student and school-level explanatory variables (see Appendix I). A five-step process was used to attain the final slopes-and-intercepts-as-outcomes model. First, each school-level variable was entered into a multilevel model containing only that variable. Second, each statistically significant school-level variable was entered into a slopes-and-intercepts-as-outcomes model, with age and gender entered as random and fixed effects. Third, all school-level variables that were statistically significant when controlled for age and gender were entered into a slopes-and-intercepts-as-outcomes model. Fourth, school demographic and SHAPES module variables were entered in the model. Fifth, non-significant variables were removed in a stepwise fashion, starting with the least significant interactions (i.e. interactions with the highest p-values), then the least significant main effects, until only significant variables remained. A significance level of alpha <.05 was considered significant for variables with degrees of freedom based on the number of schools. However, due to the large number of students in the sample, a significance level of alpha <.005 was considered significant for variables with degrees of freedom based on the number of students to reduce the chances of Type I error.

One of the limitations of using school-level variables that consisted of aggregating student-level responses was that data from students were used to predict data that were obtained from the same students. Two models were used to examine whether this methodology may have influenced the results. First, data from participants who completed the Physical Activity Module were aggregated to create the school-level variables. These school-level variables were then used to predict the physical activity levels of participants who completed the Tobacco Module. Thus, the school-level variables were not being used to predict the physical activity levels of the students from which the data were aggregated. Second, data from half of the participants who completed the Physical Activity Module, selected at random using the SAS RAND function, were aggregated to create the school-level variables. These school-level variables were used to predict the physical activity levels of the other half of the participants who completed the Physical Activity Module. Again, this created a model in which the school-level variables were not being used to predict the physical activity levels of the students from which the data were aggregated.

4.8.5 Research Question 5

A slopes-and-intercepts-as-outcomes model was used to examine the relationship between junior student physical activity levels and senior student rate of participation in school-related physical activities (Research Question 5). Junior students were defined as students in grades 9 and 10, and senior students were defined as students in grades 11 and 12. A process identical to that described above was used to determine the final model.

All statistical analyses were performed using SAS (version 9.1.3; SAS Institute Inc., Cary, NC) and the PROC MIXED procedure was used for the multilevel analyses.

5.0 RESULTS

5.1 Descriptive Statistics

5.1.1 School Characteristics

Of the 76 schools, 51 were from public school boards. The remaining 25 schools were from separate school boards. In addition, 66 were located in an urban area and 10 were located in a rural area. The enrollment averaged 922 students (± 358) and ranged from 160 to 1939 students. The mean income of households in the school area was \$33,880 (± \$7495) and ranged from \$21,933 to \$60,235. On average, the school mean MVPA was 17.6 hr/wk (± 1.77) and ranged from 13.5 to 22.0 hr/wk (see Figure 5). There was no significant difference in school mean MVPA, on average, between the Physical Activity Module and the Tobacco Module (p>.10).

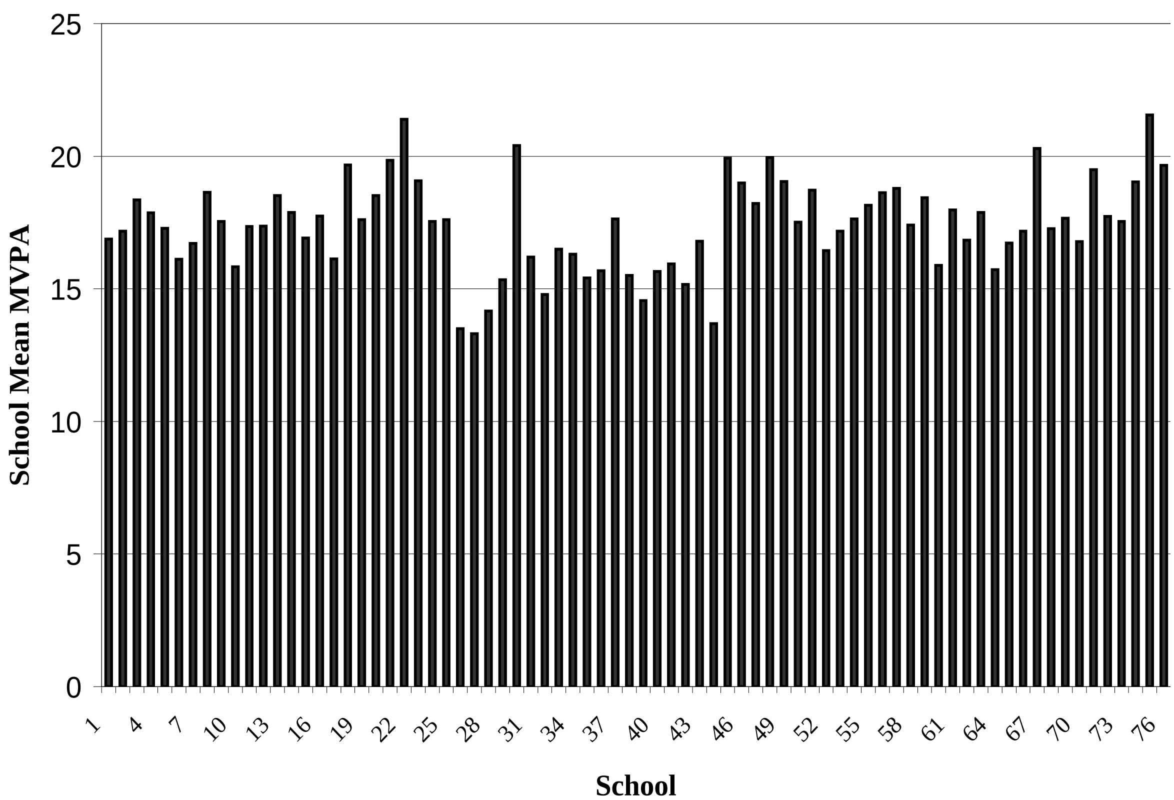


Figure 5. School mean moderate-to-vigorous (MVPA) physical activity for the 76 schools included in the study

Across the 76 participating schools, the mean response rate was 73.6% (± 9.3%) and ranged from 35.6% to 93.0% with a median of 75.4%. The mean student response rate for rural schools was 73% (range 57%-82%), whereas the mean student response rate for urban schools was 75% (range 36%-93%). The mean student response rate for schools with income greater than the mean income of participating schools was 74% (range 35%-88%), whereas mean student response rates for schools with income lower than the mean was 78% (range 68%-93%).

As an indication of potential response bias, the relationship between response rate and school mean physical activity was examined. Results of regression analysis showed that school response rates were significantly negatively associated with school mean physical activity levels ($p<0.05$). The lower the school response rate, the higher the school mean physical activity. There is some preliminary evidence to suggest that physically inactivity is associated with truancy[58]. Thus, response bias may have been due to physically inactive students being less likely to attend school and subsequently less likely to complete the questionnaire. The low response rates in some schools may have resulted in school-level variables that did not accurately reflect the school situation. Although the response rate in some schools was low (e.g. 35.6%), the response rate in most schools was high (mean 73.6%, median 75.4%). Thus, it is unlikely that the schools with low response rates biased the models which examined the relationship between school-level variables and student physical activity.

5.1.2 Student Characteristics

A total of 51,739 questionnaires were completed. Of these, 26,596 (51.4%) were Tobacco Module questionnaires and 25,143 (48.6%) were Physical Activity Module questionnaires. Students were excluded from the analyses if they reported being in grades 5-8 (n=313) or if they reported the maximum value of physical activity per week, 66.5 hr/wk (n=204) (see Appendix J for rationale and details). Thus, 51,222 students were included in the analyses. Of these, 26,268 (51.3%) completed Tobacco Module questionnaires and 24,954 (48.7%) completed Physical Activity Module questionnaires

Overall, 50.9% (N=25,933) reported being male and 49.1% (N=25,005) reported being female (missing data for 284 students; 0.6%). Mean age, grade, BMI and MVPA, by grade and gender, are reported in Tables 2-5. On average, males were older, had a higher BMI and spent more time performing MVPA (all $p<.0001$) compared to females. However, the difference in mean age was small (0.1 years). Time spent performing MVPA tended to decrease with increasing age and grade, respectively, (both $p<.0001$). Time spent performing MVPA by grade and gender is shown in Table 5. Mean age, grade, gender and MVPA were not significantly different between the Physical Activity Module and the Tobacco Module (all $p>.10$). The difference in BMI was significant ($p<.05$), but small (0.0042 kg/m^2).

Table 2. Distribution of the study sample, by grade; N

Grade	Overall	Male	Female
9	14,314	7,252	6,979
10	13,756	6,943	6,736
11	11,845	5,878	5,900
12	11,307	5,860	5,390
All Grades	51,222	25,933	25,005

Table 3. Age (yr) distribution of the study sample, by grade; mean (SD)

Grade	Overall	Male	Female
	N=51,139	N=25,882	N=24,981
9	14.1 (0.5)	14.1 (0.5)	14.1 (0.4)
10	15.1 (0.5)	15.1 (0.5)	15.1 (0.5)
11	16.1 (0.5)	16.1 (0.5)	16.1 (0.5)
12	17.2 (0.6)	17.3 (0.5)	17.2 (0.5)
All Grades	15.5 (1.3)	15.6 (1.3)	15.5 (1.2)*

* significantly different between males and females ($p < .0001$)

Table 4. Body mass index (kg/m^2) distribution of the study sample, by grade; mean (SD)

Grade	Overall	Male	Female
	N=44,562	N=22,450	N=22,112
9	20.9 (3.2)	21.2 (3.3)	20.6 (3.1)
10	21.6 (3.3)	22.1 (3.5)	21.2 (3.0)
11	22.1 (3.3)	22.5 (3.5)	21.6 (3.0)
12	22.6 (3.4)	23.2 (3.5)	21.9 (3.2)
All Grades	21.7 (3.3)	22.2 (3.5)	21.3 (3.1)*

* significantly different between males and females ($p < .0001$)

Table 5. Hours per week spent performing moderate-to-vigorous physical activity, by grade; mean (SD)

Grade	Overall	Male	Female
	N=49,037	N=24,628	N=24,165
9	18.8 (11.9)	20.6 (12.6)	16.9 (10.7)
10	17.7 (11.9)	19.8 (12.6)	15.6 (10.6)
11	16.7 (11.5)	19.0 (12.1)	14.5 (10.3)
12	15.8 (11.4)	18.1 (12.3)	13.4 (9.9)
All Grades	17.3 (11.7)	19.4 (12.5)	15.2 (10.5)*

* significantly different between males and females ($p < .0001$)

Based on classification using CDC growth chart age- and gender-adjusted BMI cut-points, 15.7% of the students were underweight, 68.6 % were normal weight, 10.7% were at risk of overweight and 5.0% were overweight (Note: terminology associated with the CDC cut-points changed when the growth charts were updated in 2000. The category “at risk of overweight” was formerly “overweight”, whereas the category “overweight” was formerly “obese”). By comparison, using data from the 2004 CCHS and international age- and gender-adjusted BMI cut-points[59], it was estimated that 20% of Canadian youth aged 12-19 were overweight and 9% were obese[60]. Estimates of the prevalence of overweight and obesity for the SHAPES-ON sample were lower than the national prevalence of overweight and obesity as estimated by the CCHS. Differences in estimates may be due in part to differences in methodology (self-report vs. directly measured), BMI cut-points, and region (Ontario vs. national).

Based on estimated energy expenditure, 12.1% of the students were physically inactive (<3 KKD), 28.0% were moderately active (3-7.9 KKD) and 59.9% were physically active (≥8 KKD). By comparison, the 2004 CCHS estimated that 28% of Canadian youth aged 12-19 were inactive (<1.5KKD), 23% were moderately active (1.5-2.9KKD), 27% were physically active (>3.0KKD), and 21% were physically active according to higher criteria (>6.0KKD)[6]. Despite the use of higher cut-points in SHAPES-ON, estimates of the prevalence of physical inactivity for the SHAPES-ON sample were substantially lower than the national prevalence of physical inactivity as estimated by the CCHS. Differences in estimates may be due in part to differences in methodology (physical activity for the three months prior to the survey vs. the week prior to the survey) and region (Ontario vs. national).

A total of 2185 students were missing MVPA data. Students with missing MVPA data tended to be male (p<.0001) and significantly older (p<.0001) compared to students who reported MVPA, see Table 6. However, grade and BMI were not significantly different (p>.50).

Table 6. Comparison of participants with and without moderate-to-vigorous physical activity data; mean (SD)

	Participants with MVPA Data	Participants Missing MVPA Data
	(N = 49037)	(N=2185)
Age (yr)	15.5 (1.3)	15.6 (1.3)*
Grade	10.4 (1.1)	10.4 (1.1)
BMI (kg/m^2)	21.7 (3.4)	21.7 (3.4)
Gender	50.5% male	60.8% male*

BMI = body mass index, MVPA = moderate-to-vigorous physical activity
* significantly different between participants with and without MVPA data (p < .0001)

5.2 Research Question 1

A fully unconditional model was used to determine the between-school variability in physical activity. Results of hypothesis tests of a fully unconditional model of the entire sample indicated that both variance components were significantly different from 0 (p<.0001). The ICC indicated that 0.019 of the variance observed occurred between schools. The estimate of the single fixed effect, the intercept, was 17.3 hr/wk, which was the mean school-level MVPA in this sample of schools.

The within school variance component, between school variance component and estimate of the fixed effect of fully unconditional multilevel models, overall, by module, by gender and by grade are shown in Appendix K. The within and between school variance were significant (p<.0001) for each model. The ICCs ranged from 0.017 to 0.032. ICCs based on the Physical

Activity Module only were higher than those based on the Tobacco Module only, which indicated that a greater proportion of the total variance was attributed to being between schools when physical activity was reported using the Physical Activity Module compared to the Tobacco Module.

In summary, there was significant between-school variability in student physical activity, overall, by grade and by gender. ICCs ranged from 0.017 to 0.032

5.3 Research Question 2

A random coefficient model was used to determine if the relationship between physical activity and age differed between schools (see Table 7).

Table 7. Results of a random coefficient model examining the association between physical activity and age, with age as a fixed and random effect

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Variances, Covariance				
Intercept	2.6407	0.4779		<.0001
Slope	0.0810	0.0362		0.0126
Covariance	-0.0301	0.0958		0.7535
Residual	133.90	0.8571		<.0001
Fixed Effects				
Intercept	17.3730	0.1955	75	<.0001
Age	-0.7692	0.0548	>49,000	<.0001

The estimate for the fixed effect, intercept, indicated that the estimated average school mean physical activity level, controlling for student age, was 17.4 hr/wk. The estimate for the fixed effect, age, indicated that the estimated average slope representing the relationship between student age and physical activity was –0.77. On average, there was a statistically significant negative relationship between student age and physical activity levels ($p<.0001$); older students tended to be less physically active compared to younger students.

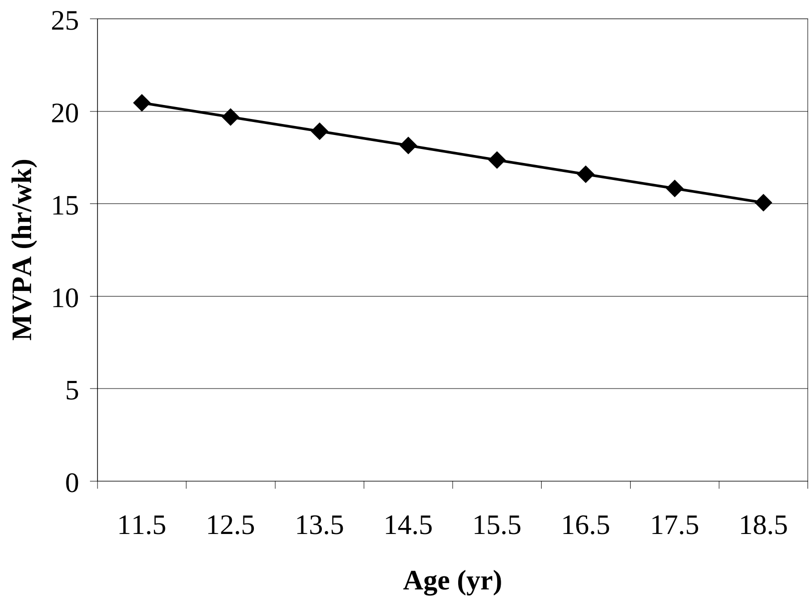


Figure 6. The fitted mean relationship between student age and moderate-to-vigorous physical activity (MVPA) across 76 secondary schools

Results indicated that intercepts were variable ($p<.0001$); schools differed in average physical activity levels. The results also indicated that slopes were variable ($p<.05$). The relationship between student age and physical activity levels differed significantly between schools. However, there was little correlation between intercepts and slopes ($p>.50$). In other words, there was little evidence that the relationship between student age and physical activity depended on the average physical activity of the school.

In summary, there was a significant negative association between physical activity and age. On average, for every one year increase in age, there was a 0.77 hr/wk decrease in physical activity. The strength of the relationship between physical activity and age differed significantly between schools.

5.4 Research Question 3

A random coefficient model was used to determine if the relationship between physical activity and gender differed between schools (see Table 8). The estimate for the fixed effects indicated that the estimated average school mean physical activity level was 19.5 hr/wk for males and 15.2 hr/wk for females. The estimate for the fixed effect, gender, indicated that the estimated average slope representing the relationship between student gender and physical activity was –4.20. On average, there was a statistically significant relationship between student gender and physical activity levels ($p<.0001$).

Table 8. Results of a random coefficient model examining the association between physical activity and gender, with gender as a fixed and random effect

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Variances, Covariance				
Intercept	3.2099	0.6108		<.0001
Slope	0.5365	0.2363		0.0116
Covariance	-0.9020	0.3149		0.0042
Residual	130.56	0.8372		<.0001
Fixed Effects				
Intercept	19.4501	0.2204	75	<.0001
Gender	-4.2029	0.1360	<49,000	<.0001

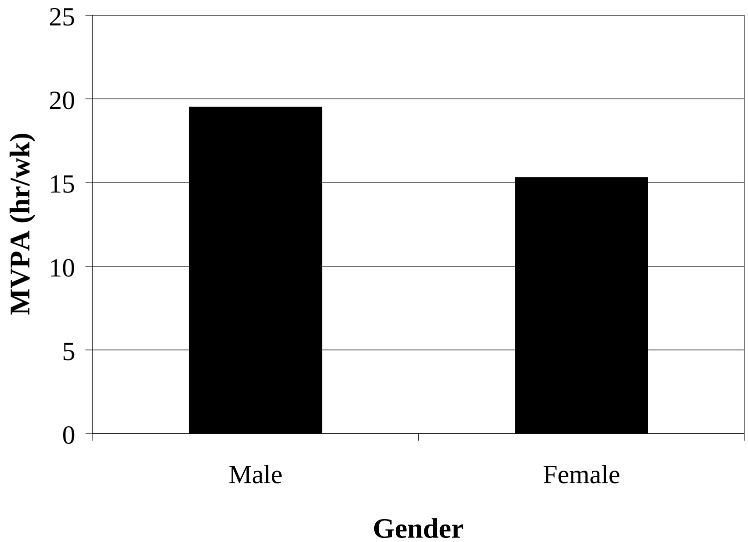


Figure 7. School mean moderate-to-vigorous physical activity (MVPA), by gender, across 76 secondary schools

Results indicated that intercepts were variable ($p<.0001$); schools differed in average physical activity levels. The results also indicated that slopes were variable ($p<.05$). The relationship between student gender and physical activity levels differed significantly between schools. In addition, there was a significant correlation between intercepts and slopes ($p<.05$). In other words, there was evidence that the relationship between student gender and physical activity depended on the average physical activity of the school. The correlation was negative, indicating that the higher the intercept, the lower the slope. In other words, in schools with higher school mean physical activity levels, the association between gender and physical activity levels was not as strong.

In summary, there was a significant association between physical activity and gender. On average, males performed 4.20 hr more MVPA per week compared to females. The strength of the relationship between physical activity and gender differed significantly between schools.

5.5 Research Question 2b and 3b

A random coefficient model containing both student-level explanatory variables, age and gender, was used to determine if the relationship between physical activity and age differed between schools when controlled for gender and if the relationship between physical activity and gender differed between schools when controlled for age (see Table 9). The estimate for the fixed effect indicated that, on average, there was a statistically significant relationship between student age and physical activity levels, when controlled for student gender ($p<.0001$). For every one-unit increase in years, there was a 0.81 hr decrease in MVPA per week, when controlled for gender. Similarly, on average, there was a statistically significant relationship between student gender and physical activity levels, when controlled for student age ($p<.0001$). On average, females spent 4.2 hr less per week performing MVPA compared to males, when controlled for age.

Table 9. Results of a random coefficient model examining the association between physical activity, age and gender, with age and gender as fixed and random effects

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Variances, Covariances				
Age				
Intercept	3.2171	0.6117		<.0001
Slope	0.0728	0.0340		0.0161
Covariance	-0.1185	0.1064		0.2654
Gender				
Intercept	-0.9085	0.3154		0.0040
Slope	0.5409	0.2360		0.0109
Covariance	0.1226	0.0651		0.0598
Residual	129.35	0.8306		<.0001
Fixed Effects				
Intercept	19.4688	0.2205	75	<.0001
Age	-0.8115	0.5314	>49,000	<.0001
Gender	-4.2419	0.1358	>49,000	<.0001

Results indicated that age intercepts were variable ($p<.0001$). The results also indicated that the relationship between student age and physical activity levels differed significantly between schools, when controlled for student gender ($p<.05$). Results indicated that gender intercepts were variable ($p<.01$). The relationship between student gender and physical activity levels differed significantly between schools, when controlled for student age ($p<.05$). There was little correlation between intercepts and the slopes of age and physical activity, when controlled for student gender ($p>.10$). Similarly, there was little correlation between intercepts and the slopes of gender and physical activity, when controlled for student age ($p>.05$).

In summary, the strength of the relationship between physical activity and age differed between schools when controlled for gender, and the strength of the relationship between physical activity and gender differed between schools when controlled for age.

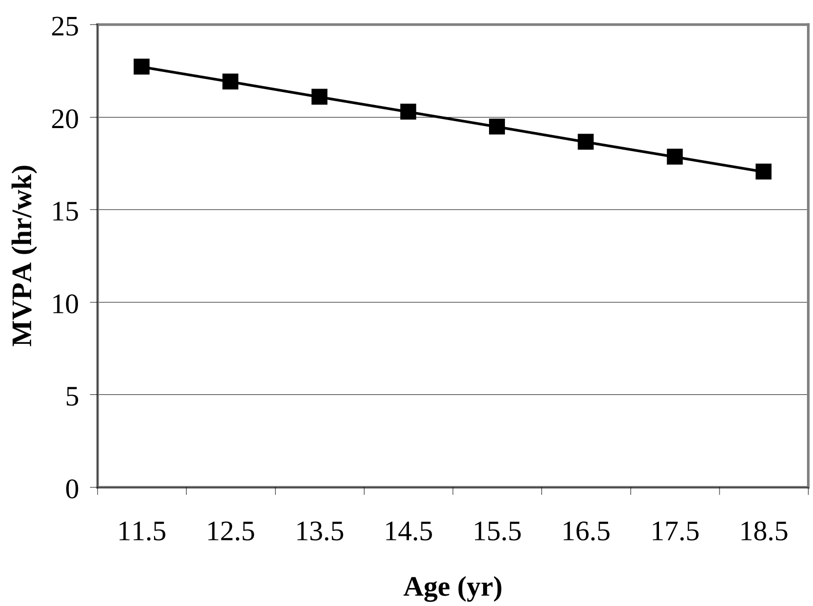


Figure 8. The fitted mean relationship between student age and moderate-to-vigorous physical activity (MVPA), controlled for gender, across 76 secondary schools

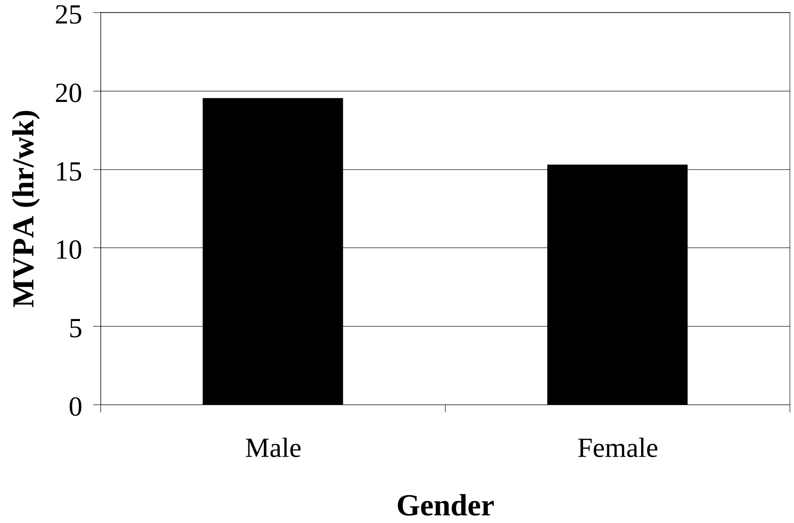


Figure 9. School mean moderate-to-vigorous physical activity (MVPA), by gender, controlled for age, across 76 secondary schools

5.6 Research Question 4

A slopes-and-intercepts-as-outcomes model was used to examine the relationship between physical activity and school characteristics. A five-step process was used to attain the final slopes-and-intercepts-as-outcomes model.

In the first step, each school-level variable was entered as a fixed effect into a multilevel model containing only that variable. Of the nine school-level variables, four were statistically significantly associated with student physical activity; intramurals, other physical activities at school, PE and outdoor facilities ($p<.05$; see Appendix L).

In the second step, each statistically significant school-level variable was entered as a fixed effect into a multilevel model with age and gender as fixed and random effects, and interactions between the school-level variable and age and gender, respectively. Results indicated that each school-level variable remained significantly associated with student physical activity when controlled for age and gender (see Appendix M).

In the third step, all school-level variables that were statistically significant when controlled for age and gender were entered into a slopes-and-intercepts-as-outcomes model (see Appendix N). Only PE remained significant ($p<.01$) when controlled for age, gender and other school-level variables.

In the fourth step, PE was entered into a model with school demographic variables and module (see Appendix O). PE remained significant ($p<.05$) when controlled for age, gender, school demographics and module.

In the fifth step, non-significant variables were removed in a stepwise fashion, starting with the least significant variable, until only significant variables remained (see Table 10).

Table 10. Results of a slopes-and-intercepts-as-outcomes model examining the association between physical activity, school characteristics, school demographics and module, controlled for age and gender

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Variances, Covariances				
Age				
Intercept	1.9860	0.4788		<.0001
Slope	0.0731	0.0368		0.0235
Covariance	-0.2288	0.1014		0.0240
Gender				
Intercept	-0.5063	0.2783		0.0688
Slope	0.4725	0.2533		0.0311
Covariance	0.1113	0.0698		0.1109
Residual	127.87	0.9273		<.0001
Fixed				
Intercept	24.3786	1.4104	50	<.0001
Age	-0.6414	0.0769	>38,000	<.0001
Gender	-7.0950	0.7892	>38,000	<.0001
PE	-10.9192	2.5929	50	0.0001
Gender*PE	5.2885	2.0228	>38,000	0.0089
School Income	-0.0583	0.0236	50	0.0168
School Size	0.1311	0.0550	50	0.0210
Module	-0.7577	0.1637	>38,000	<.0001
Age*Module	-0.4670	0.0941	>38,000	<.0001
Gender*Module	1.6360	0.2325	>38,000	<.0001

PE=school physical education non-participation rate

Being female was negatively associated with physical activity. On average, adjusted for age, school demographics and module, females performed 7.1 hr/wk less physical activity compared to males (see Figure 10). Age was negatively associated with physical activity ($p<.0001$), such that for every one year increase in age there was a 0.64 hr/wk decrease in physical activity (see Figure 11). Over the four years from grade 9 to grade 12, this would mean a 2.6 hr/wk decrease in physical activity.

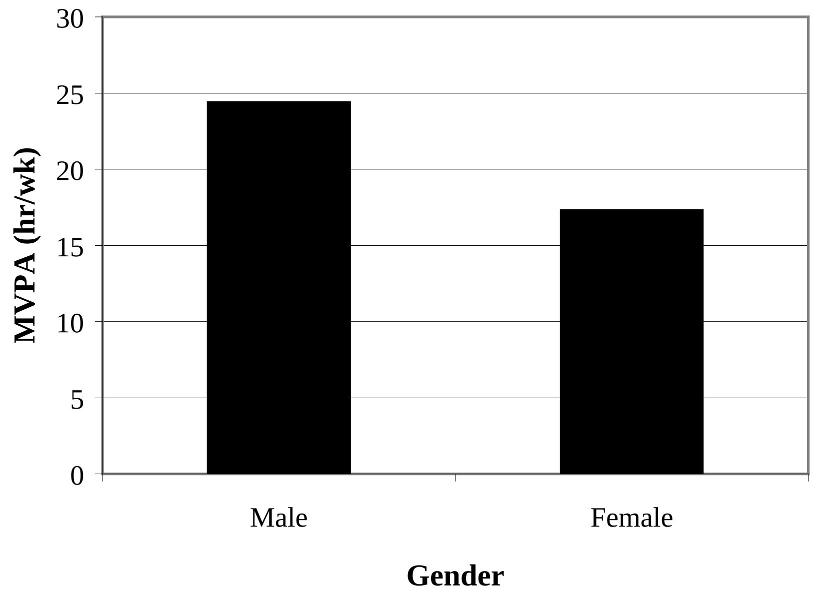


Figure 10. School mean moderate-to-vigorous physical activity (MVPA), by gender, controlled for age, school-level variables, school demographics and module

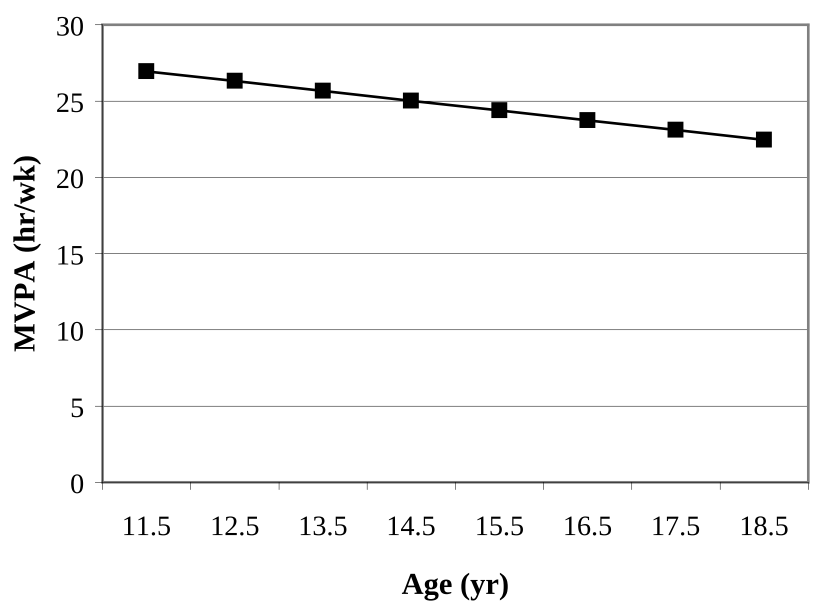


Figure 11. The fitted mean relationship between student age and moderate-to-vigorous physical activity (MVPA), controlled for gender, school-level variables, school demographics and module

The PE non-participation rate was negatively associated with physical activity ($p<.001$). The mean PE non-participation rate was 0.37 ± 0.08, and ranged from 0.19-0.73. There was also a statistically significant interaction between PE non-participation rate and gender ($p<.01$), such that the association between PE non-participation rate and physical activity was stronger for females than males. Thus, for every 10 percentage point increase in the PE non-participation rate, there was a 1.1 hr/wk decrease in student physical activity for males, whereas for every 10 percentage point increase in the PE non-participation rate, there was a 1.5 hr/wk decrease in physical activity for females.

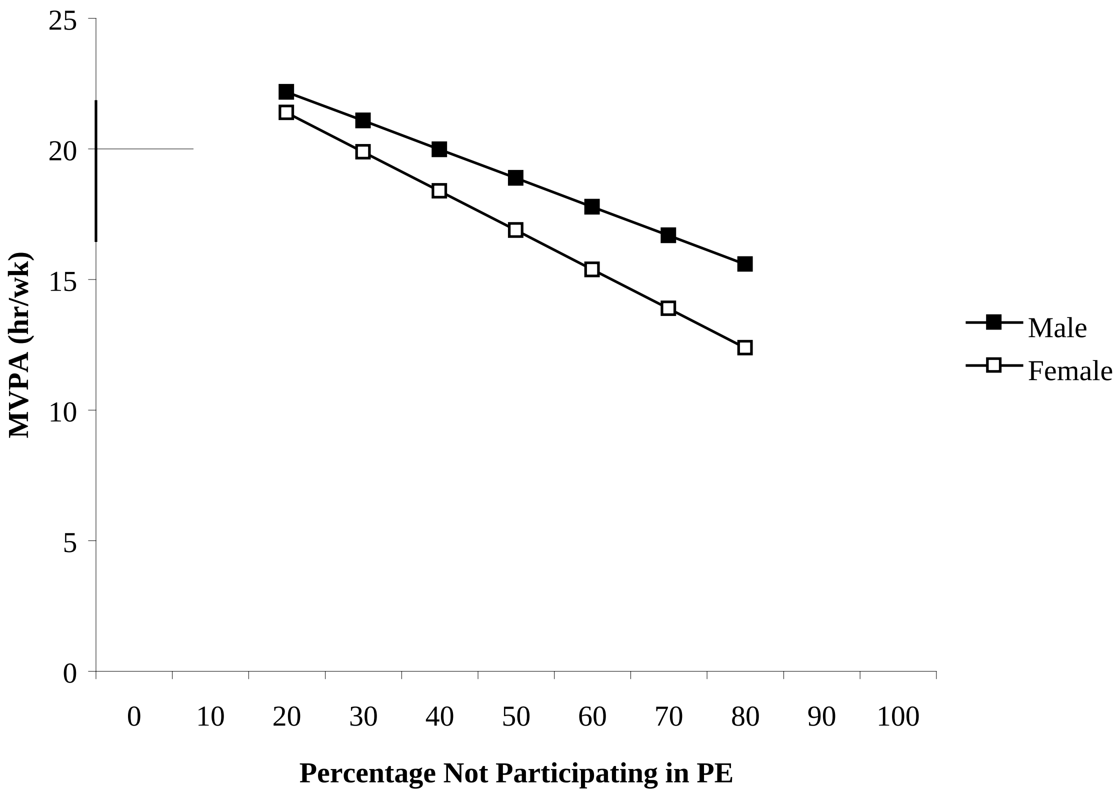


Figure 12. The fitted mean relationship between the school physical education (PE) non-participation rate and moderate-to-vigorous physical activity (MVPA), controlled for age, gender, school demographics and module

School income was negatively associated with physical activity ($p<.05$), such that every \$10,000 increase in school income was associated with a 0.58 h/wk decrease in physical activity. School size was positively associated with physical activity ($p<.05$); for every 100 student increase in school size, there was a 0.13 hr/wk increase in physical activity. There was also a significant main effect of SHAPES module ($p<.0001$), and significant interactions between module and student age and gender, respectively (both $p<.0001$). On average, physical activity was lower by 0.76 hr/wk for the Physical Activity Module compared to the Tobacco Module. As age increased, the difference between physical activity for the Physical Activity Module compared to the Tobacco Module increased by 0.47 hr/wk. In addition, the difference in physical activity between modules was 1.64 hr/wk greater for females compared to males.

Results indicated that age intercepts were variable ($p<.0001$). The results also indicated that the relationship between student age and physical activity levels differed significantly between schools ($p<.05$). Results indicated that gender intercepts were not variable ($p>.05$). The relationship between student gender and physical activity levels differed significantly between schools ($p<.05$). There was a significant correlation between intercepts and the slopes of age and physical activity ($p<.05$). Similarly, there was a significant correlation between intercepts and the slopes of gender and physical activity ($p<.05$).

In summary, the PE non-participation rate was negatively associated with physical activity. School income was negatively associated with physical activity, whereas school size was positively associated with physical activity.

5.6.1 Effect of Methodology

Results of the two models examining the effect of using aggregated student data to predict data from the same students indicated that PE non-participation rate remained significant (see Appendix P). The association between student physical activity and physical education non-participation rate remained significant when using multilevel models that 1) predicted physical activity from a random half of the Physical Activity Module, and 2) predicted physical activity from the Tobacco Module only. However, the significance of the remaining fixed effects depended on whether the outcomes were based on responses from the Tobacco Module or a random half of the Physical Activity Module. School income and the interaction between gender and physical education non-participation rate were significant for the Physical Activity model, but not for the Tobacco model. However, school size was significant for the Tobacco model, but not the Physical Activity model. Significance for age and gender variances and variance components were consistent between the two models. Age intercepts and slopes were significant ($p<.05$), but the correlation between intercepts and slopes was not ($p>.05$). Gender intercepts, slopes and the correlation between intercepts and slopes were not significant ($p>.05$).

5.6.2 Student Physical Education

Results of a slopes-and-intercepts-as-outcomes model that examined potential confounding due to student PE participation are shown in Appendix Q. At the student level, non-participation in PE was negatively associated with physical activity. Students who participated in PE performed 4.05 hr/wk more physical activity compared to students who did not participate in

PE. Controlling for student participation in PE did not change the significance or coefficients for PE non-participation rate or the interaction between PE non-participation rate and gender. Thus, controlled for student PE, for every 10 percentage point increase in the PE non-participation rate, there was a 1.06 hr/wk decrease in student physical activity for males, whereas for every 10 percentage point increase in the PE non-participation rate, there was a 1.6 hr/wk decrease in physical activity for females.

5.6.3 Effect of Module

The final slopes-and-intercepts-as-outcomes model found a significant main effect for SHAPES module, as well as interactions of module with age and gender, respectively. Thus, the statistical analyses were repeated twice; once with the outcome variable and student-level variables from students who completed the Tobacco Module only and once with the Physical Activity Module only. In both cases, the only school characteristic variable that was significant and remained in the model was the school rate of non-participation in PE.

5.7 Research Question 5

There was significant between-school variability in the school mean physical activity of junior students ($p<.0001$), with an ICC of 0.021 (see Appendix R). The intercepts and slopes for age and gender, respectively, varied between schools ($p<.05$) (see Appendix S). However, the slope for age did not remain significant when controlled for gender (see Appendix T). Thus, age was constrained to a fixed effect in subsequent models. Of the six school-level explanatory variables examined, only the senior student participation rate in other physical activities at school was significant ($p<.005$) (see Appendix U). The senior student participation rate in other physical activities at school remained significant when controlled for student age and gender ($p<.005$), school demographics ($p<.05$) and module ($p<.05$) (see Appendix V).

Results of the final slopes-and-intercepts-as-outcomes model used to examine the relationship between junior student physical activity levels and senior student rate of participation in school physical activities are shown in Table 11.

Table 11. Results of a slopes-and-intercepts-as-outcomes model examining the association between grade 9 and 10 student physical activity, school characteristics, school demographics and module, controlled for age and gender

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Variances, Covariance				
Gender				
Intercept	2.8293	0.6276		<.0001
Slope	0.8960	0.4006		0.0127
Covariance	-1.1188	0.4238		0.0083
Residual	133.59	1.1631		<.0001
Fixed Effects				
Intercept	18.6853	0.8139	73	<.0001
Age	-0.4940	0.1083	>26,000	<.0001
Gender	-3.9520	0.1833	>26,000	<.0001
Other	3.9909	1.4844	73	0.0089
Module	-0.2424	0.0566	>26,000	<.0001

Other = senior student participation rate in other physical activities at school

The estimated mean physical activity level was 18.7 hr/wk for males and 14.7 hr/wk for females. Being female was negatively associated with physical activity. On average, females performed 4.0 hr/wk less physical activity compared to males. Age was negatively associated with physical activity ($p<.0001$), such that for every one year increase in age there was a 0.49 hr/wk decrease in physical activity.

The senior student participation rate in other physical activities at school was positively associated with junior student physical activity ($p<.05$). For every 10 percentage point increase in the senior student participation rate in other physical activities at school, there was a 0.40 hr/wk increase in junior student physical activity (see Figure 12). The mean senior student participation rate in other physical activities at school was 0.52 ± 0.13, and ranged from 0.17-0.86.

Gender intercepts and slopes were variable ($p<.05$), and there was a significant correlation between intercepts and the slopes for gender ($p<.05$).

In summary, the senior student participation rate in other physical activities at school was positively associated with junior student physical activity ($p<.05$).

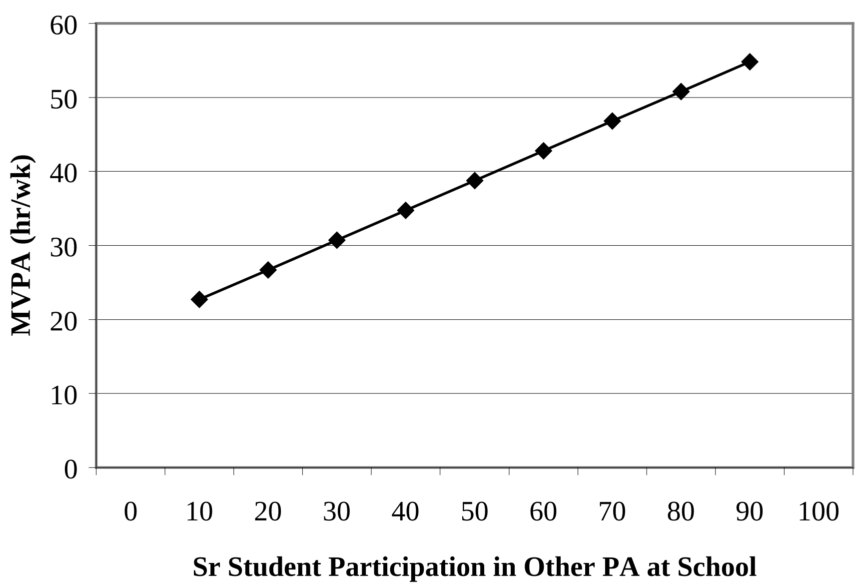


Figure 13. The mean relationship between the senior student participation rate in other physical activities at school and moderate-to-vigorous physical activity (MVPA), controlled for age, gender, school demographics and module

5.9.1 Effect of Module

The final slopes-and-intercepts-as-outcomes model found a significant main effect for SHAPES module. Thus, the statistical analyses were repeated twice; once with the outcome variable and student-level variables from students who completed the Tobacco Module only and once with the Physical Activity Module only. In both cases, the only senior student participation variable that was significant was the senior student participation rate in other physical activities at school.

6.0 DISCUSSION

Results from the current study support the social-ecological notion that the school environment can influence adolescent physical activity behaviour. These findings have important implications for research and practice, and identify directions for future research.

6.1 Research Question 1

There was significant between-school variability in student physical activity, with ICCs ranging from 0.017 to 0.032. Two previous studies examining between-school variability in physical activity found ICCs of 0.021[45] and 0.040[18], respectively. However, one study examining between-school variability in physical activity and another examining between-school variability in physical fitness found ICCs of 0.224 and 0.290, respectively[17]. Due to the limited number of studies, it remains unclear if the wide range of ICCs were due to differences in methodology, sample size, sample population, school level or country.

Other school-based research has also identified significant between-school variability in student health behaviour. A review of 63 estimates of ICCs for weekly smoking prevalence and 62 estimates of ICCs for number of cigarettes smoked per week found that the mean ICC for weekly smoking prevalence was 0.019 (± 0.022), whereas the mean ICC for number of cigarettes smoked per week was 0.011 (± 0.018)[61]. More recently, ICCs were reported for 13 dependent variables that are commonly used as primary or secondary endpoints in smoking prevention studies, such as weekly smoking, modeling influences, and access to cigarettes, based on a cohort that was followed from 1994-1997[62]. The ICCs for weekly smoking ranged from 0.020-0.031. The ICCs for the other variables ranged from 0.005-0.050, with means between 0.010-0.020[62]. Thus, previous findings from tobacco control are consistent with the ICCs for physical activity observed in the current study.

The results of this study and previous studies have consistently demonstrated that there is significant between-school variability in student physical activity. Although there was a wide range in the magnitude of the ICCs across studies, the magnitude of ICCs for physical activity in the current study was similar to those previously observed for smoking. Further study of between-school variability is required to explain the wide range in the observed ICCs for physical activity.

6.2 Research Questions 2 and 3

Results indicated that there was a significant negative association between student physical activity and age, older students tended to be less active than younger students. There was also a significant association between physical activity and gender, with males tending to be more active than females. These are the two most commonly examined and consistently observed relationships among physical activity research[15].

Results also indicated that the relationship between physical activity and age varied significantly between schools. In other words, the rate at which student physical activity levels decline as they get older was slower for students in some schools compared to those in other schools. The significant variability in the relationship between physical activity and age was similar to the results of a previous study, which found that the relationship between age and physical fitness varied significantly between schools[16].

Results also showed that the relationship between physical activity and gender varied significantly between schools. In other words, the difference in physical activity levels between males and females was greater in some schools compared to those in other schools. This was in contrast to the results of a previous study, which found that the relationship between physical fitness and gender did not vary between schools[16]. Discrepancies between the results of these studies may be due to differences in the sample population (i.e. elementary vs. secondary school students), as well as the outcome (i.e. physical fitness vs. physical activity). Further research is required to determine the reason for the discrepant findings.

Further research is also required to identify school characteristics that prevent age related decline in physical activity, as well as gender differences in physical activity. Identifying these characteristics may provide direction for the development of new prevention programs. In addition, identification of these school characteristics may enable researchers and practitioners to target prevention programs to at-risk schools (i.e. schools in which physical activity levels decline faster with age, or schools which have greater gender differences in physical activity levels).

6.3 Research Question 4

The only school characteristic associated with student physical activity levels was the school rate of participation in PE; the higher the rate of participation in PE, the higher the physical activity levels. There was also a significant interaction between PE participation rate and gender, such that the association between PE participation rate and physical activity was stronger for females than males. The association between physical activity and school rate of participation in PE remained significant even when adjusted for student participation in PE. In other words, students in a school with a higher PE participation rate tended to have higher physical activity levels than students in a school with a lower PE participation rate, regardless of whether or not those students were taking PE.

The mechanism by which school participation rate in PE may influence student physical activity levels is unclear. Of note is that the only school characteristic that was significantly associated with student physical activity was also the only variable related to curricular physical activity. Other school characteristics examined were related to leisure-time physical activities, such as extracurricular physical activity (e.g. intramurals, interscholastic sports). The remaining school characteristics examined were related to performing physical activity for transportation (i.e. commuting to school), and to physical activity facilities (e.g. indoor, outdoor).

An understanding of the Ontario secondary school curriculum at the time of data collection may provide insight. School curriculum requirements are determined at the provincial level by the Ontario Ministry of Education[63]. At the time of SHAPES-ON data collection, PE was not mandatory for students in grades 9-12. Secondary school students were required to obtain one Physical and Health Education (PHE) credit in order to graduate. PHE courses were offered from grades 9-12. There was an opportunity cost associated with participating in PE. Students had to choose between PE and subjects that were traditionally viewed as more academic, such as math, science and English, as well as those that were traditionally viewed as less academic, such as art, music and drama. Some of these were required for graduation (e.g. math, English), whereas others allowed students to pursue their interests and potential career paths (e.g. science, music, drama). To enroll in physical education, students had to choose PE over another course that was either required or of interest.

PE participation rates may be related to student enjoyment of physical education. Previous research has shown a positive relationship between enjoyment and participation in physical activity[15]. Thus, participating in PE beyond the one course required for graduation may depend on the degree to which students enjoyed PE. Teacher praise and encouragement, student input, choice in PE uniform, choice in activities, diversity of activities, improvements in change rooms, and an emphasis on participation rather than competition may contribute to student enjoyment of PE[64].

High rates of PE participation may reflect a school environment in which physical activity is be portrayed as having equal importance to academics. Schools that emphasize the importance of physical activity as an important part of life may result in students being more active, both during school as well as outside of school. An example of a school policy that may promote and encourage physical activity are policies restricting physical activity from being used as a form of punishment since this may cause students to associate physical activity with negative experiences. School-based physical activity related special events, such as the Terry Fox Run and Jump Rope for Heart, may promote physical activity. Further, policies that discourage the cancellation of PE classes so that the gymnasium can be used for other events may contribute to conveying the importance of PE.

Mandatory PE policies for all grades may contribute to a school environment that promotes physical activity by conveying and supporting the importance of participating in physical activity throughout the lifespan. Although policies that mandate PE for students in grades 9-12 would increase PE participation rates, it would no longer be on a voluntary basis. Thus, the relationship between school PE participation rate and student physical activity levels may differ depending on whether there are mandatory PE policies in effect. For example, the association between PE participation rates and physical activity may not be significant when adjusted for student participation when PE is mandatory, since mandatory PE may influence student physical activity more directly through the time spent performing physical activity in PE classes.

The extent to which school programs and policies are related to higher rates of PE participation is unknown. Previous studies have examined the prevalence of various school PE policies, but have not examined their association with student participation in physical education or school PE participation rates[65, 66]. Other studies have reported the levels of student PE participation, but have not examined causes or correlates of PE participation[67, 68].

Because of the cross-sectional study design, it is not possible to determine the direction of the association. It may be that school participation rate in PE influences student physical activity levels. However, it may be student physical activity levels influence school participation rates in PE. Further, the direction of association does not have to be mutually exclusive. Social Cognitive Theory posits that the person and the environment interact in a dynamic, reciprocal fashion[25]. Thus, school participation rate in PE may influence student physical activity levels and vice versa. Alternatively, there may be a third, unknown factor, which influences both school participation rates in PE and student physical activity levels.

Results of this study also showed that school income was negatively associated with physical activity. This is in contrast to well-established negative associations between SES and health[69]. Further, previous research has shown that school mean SES is positively associated with academic achievement[70]. Thus, it was expected that school income would be positively associated with physical activity. A number of factors may have contributed to the unexpected findings. Income data were available only for schools located within large urban centres. Further, school income was based on the neighbourhood in which the school was located using the school postal code, rather than on the household income of the students. School catchment areas may not have corresponded to the neighbourhood in which the school was located. Further, student SES was not controlled for since student SES data were not available.

Results also showed that school size was positively associated with physical activity. Schools with larger enrollments have been shown to have more health-promoting policies, programs and facilities [71], as well as more policies, programs and facilities that support physical activity in particular[48]. Although these studies did not examine the relationship between student physical activity and policies, programs or facilities, the findings do suggest a mechanism by which school size may be associated with physical activity. In contrast to the results of the current study, a previous study found a negative association between school size and physical activity[17]. The discrepancy may be due to differences in the sample population (i.e. elementary vs. secondary school students) or province (i.e. Ontario vs. New Brunswick). Further research is required to determine the reason for the discrepant findings.

SHAPES Module (Physical Activity Module vs. Tobacco Module), as well as the interactions between module and age and gender, respectively, was also significantly associated with student physical activity levels. Since the modules were distributed to classes at random, it is unlikely that the differences in physical activity levels between modules represent true differences in physical activity levels between the classes who completed the Physical Activity Module and those who completed the Tobacco Module. These findings suggest that students were not responding the same way to the 7-day physical activity recall items. This is consistent with previous research which found significant differences in responses to the same questions associated with different modes of data collection (i.e. mode effects). For example, an examination of CCHS data showed that there were differences in physical activity depending on whether respondents completed the identical questionnaire through a telephone interview or an in-person interview at their home[72].

Students may have responded differently to the SHAPES modules due to the placement of the items. For example, in the Physical Activity Module, the two 7-day physical activity recalls were located approximately mid-way through the questionnaire. However, in the Tobacco Module, these items were located near the very end of the questionnaire. These items were longer and more complex compared to most of the other items. Thus, Tobacco Module respondents may have been losing interest and/or motivation as they neared the end of the questionnaire and subsequently made less of an effort to complete the items accurately.

In addition, students may have responded differently due to the different focus of each questionnaire. Physical Activity Module respondents would have read and responded to numerous items related to physical activity before completing the 7-day physical activity recall items. However, Tobacco Module respondents would have read and responded to numerous items related to tobacco use prior to completing the 7-day physical activity recall. Thus, Physical Activity Module respondents may have responded differently from Tobacco Module respondents because they had been thinking about physical activity and their physical activity behaviours prior to completing the physical activity recall items, whereas the Tobacco Module respondents would have had to switch from thinking about tobacco use to physical activity.

Based on the currently available data, it is not possible to determine which module is a more valid and reliable tool for measuring physical activity. The reliability and validity of the SHAPES Physical Activity Module has previously been determined to be satisfactory[51]. Although the height, weight and physical activity related items on the Tobacco Module were identical to the ones in the Physical Activity Module, the reliability and validity of these items as part of the Tobacco Module has not been established. Thus, estimates of physical activity obtained using the Physical Activity Module should be considered adequately reliable and valid, whereas the reliability and validity of estimates of physical activity obtained from the Tobacco Module are unknown and should be interpreted with caution.

6.4 Research Question 5

Adjusted for student composition and school demographic characteristics, the only senior student participation variable associated with junior student physical activity levels was the senior student rate of participation in other physical activities at school; the higher the rate of senior student participation in other physical activities at school, the higher the junior student physical activity levels. This is consistent with research in tobacco control, which found that senior student smoking rates are associated with junior student smoking initiation and susceptibility[10-12, 42-44].

The mechanism by which high rates of senior student participation in other physical activities at school may influence junior student physical activity levels is unclear. Social Cognitive Theory would suggest that physically active senior students might act as social models that predispose junior students to be physically active through observational learning. Alternatively, the behaviour of senior students may act as a reinforcing factor by creating a school culture that encourages and supports physical activity. Another possibility is that high rates of senior student participation in other physical activities at school would increase the chance of making a physically active friend. However, evidence to support the role of peer influence on adolescent physical activity behaviour has been mixed[15]. Further research is required to increase our understanding of social influences on adolescent physical activity.

The importance of senior student participation in other physical activities at school is unknown. Understanding is complicated by the lack of a clear definition of ‘other physical activities at school’. The ‘other physical activities at school’ item was asked after students were asked if they participated in intramurals or interscholastic sports. Examples of other physical activities at school provided on the questionnaire were “playing in the gym and playing outside”. Thus, ‘other physical activities at school’ would include using outdoor basketball courts, tennis courts, sports fields, weight rooms and the gym during open gym times, before school, at lunch, after school or during study periods. However, it is unclear if students would include participation in physical activities as part of clubs in their definition of ‘other physical activities at school’. For example, some school clubs, such as dance or cheerleading, may perform physical activities on school property, whereas other school clubs, such as hiking or mountain biking, may perform physical activities off school property.

The unique aspects of the ‘other physical activities at school’ variable compared to the other variables that were examined may provide insight into the mechanism. ‘Other physical activities’ differs from PE in that it consists of extracurricular, rather than curricular, physical activity. ‘Other physical activities’ may consist of unstructured and structured extracurricular physical activities, depending on how it is defined, whereas intramural and interscholastic sports consist of structured extracurricular physical activities. However, the structured ‘other physical activities’ differs from the structured physical activities offered as part of an intramural or interscholastic sports program. Clubs are typically started based on student interest and require club members to take leadership in organizing the club and determining club activities. By contrast, intramural activities are typically chosen and organized by school staff and administration. Thus, school clubs may enable students the opportunity to be physically active while pursuing their own interests, rather than not participating in intramurals because the activities are not of interest. Further research is required to determine the relationship between personal autonomy and participation in physical activities.

School policies and programs may be one way that schools can influence senior student participation in other physical activities at school. In terms of policies that encourage unstructured physical activity, school policies that allow students to access facilities and equipment when they are not otherwise scheduled for use (e.g. PE, intramurals, interscholastic team practices) may be important. The availability of facilities, such as weight rooms, may also encourage unstructured physical activity. Policies that allow students to start new school clubs may be important for encouraging structured 'other physical activities'. Providing support for the clubs, such as providing places to meet, methods for the club to advertise and attract new members, and methods to communicate between members, as well as recognition for students who participate and take leadership, may also be important.

Because of the cross-sectional study design, it is not possible to determine the direction of the association between senior student participation in other physical activities at school and junior student physical activity levels. Thus, rather than senior student participation in other physical activities influencing junior student physical activity levels, it may be that junior physical activity levels influence senior student participation in other physical activities, or that both variables influence each other simultaneously. Alternatively, there may be a third, unknown factor, which influences both senior student participation in other physical activities at school and junior student physical activity levels.

6.5 Significance and Potential Implications

There were numerous novel findings from the current study. The results indicated that there was significant between-school variability in the relationship between physical activity and age, as well as between physical activity and gender. In addition, the rate of school participation in PE was significantly associated with student physical activity levels. Further, the rate of senior student participation in other physical activities at school was significantly associated with junior student physical activity levels. To the author's knowledge, this is the first time these relationships have been examined.

These findings provide empirical support for the use of social-ecological models for understanding adolescent physical activity behaviour. This, in turn, provides the theoretical framework required for the development and implementation of mid-stream, institutional-level and upstream, population-level interventions. The field of tobacco control has already demonstrated the substantial impact that mid-stream and upstream interventions can have when combined with downstream interventions[35]. A full spectrum of interventions, ranging from downstream to upstream, may also be required to substantially increase adolescent physical activity levels.

Identifying characteristics of the school environment that are associated with physical activity could contribute to the development of effective school-based policies, programs and interventions to increase physical activity. Rather than viewing schools simply as a setting for the physical activity interventions, these findings suggest that the school environment itself may influence physical activity behaviour. Identifying school characteristics that are associated with physical activity behaviour can provide the basis upon which to intervene. For example, further research may identify school policies that influence PE participation rates. Modifying these school policies may provide a strategy for increasing both PE participation rates and adolescent physical activity levels. The PRECEDE-PROCEED planning model may aid in the planning, development and implementation of effective interventions. Categorizing school characteristics as predisposing, reinforcing and enabling factors provides an organizational framework for understanding which school characteristics have the ability to cause behaviours to occur or inhibit their occurrence.

These findings also suggest that school characteristics should be considered in the design and implementation of school-based interventions. For example, these findings may contribute to the identification of school characteristics that could moderate the effectiveness of school-based interventions. Previous research has demonstrated that a social influences smoking prevention program was effective in schools with high senior student smoking rates (high risk schools), but not in schools with low senior student smoking rates (low risk schools)[13]. Similarly, the results of this study raises the possibility that physical activity interventions based on social influences may be more effective in schools with low senior student participation rates in other physical activities school (high risk schools) compared schools with high senior student participation rates in other physical activities at school (low risk schools). If so, then collecting data to classify schools as high or low risk prior to implementing interventions may help to identify schools where the interventions are more likely to be effective. Targeting interventions towards these high risk schools may increase the cost effectiveness of physical activity initiatives.

In addition, these findings suggest that between-school variability in physical activity needs to be accounted for in the design and analysis of group-randomized trials. Group-randomized trials should consider the design effect when determining the sample size required. These findings provide estimates of ICCs that could be used for sample size calculations of group-randomized physical activity trials in similar populations. Statistical techniques that account for clustering of physical activity behaviour, such as multilevel modeling, should be used when analyzing student physical activity data that have been collected from multiple schools.

The significant association between SHAPES modules and physical activity has potential implications for the use of a modular approach to data collection for research, monitoring and surveillance. It cannot be assumed that items taken from a tool with satisfactory reliability and validity and combined with items from another tool with satisfactory reliability and validity will perform in the same way. It is important to determine the reliability and validity of tools before using them, even if the tool consists of a combination of previously tested items. If the reliability and validity of the items depends on the combination of items on the questionnaire, as well as the placement, then the current modular approach used in SHAPES may need to be re-evaluated. For example, modules may need to be restricted to addressing one health behaviour rather than addressing multiple behaviours briefly and one behaviour in detail.

6.6 Strengths and Limitations

There were a number of limitations associated with this study. One limitation was the cross-sectional nature of the data. Although causality cannot be determined, results of cross-sectional studies play a critical role in building a knowledge base. For example, observed associations from cross-sectional studies can be used to inform the development and design of longitudinal studies and randomized controlled trials, which are generally much more expensive, labour intensive and time consuming than cross-sectional studies.

Another limitation was that health units and schools in Ontario were purposively selected, so the resulting data were not representative of the province. This limited the ability to generalize some of the results. For example, the prevalence of overweight and obesity in this sample population cannot be generalized to the adolescent population in Ontario. However, the purpose of this study was not to determine the prevalence of any of the variables. The high student response rate within schools suggested that the data were likely representative of the participating schools. The large sample size, both in terms of the number of schools as well as the number of students, constituted one of the strengths of this study.

The reliance on self-reported data was another limitation. Self-reported data are subject to social desirability, misinterpretation of questions and errors in recalling information. However, objective measures of physical activity also have limitations including an inability to distinguish intensity of physical activity (pedometers, double labelled water), inaccuracy for certain physical activities (e.g. pedometers and accelerometers are inaccurate for bicycling) and inability to measure some activities (e.g. pedometers and accelerometers cannot be worn during swimming). Many of these objective measures are also prohibitively expensive for large-scale data collection. Further, although they can provide an objective measure for physical activity they are unable to collect critical related information, such as whether the activity was performed as part of intramurals or interscholastic sports. Thus, questionnaires and interviews are the standard methods for large-scale data collection in physical activity research. The use of valid and reliable tools, such as the SHAPES student questionnaires, helped to ensure that the data collected were valid and reliable and constituted another strength of this study.

The use of secondary data was another limitation. Since the SHAPES questionnaires and the SHAPES-ON project were not designed specifically for this study, data were not available for some variables of interest. For example, the SES of the students, as well as the schools, has been associated with student outcomes[70]. Although an approximation of school SES was obtained from population census data and the school postal codes, there were no corresponding student SES data available. Having the postal codes of students' place of residence would have provided an approximation of student SES, as well as a better approximation of school mean SES. However, the strength of using secondary data was capitalizing on the opportunity to use existing data to advance the understanding of the association between the school environment and physical activity. This enabled more knowledge to be generated from the financial and human resources that were required for data collection, as well enabling this knowledge to be generated in a relatively short period of time. Moreover, the advantage of using SHAPES-ON data in particular, was that the design and large sample size enabled the use of MLM to examine school characteristics while controlling for student composition. There is much knowledge to be gained by using this statistical technique to examine the application of a social-ecological approach to youth physical activity behaviour.

There were also limitations associated with the variables that were used. For example, the results of criterion validity testing[51] and comparison with data from the CCHS[6] suggested that the outcome variable, physical activity, was likely over-reported. Although this prevented using the data to accurately estimate physical activity levels, it did not preclude using the data to provide insight into associations with physical activity. In order to prevent misclassification of students' physical activity levels, the data were used as a continuous variable rather than using externally determined cut-points to classify students into physical activity levels. The limitation of this approach was that it assumed that all students over-reported to the same extent. However, this may not have been an accurate assumption. For example, students who were more active may have over-reported to a lesser extent while students who are less active may have over-reported to a greater extent. Although this would reduce the magnitude of the difference in time spent performing MVPA between students who were physically active compared to those who were not, it would strengthen the findings if significance is found.

There were also limitations associated with the school characteristic variables. Some of the items that the school characteristic variables were based on, such as other physical activities at school, were not well defined. Similarly, participation in PE was not defined as a PHE course with a physical activity component so students may have included participation in PHE courses that did not have a physical activity component, such as Grade 12 Exercise Science. Thus, some items may have been subject to greater variability in interpretation by students. Despite this limitation, a significant association between senior student participation in other physical activities at school and junior student physical activity was observed. The lack of definition also created difficulty in interpreting the results. Further, the school characteristic variables were limited in their ability to inform the mechanisms by which the variables were associated with student physical activity, and subsequently limited their ability to inform interventions. However, the examination of these school characteristics did provide new insight into the relationship between the school environment and physical activity. These findings will inform future directions for physical activity research, as well as the development of effective interventions for increasing adolescent physical activity.

6.7 Future Research

6.7.1 Short-term

Findings from the current study identify numerous short-term research directions that could be examined using existing data from SHAPES-ON. Slopes-and-intercepts-as outcomes multilevel models should be used to examine whether any of the school characteristics in the current study account for a significant amount of the between-school variability in the relationship between age and physical activity, as well as in the relationship between gender and physical activity.

Schools with high and low rates of participation in PE should also be examined. A comparison of the school demographics (e.g. school size, urban/rural) between schools with high and low PE participation rates should be conducted. This may provide insight into correlates of school PE rates. Similar comparisons should be conducted for schools with high vs. low: 1) gender differences in physical activity, 2) decrease in physical activity with age and 3) senior student participation rates in other physical activities.

In addition, PE participation by grade and gender should be examined. This may identify whether high PE schools are better at encouraging some sub-groups to take PE compared to low PE schools, or whether there is an overall effect where more students in all sub-groups are taking PE. For example, results may show that female PE participation is significantly higher in high PE schools compared to low PE schools. Similarly, senior student participation in other physical activities at school by grade and gender should be examined.

Schools with high rates of participation in PE, small gender differences in physical activity, small decreases in physical activity with age, and high senior student participation in other physical activities, respectively should be examined to determine if these were the same schools. These directions for future research would extend the findings from the current study, and provide additional insight that would contribute to a greater understanding of the results and identification of potential applications.

The effect of SHAPES module on data collection should be examined further. Differences in physical activity between modules should be examined by age, gender and grade to determine if some sub-groups are responding differently than others. Further, smoking outcomes should be examined to determine if there are differences depending on whether the data are collected using the Tobacco Module or the Physical Activity Module.

Existing and previous studies should re-examine their samples to determine ICCs for physical activity. The availability of estimates of ICCs for physical activity would assist in the sample size determination of group-randomized trials and reduce the need to conduct pilot studies to obtain this information. Studies that collected self-reported or objectively measured physical activity data from a minimum of approximately 30 schools would be suitable.

6.7.2 Long-term

Findings from the current study identify a number of long-term research directions. Future research should try to identify the factors that influence school PE participation rates and senior student participation rates in other physical activities at school, as well as the mechanisms by which these school characteristics are associated with student physical activity levels. Such research may require a combination of qualitative and quantitative research methods.

Future research should also try to identify additional school characteristics, such as school policies and programs, which are associated with student physical activity. School policy and program data should be collected from school staff or administration, rather than from students. Further, the data collection tool(s) should have satisfactory reliability and validity. Student-level physical activity and demographic data should also be collected in conjunction with school-level data collection. This would enable examination of associations between policies and programs and student physical activity behaviour, as well as enable student composition to be controlled for. The development of a reliable and valid administrator questionnaire to assess school physical activity programs and policies is currently in progress as part of the SHAPES research program.

Future research should also include longitudinal studies to enable causality to be assessed. School environments that promote and encourage physical activity may cause students to be more physically active. However, it is also possible that schools with a large proportion of physically active students would create a school environment that promotes physical activity, and encourages school administrators to implement policies and programs that support physical activity. Although randomized controlled trials can also assess causality, it would not be appropriate or possible to use a randomized controlled trial design to examine the relationship between physical activity and many characteristics of the school environment.

7.0 CONCLUSION

In conclusion, these findings support the social-ecological notion that the school environment can influence adolescent physical activity behaviour. School characteristics that were associated with student physical activity were identified. Specifically, school rates of participation in PE were associated with student physical activity levels. Further, senior student rate of participation in other physical activities at school were associated with junior student physical activity levels. Evidence from the field of tobacco control suggests that a full spectrum of interventions, ranging from downstream, individual-level interventions to upstream, population-level interventions, are required to substantially change health behaviour at the population level. Findings from the current study improve our understanding of the relationship between the school environment and physical activity and may contribute to the development of effective midstream interventions that will be required to substantially reduce the prevalence of physical inactivity. As such, these findings have important implications for research and practice, and identify directions for future research.

8.0 REFERENCES

1. World Health Organization Global Strategy on Diet, Physical Activity and Health. Geneva, Switzerland: World Health Organization; 2004.

2. The World Health Report 2002 - Reducing Risks, Promoting Healthy Life. Geneva, Switzerland: World Health Organization; 2002.

3. Canada's Physical Activity Guide for Children. In: Health Canada; 2002.

4. Canada's Physical Activity Guide for Youth. In: Health Canada; 2002.

5. Malina RM. Tracking of physical activity and physical fitness across the lifespan. Res Q Exerc Sport 1996;67(3 Suppl):S48-57.

6. Physical Activity Levels Across Canada: Physical Activity Among Youth. Canadian Fitness and Lifestyle Research Institute. (Accessed October 5, 2006, at http://www.cflri.ca/eng/levels/youth_levels.php)

7. Bronfenbrenner U. The Ecology of Human Development. Cambridge, MA: Harvard University Press; 1979.

8. Cameron C, Craig CL, Coles C, Cragg S. Increasing Physical Activity: Encouraging Physical Activity Through School. Ottawa, ON: Canadian Fitness and Lifestyle Research Institute; 2001.

9. Aveyard P, Markham WA, Cheng KK. A methodological and substantive review of the evidence that schools cause pupils to smoke. Soc Sci Med 2004;58(11):2253-65.

10. Leatherdale ST, Manske S. The relationship between student smoking in the school environment and smoking onset in elementary school students. Cancer Epidemiol Biomarkers Prev 2005;14(7):1762-5.

11. Leatherdale ST, Brown KS, Cameron R, McDonald PW. Social modeling in the school environment, student characteristics, and smoking susceptibility: a multi-level analysis. J Adolesc Health 2005;37(4):330-6.

12. Leatherdale ST, Cameron R, Brown KS, McDonald PW. Senior student smoking at school, student characteristics, and smoking onset among junior students: a multilevel analysis. Prev Med 2005;40(6):853-9.

13. Cameron R, Brown KS, Best JA, et al. Effectiveness of a social influences smoking prevention program as a function of provider type, training method, and school risk. Am J Public Health 1999;89(12):1827-31.

14. Ferreira I, van der Horst K, Wendel-Vos W, Kremers S, van Lenthe FJ, Brug J. Environmental correlates of physical activity in youth - a review and update. Obes Rev 2007;8(2):129-54.

15. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Med Sci Sports Exerc 2000;32(5):963-75.

16. Zhu W. A multilevel analysis of school factors associated with health-related fitness. Res Q Exerc Sport 1997;68(2):125-35.

17. Ma X. Health outcomes of elementary school students in New Brunswick. The education perspective. Eval Rev 2000;24(5):435-56.

18. Maes L, Lievens J. Can the school make a difference? A multilevel analysis of adolescent risk and health behaviour. Soc Sci Med 2003;56(3):517-29.

19. Moos RH. Social-Ecological Perspectives on Health. In: Stone GC, Cohen F, Adler NE, eds. Health Psychology: A Handbook. San Francisco: Jossey-Bass; 1980.

20. Stokols D. Establishing and maintaining healthy environments. Toward a social ecology of health promotion. Am Psychol 1992;47(1):6-22.

21. Sallis JF, Owen N. Ecological models of health behavior. In: Glanz K, Rimer, B.K., Lewis, F.M., ed. Health Behavior and Health Education: Theory, Research and Practice. 3 ed. San Francisco, CA: Jossey-Bass; 2002.

22. McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. Health Educ Q 1988;15(4):351-77.

23. Active2010: Ontario's Sport and Physical Activity Strategy: Ministry of Health Promotion; 2005 August 26.

24. Green LW, Kreuter MW. Health Promotion Planning: An Educational and Ecological Approach. 3rd ed. Mountain View, CA: Mayfield; 1999.

25. Bandura A. Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice Hall; 1986.

26. Raudenbush SW, Bryk AS. Hierarchical Linear Models: Applications and Data Analysis Methods. Thousand Oaks: Sage Publications; 2002.

27. Murray DM, Rooney BL, Hannan PJ, et al. Intraclass correlation among common measures of adolescent smoking: estimates, correlates, and applications in smoking prevention studies. Am J Epidemiol 1994;140(11):1038-50.

28. Kish L. Survey Sampling. New York, NY: John Wiley & Sons; 1965.

29. Donner A, Birkett N, Buck C. Randomization by cluster. Am J Epidemiol 1981;114:906-14.

30. Frohlich KL, Potvin L, Gauvin L, Chabot P. Youth smoking initiation: disentangling context from composition. Health Place 2002;8(3):155-66.

31. Sallis JF. Age-related decline in physical activity: a synthesis of human and animal studies. Med Sci Sports Exerc 2000;32(9):1598-600.

32. Mercer SL, Green LW, Rosenthal AC, Husten CG, Khan LK, Dietz WH. Possible lessons from the tobacco experience for obesity control. The American journal of clinical nutrition 2003;77(4 Suppl):1073S-82S.

33. Yach D, McKee M, Lopez AD, Novotny T. Improving diet and physical activity: 12 lessons from controlling tobacco smoking. Bmj 2005;330(7496):898-900.

34. Green LW, Orleans CT, Ottoson JM, Cameron R, Pierce JP, Bettinghaus EP. Inferring strategies for disseminating physical activity policies, programs, and practices from the successes of tobacco control. Am J Prev Med 2006;31(4 Suppl):S66-81.

35. Swinburn BA. The obesity epidemic in Australia: can public health interventions work? Asia Pacific journal of clinical nutrition 2003;12 Suppl:S7.

36. Orleans CT, Gruman J, Ulmer C, Emont SL, Hollendonner JK. Rating our progress in population health promotion: report card on six behaviors. Am J Health Promot 1999;14(2):75-82.

37. Moore L, Roberts C, Tudor-Smith C. School smoking policies and smoking prevalence among adolescents: multilevel analysis of cross-sectional data from Wales. Tob Control 2001;10(2):117-23.

38. Wakefield MA, Chaloupka FJ, Kaufman NJ, Orleans CT, Barker DC, Ruel EE. Effect of restrictions on smoking at home, at school, and in public places on teenage smoking: cross sectional study. Bmj 2000;321(7257):333-7.

39. Reitsma AH, Manske S. Smoking in Ontario schools: does policy make a difference? Can J Public Health 2004;95(3):214-8.

40. Lovato CY, Sabiston CM, Hadd V, Nykiforuk CI, Campbell HS. The impact of school smoking policies and student perceptions of enforcement on school smoking prevalence and location of smoking. Health Educ Res 2006.

41. Kumar R, O'Malley PM, Johnston LD. School tobacco control policies related to students' smoking and attitudes toward smoking: national survey results, 1999-2000. Health Educ Behav 2005;32(6):780-94.

42. Leatherdale ST, Cameron R, Brown KS, Jolin MA, Kroeker C. The influence of friends, family, and older peers on smoking among elementary school students: low-risk students in high-risk schools. Prev Med 2006;42(3):218-22.

43. Leatherdale ST, McDonald PW, Cameron R, Brown KS. A multilevel analysis examining the relationship between social influences for smoking and smoking onset. Am J Health Behav 2005;29(6):520-30.

44. Leatherdale ST, McDonald PW, Cameron R, Jolin MA, Brown KS. A multi-level analysis examining how smoking friends, parents, and older students in the school environment are risk factors for susceptibility to smoking among non-smoking elementary school youth. Prev Sci 2006;7(4):397-402.

45. Murray DM, Catellier DJ, Hannan PJ, et al. School-level intraclass correlation for physical activity in adolescent girls. Med Sci Sports Exerc 2004;36(5):876-82.

46. Bouchard C, Perusse L. Heredity, activity level, fitness and health. In: Bouchard C, Shephard RJ, Stephens T, eds. Physical Activity, Fitness and Health: International Proceedings and Consensus Statement. Champaign, Ill.: Human Kinetics Publishers; 1994:106-18.

47. Cameron R, Manske S, Brown KS, Jolin M, Murnaghan D, Lovato C. Integrating public health policy, practive, evaluation, surveillance, and research using local data collection and feedback systems: A prototype focused on schools. Am J Public Health In press.

48. Cameron C, Craig CL, Coles C, Cragg S. Increasing physical activity: Encouraging physical activity through school. Ottawa, ON: Canadian Fitness and Lifestyle Research Institute; 2003.

49. Ahmed R, Leatherdale ST, Wong SL, Manske SR, Reid J. The SHAPES-Ontario Project: technical report and descriptive statistics of the baseline sample. J Sch Health Submitted.

50. Grewal K, Manske SR, Wong SL, Leatherdale ST, D'Souza J. Practice-based evidence: Designing and testing a school-based questionnaire for physical activity assessment. Unpublished.

51. Wong SL, Leatherdale ST, Manske SR. Reliability and validity of a school-based physical activity questionnaire. Med Sci Sports Exerc 2006;38(9):1593-600.

52. The School Smoking Profile: Background. 2005. (Accessed March 20, 2006, at http://www.phr.uwaterloo.ca/products/product_details.cfm?productID=100)

53. Canada Post Guide. Canada Post, 2006. (Accessed October 16, 2006, at http://www.canadapost.ca/tools/pg/manual/b03-e.asp)

54. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, et al. CDC growth charts: USA. Advance Data from the Centers for Disease Control and Prevention/National Center for Health Statistics 2000;314:1-28.

55. Canadian Paediatric Society. The use of growth charts for assessing and monitoring growth in Canadian infants and children. . Paediatrics & Child Health 2004;9:171-80.

56. Corbin CB, Pangrazi RP, Welk GJ. Toward an understanding of appropriate physical activity levels for youth. PCPFS Research Digest 1994;8:1-12.

57. Centers for Disease Control and Prevention. Physical Activity Terms. (Accessed June 30, 2007, at http://www.cdc.gov/nccdphp/dnpa/physical/terms/)

58. Nelson MC, Gordon-Larsen P. Physical activity and sedentary behavior patterns are associated with selected adolescent health risk behaviors. Pediatrics 2006;117(4):1281-90.

59. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. Bmj 2000;320(7244):1240-3.

60. Shields M. Measured obesity: Overweight Canadian children and adolescents. Ottawa, ON: Statistics Canada; 2005. Report No.: 82-620-MWE2005001.

61. Murray DM, Alfano CM, Zbikowski SM, Padgett LS, Robinson LA, Klesges R. Intraclass correlation among measures related to cigarette use by adolescents: estimates from an urban and largely African American cohort. Addict Behav 2002;27(4):509-27.

62. Murray DM, Short BJ. Intraclass correlation among measures related to tobacco use by adolescents: estimates, correlates, and applications in intervention studies. Addict Behav 1997;22(1):1-12.

63. Ontario Ministry of Education. (Accessed June 30, 2007, at www.edu.gov.on.ca)

64. Brooks F, Magnusson J. Taking part counts: adolescents' experiences of the transition from inactivity to active participation in school-based physical education. Health Educ Res 2006;21(6):872-83.

65. Burgeson CR, Wechsler H, Brener ND, Young JC, Spain CG. Physical education and activity: results from the School Health Policies and Programs Study 2000. J Sch Health 2001;71(7):279-93.

66. Dwyer JJ, Allison KR, LeMoine KN, et al. A provincial study of opportunities for school-based physical activity in secondary schools. J Adolesc Health 2006;39(1):80-6.

67. Participation in high school physical education--Ontario, Canada, 1999-2005. MMWR Morb Mortal Wkly Rep 2007;56(3):52-4.
68. Participation in high school physical education--United States, 1991-2003. MMWR Morb Mortal Wkly Rep 2004;53(36):844-7.

69. Federal, Provincial and Territorial Advisory Committee on Population Health. Second Report on the Health of Canadians: Toward a Healthy Future; 1999 September.

70. Reading Achievement in Canada and the United States: Findings from the OECD Programme for International Student Assessment - May 2004. Human Resources and Social Development Canada, 2004. (Accessed October 16, 2006, at http://www11.hrsdc.gc.ca/en/cs/sp/hrsdc/lp/publications/2004-002611/page06.shtml)

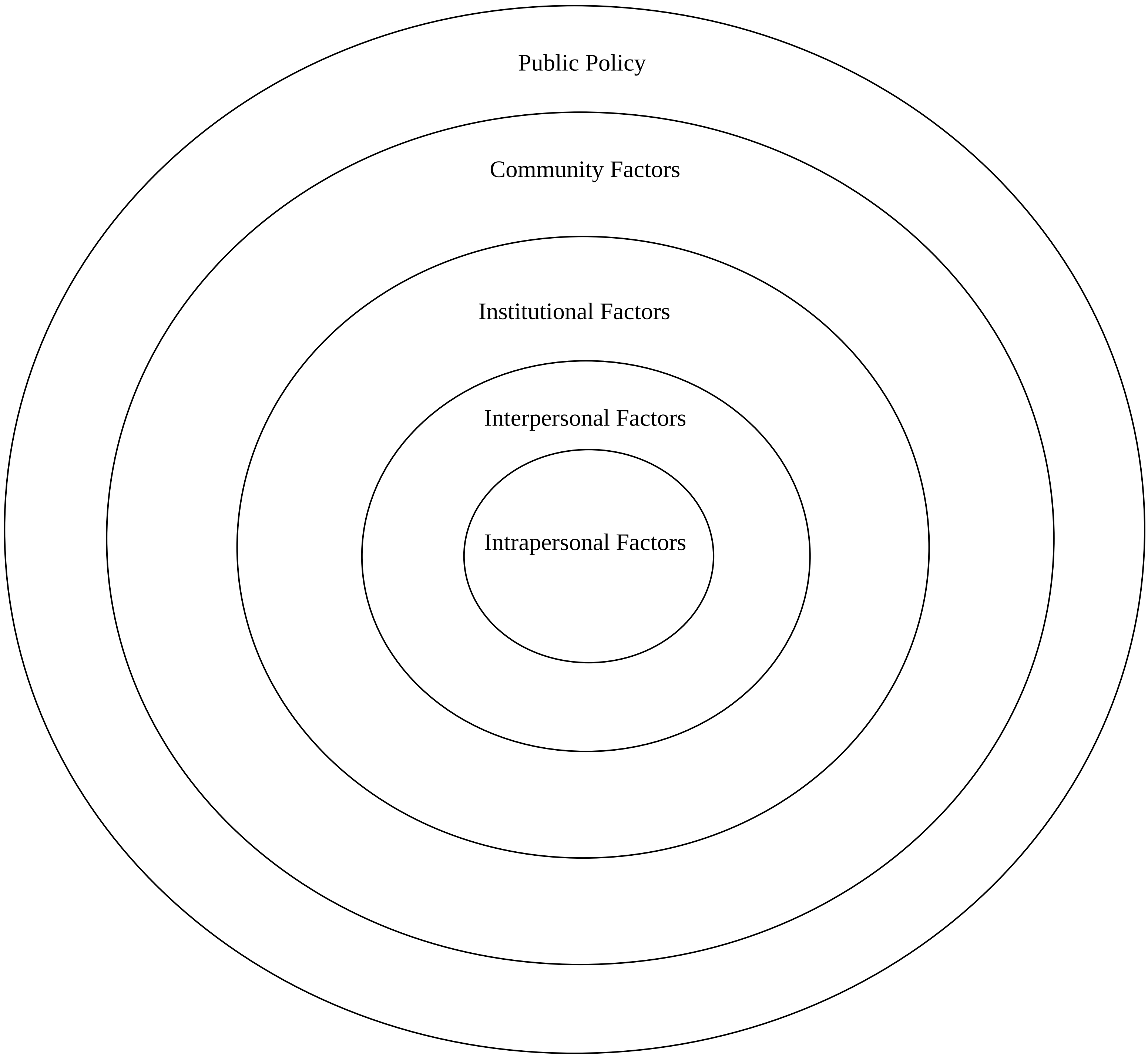
71. Everett Jones S, Brener ND, McManus T. Prevalence of school policies, programs, and facilities that promote a healthy physical school environment. Am J Public Health 2003;93(9):1570-5.

72. St.Pierre M, Beland Y. Mode effects of the Canadian Community Health Survey: a comparison of CAPI and CATI. In: 2004 Proceedings of the American Statistical Association Meeting, Survey Research Methods; Toronto, ON: American Statistical Association; 2004.

73. McNeely CA, Nonnemaker JM, Blum RW. Promoting school connectedness: evidence from the National Longitudinal Study of Adolescent Health. J Sch Health 2002;72(4):138-46.

Appendix A

Social-ecological Model; Levels of Influence



A social-ecological model of health behaviour from McLeroy et al., *Health Educ Q*. 15:351-377, 1988.

Appendix B

Author Contributions to the SHAPES Research Program

Author Contributions to SHAPES Research Program

My involvement with the SHAPES research program began when I started my doctoral studies at the University of Waterloo in September, 2003. I have primarily been involved in the development and use of the SHAPES Physical Activity Module.

Development of SHAPES Physical Activity Module

I assisted in determining the content, wording and format of the Physical Activity Module student questionnaire and feedback report. In addition, I provided input and feedback on the development of Physical Activity Module report card, which is used to provide the results of the administrator questionnaire to corresponding schools.

Multiple studies were conducted to determine the reliability and validity of the Physical Activity Module student questionnaire. I assisted in designing and collecting data for the quantitative validation study, and analyzed the data for both the test-retest reliability study and quantitative validation study. I led the writing and revising of the corresponding manuscript, which has been published (Wong et al., 2006). I assisted in designing the qualitative validation study and the presentation of the results as a conference poster (Grewal et al., 2006). In addition, I assisted in designing the study to validate the physical education items, the presentation of the results as a conference poster (Costa et al., 2006) and a manuscript, which is under review (Costa et al.).

I also co-authored a manuscript that describes the SHAPES concept, and in particular, how the development of the Physical Activity Module extends SHAPES and enables it to address the issues of child and adolescent physical inactivity and obesity (Leatherdale et al., 2007). In addition, I have authored and co-authored multiple conference presentations describing the SHAPES concept (Wong et al., 2004; Manske et al., 2004; Leatherdale et al., 2006; Cameron et al., 2007).

SHAPES Projects

The SHAPES Ontario Project

As a co-investigator on SHAPES-ON, I worked in close collaboration with the co-principal investigators to lead the development and implementation of the project. This included attending regular meetings and helping to make decisions about all aspects of the project, such as consent procedures and recruitment, as well as data collection, management and sharing. In addition to using SHAPES-ON data to perform secondary data analysis for my dissertation, I have presented results as a conference poster (Wong et al., 2006), co-authored a conference presentation (Hobin et al., 2007) and co-authored multiple manuscripts that are in press (Leatherdale et al.) or under review (Leatherdale et al.; Leatherdale and Wong; Ahmed et al.; Robertson-Wilson et al.; Hobin et al.).

The SHAPES-ON Knowledge Exchange Extension – Phases 1 and 2

The objective of the Knowledge Exchange (KE) Extension to SHAPES-ON, funded by the Canadian Institutes of Health Research (CIHR), Centre for Behavioural Research and Program Evaluation (CBRPE) and participating public health units, is to facilitate evidence-informed practice in public health units. A knowledge broker links public health staff and researchers to develop resources and share expertise to make the best use of the SHAPES-ON data, both at the school level and at the health unit level. SHAPES-ON collected data from eight public health unit regions. Of these, six are participating in the KE Extension.

I am a co-investigator on Phase 2 of the KE Extension, which is funded by CIHR, NB Department of Wellness, Culture & Sport, participating public health units and CBRPE. Phase 2 will enable us to continue working with the six public health units to make the best use of SHAPES-ON data. In addition, it will enable us to extend these knowledge exchange activities to New Brunswick, where SHAPES was recently used to collect provincial baseline data on smoking, physical activity, healthy eating and mental wellness from students in grades 6-12.

School Health Environment Survey

I am also a co-investigator on a project to pilot test and implement the School Health Environment Survey (SHES), funded by the Ontario Ministry of Health Promotion. SHES is an administrator questionnaire that is designed to collect data about the physical activity and healthy eating environment of schools, e.g. programs, policies and facilities. The intention is that SHES will be used as the school administrator questionnaire component of the SHAPES Physical Activity Module and Healthy Eating Module, respectively.

SHAPES Publications

Peer Reviewed Journals

Robertson-Wilson JE, Leatherdale ST, Wong SL. Social-ecological correlates of active commuting to school among high school students. *Journal of Adolescent Health.* In press.

Leatherdale ST, Wong SL. Modifiable factors associated with sedentary behaviours among youth. *International Journal of Pediatric Obesity*. In press.

Leatherdale ST, Wong SL, Manske SR, Colditz GA. Susceptibility to smoking and its association with physical activity, BMI and weight concerns among non-smoking youth. *Nicotine & Tobacco Research*. In press.

Leatherdale ST, Manske S, Wong SL, Cameron R. Integrating research, policy and practice in school-based physical activity prevention programming: The School Health Action, Planning and Evaluation System (SHAPES) Physical Activity Module. *Health Promotion Practice.* In press.

Wong SL, Leatherdale ST, Manske SR. Reliability and Validity of a School-based Physical Activity Questionnaire. *Medicine and Science in Sports and Exercise.* 38:1593-1600, 2006

Submitted

Leatherdale ST, Wong SL, Manske SR, Colditz GA. Physical activity and smoking among youth: an exploratory analysis of their associations with BMI, weight perceptions and screen time sedentary behaviour. *Journal of Physical Activity and Health*. Submitted.

Hobin EP, Bonin EN, Wong SL, Leatherdale ST, Manske SR, Burkhalter RJ. Secondary school students' physical activity behaviour: Evidence to inform school-based programs. *Canadian Journal of Public Health*. Submitted.

Ahmed R, Leatherdale ST, Wong SL, Manske SR, Reid J. The SHAPES-Ontario Project: technical report and descriptive statistics of the baseline sample. *Journal of School Health.* Submitted.

Costa ML, Wong SL, Manske SR, Leatherdale ST. Validation of a measure of active time in physical education: The SHAPES physical activity questionnaire. *Journal of Adolescent Health.* Submitted.

Published Abstracts and other Conference Proceedings

Cameron R, Manske S, Leatherdale S, Wong S, Morrison B. Creation of the School Health Action, Planning and Evaluation System (SHAPES) as a National Asset for Integrating Research, Evaluation, Policy, Practice and Surveillance. International Society of Behavioral Nutrition and Physical Activity, June 20-23, 2007, Oslo, Norway.

Hobin E, Bonin E, Leatherdale S, Wong S, Manske S, Burkhalter R. Secondary school students school-based physical activity behaviours: Results from SHAPES-Ontario. International Union for Health Promotion and Education, June 10-15, 2007. Vancouver, British Columbia.

Grewal K, Manske SR, Wong SL, Leatherdale ST. Practice-based evidence: Designing and testing a school-based questionnaire for physical activity assessment. Healthy Eating and Active Living Conference, November 29-30, 2006, Toronto, Ontario.

Wong SL, Hobin E, Bonin E, Leatherdale ST, Manske SR. The School Health Action, Planning and Evaluation System (SHAPES) Ontario Project: Transforming the Relationship Between Research, Policy and Practice. Healthy Eating and Active Living Conference, November 29-30, 2006, Toronto, Ontario.

Costa M, Wong SL, Manske S. Validity of Self-Reported Time Spent Active in Physical Education Class. Chronic Diseases Prevention Alliance of Canada Conference, November 5-8, 2006, Ottawa, Ontario.

Leatherdale ST, Manske S, Wong SL, Cameron R. Extending the School Health Action, Planning and Evaluation System (SHAPES) to Address Child and Adolescent Obesity: Transforming the Relationship Between Research, Policy and Practice. UICC World Cancer Congress 2006, July 9-12, 2006, Washington, D.C.

Manske S, Wong S, Robinson S, Leatherdale S, Brawley L. School Health Action, Planning and Evaluating System: Physical Activity Module. Chronic Disease Prevention Alliance of Canada Conference, November 6-8, 2004, Ottawa, Ontario.

Wong SL, Manske S, Leatherdale S, Robinson SJ and Cameron R. Development of the School Health Action, Planning and Evaluation System (SHAPES), a Local Data Collection System. The Cooper Institute Conference Series, October 21-23, 2004, Dallas, Texas.

Appendix C

SHAPES-ON Parent and Student Information and Consent Letters

PHR population health research group

ideas for health | innovations in data, evidence & applications

Dear Student:

This letter describes a research study being conducted at your school by the Population Health Research Group at the University of Waterloo in partnership with your local public health unit. The main purpose of this study is to collect information from students about their physical activity and smoking behaviours and attitudes. Your participation will provide valuable information that will assist schools and public health departments to plan programs that will prevent tobacco use and increase physical activity levels in schools.

The survey is confidential and anonymous. This means that your name will **not** be written on the questionnaire. No one at your school will know your answers. **Only the researchers who are part of the Population Health Research Group at the University of Waterloo will see your answers**. Questionnaires are sealed in envelopes before they are taken out of the classroom. Codes, not names, are used when questionnaire answers are put into computer files. Questionnaires will be stored securely for 7 years after the completion of the project; after 7 years, questionnaires will be shredded. Electronic data will be retained indefinitely in a secure location. The questionnaire will take 10-20 minutes to complete during classroom time.

The decision to participate in this study is made by you and your parents. If you agree to participate now but later change your mind, you can withdraw at any time while completing the questionnaire. Your co-operation in taking part in this research is greatly appreciated. However, you may decline answering any questions you prefer not to answer, and there is no penalty of any kind if you do not participate. Your teacher can instruct you about how to use this time if you do not wish to participate. If you have any questions or desire further information with respect to this study, you may contact Jessica Reid at **1-800-667-1804, ext. 7068**.

We have received permission from your school board and principal to conduct this research. This research has been reviewed and ethics clearance has been granted by the Office of Research Ethics at the University of Waterloo. If you have any questions or concerns resulting from your school's participation in this study, please feel free to contact Dr. Susan Sykes, Director of Research Ethics at the University of Waterloo, at (519) 888-4567 ext. 6005.

Sincerely,

Jessica Reid

Steve Manske

Scott Leatherdale

Jessica Reid	Steve Manske, Ed.D.	Scott Leatherdale, Ph.D.
Project Manager	Co-Principal Investigator	Co-Principal Investigator
University of Waterloo	University of Waterloo	Cancer Care Ontario

POPULATION HEALTH RESEARCH GROUP

University of Waterloo | LHN 2704, 200 University Avenue West, Waterloo, Ontario N2L 3G1

Tel. 519-888-4747 | Fax. 519-746-8171 | www.phr.uwaterloo.ca

PHR population health research group   ideas for health innovations in data, evidence & applications

[date]

Dear Parent/Guardian:

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

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

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

Final decision on participation is that of parents and students. If you and your son or daughter agree to participate now but later change your mind, either you or your son or daughter can withdraw at any time. Your co-operation in considering permitting your son or daughter to take part in this research is greatly appreciated. However, there is no penalty of any kind if he/she does not participate. A student will not be included in the study if a parent or guardian declines his/her participation or if the student does not agree to take part. **If you do NOT want your son or daughter to participate, please contact Jessica Reid at 1-800-667-1804, ext. 7068 BY [call by date].** If you have any questions or desire further information with respect to this study, you may contact Jessica Reid at the number above or visit the project website at: **www.shapes.uwaterloo.ca/ontario.**

Sincerely,

Jessica Reid	Steve Manske, Ed.D.	Scott Leatherdale, Ph.D.
Project Manager	Co-Principal Investigator	Co-Principal Investigator
University of Waterloo	University of Waterloo	Cancer Care Ontario

POPULATION HEALTH RESEARCH GROUP

University of Waterloo | LHN 2704, 200 University Avenue West, Waterloo, Ontario N2L 3G1

Tel. 519-888-4747 | Fax. 519-746-8171 | www.phr.uwaterloo.ca

Appendix D

Quality Control Procedures

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

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

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

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

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

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

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

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

We recently evaluated this process. In this exercise, we were able to quantify the individual and synergistic contributions of these quality control activities to determine the optimal protocol for survey processing. We determined that the error rate in the machine scanned data is 0.01% prior to corrections being made to the data set. We make the corrections. We continue to monitor the scanning process and make improvements to ensure both accuracy and efficiency.

For more information:

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

(519) 888-4567 ext.6552
majolin@healthy.uwaterloo.ca

Appendix E

SHAPES Physical Activity Module Student Questionnaire

SHAPES - Physical Activity

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

Improper Marks

Please

Use an HB Pencil Only

Proper Mark

The name of my school is: ____

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

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

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

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

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

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

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

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

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

PLEASE DO NOT WRITE IN THIS AREA

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

○ 0 days	○ 4 days
○ 1 day	○ 5 days
○ 2 days	○ 6 days
○ 3 days	○ 7 days

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

○ 0 days	○ 4 days
○ 1 day	○ 5 days
○ 2 days	○ 6 days
○ 3 days	○ 7 days

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

"My height is ________________"

Example: <u>5 ft 7in</u>

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

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

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

"My weight is ________________"

Example: <u>127lbs</u>

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

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

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

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

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

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

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

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

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

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

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

- ○ Yes
- ○ No

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

- ○ Excellent
- ○ Good
- ○ Fair
- ○ Poor

19. **Do you consider yourself:**

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

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

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

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

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

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

21. Were the last 7 days a typical week in terms of the amount of HARD physical activity that you usually do?
- ○ Yes
- ○ No, I was *more* active in the last 7 days
- ○ No, I was *less* active in the last 7 days

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

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

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

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

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

23. Were the last 7 days a typical week in terms of the amount of MODERATE physical activity that you *usually* do?
- ○ Yes
- ○ No, I was *more* active in the last 7 days
- ○ No, I was *less* active in the last 7 days

24. Do you participate in intramurals/house league sports at school?
- ○ Yes
- ○ No

25. Do you participate in school team/varsity sports?
- ○ Yes
- ○ No

26. Do you participate in other physical activities at school (e.g., play in gym, play outside)?
- ○ Yes
- ○ No

27. Do you participate in league or team sports outside of school?
- ○ Yes
- ○ No

28. Do you participate in individual physical activities outside of school (e.g., jogging, yoga, aerobics)?
- ○ Yes
- ○ No

29. What do you think of the number of sports offered at your school?
- ○ Does not matter to me
- ○ Too few
- ○ Just right
- ○ Too many

30. In a *typical* Physical Education class, how much time are you actually active?
- ○ I am not taking a physical education class
- ○ Less than 15 minutes
- ○ 15 to 30 minutes
- ○ 31 to 45 minutes
- ○ 46 to 60 minutes
- ○ More than 1 hour

31. How many Physical Education classes did you have in the last 7 days?
- ○ 0 classes
- ○ 1 class
- ○ 2 classes
- ○ 3 classes
- ○ 4 classes
- ○ 5 classes

32. In your school, how much emphasis is placed on:

	None	A little	Some	A lot	I don't know
a) Student participation in competitive sports?	○	○	○	○	○
b) Student participation in recreational sports?	○	○	○	○	○
c) Developing positive attitudes about physical activity?	○	○	○	○	○
d) Developing students' self-esteem (e.g., feeling good about yourself)?	○	○	○	○	○
e) Informing students about opportunities to be physically active (e.g., bulletin boards, announcements)?	○	○	○	○	○

33. Do the subjects offered in your school teach students about:

	Yes	No	I don't know
a) Benefits of physical activity?	○	○	○
b) Illnesses related to an inactive lifestyle?	○	○	○
c) Influence of families on physical activity?	○	○	○
d) Influence of the media on physical activity?	○	○	○
e) Influence of friends on physical activity?	○	○	○

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

	Strongly agree	Agree	Disagree	Strongly disagree
a) Students should have opportunities to participate in physical activity each day.	○	○	○	○
b) Physical education should be a required subject at school.	○	○	○	○
c) Students should participate in a physical education class at school every day.	○	○	○	○
d) The indoor physical activity facilities at this school meet my needs.	○	○	○	○
e) The outdoor physical activity facilities at this school meet my needs.	○	○	○	○
f) The facilities at this school accommodate physical activity even when the weather is extreme (e.g., raining or snowing).	○	○	○	○

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

	Strongly agree	Agree	Disagree	Strongly disagree
a) I feel close to people at my school.	○	○	○	○
b) I feel I am part of my school.	○	○	○	○
c) I am happy to be at my school.	○	○	○	○
d) I feel the teachers at my school treat me fairly.	○	○	○	○
e) I feel safe in my school.	○	○	○	○

36. Have you ever been curious about smoking a cigarette?
○ Yes ○ No

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

38. Have you ever smoked a whole cigarette?
○ Yes ○ No ○ I have never smoked

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

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

41. Are you a smoker?
○ Yes ○ No

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

43. Do you think in the future you might try smoking cigarettes?
○ I already smoke
○ Definitely yes
○ Probably yes
○ Probably not
○ Definitely not

44. If one of your best friends was to offer you a cigarette, would you smoke it?
○ Definitely yes
○ Probably yes
○ Probably not
○ Definitely not

45. At any time during the next year do you think that you will smoke a cigarette?
○ Definitely yes
○ Probably yes
○ Probably not
○ Definitely not

PLEASE DO NOT WRITE IN THIS AREA

Appendix F

SHAPES Tobacco Module Student Questionnaire

SHAPES - Smoking Behaviour

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

Improper Marks

Please

Proper Mark

The name of my school is: ______________________________

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

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

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

4. Does your father (or stepfather or foster father) smoke cigarettes? Think about the father you see the most.
- ○ I have no father
- ○ No, he has never smoked
- ○ No, he has stopped smoking
- ○ Yes, he smokes cigarettes, cigars or a pipe
- ○ I don't know

5. Does your mother (or stepmother or foster mother) smoke cigarettes? Think about the mother you see the most.
- ○ I have no mother
- ○ No, she has never smoked
- ○ No, she has stopped smoking
- ○ Yes, she smokes cigarettes, cigars or a pipe
- ○ I don't know

6. Do any of your older brothers smoke cigarettes?
- ○ Yes
- ○ No
- ○ I don't know
- ○ I don't have any older brothers

7. Do any of your older sisters smoke cigarettes?
- ○ Yes
- ○ No
- ○ I don't know
- ○ I don't have any older sisters

8. How many people your age, at your school, do you think smoke cigarettes?
- ○ 91-100%
- ○ 81-90%
- ○ 71-80%
- ○ 61-70%
- ○ 51-60%
- ○ 41-50%
- ○ 31-40%
- ○ 21-30%
- ○ 11-20%
- ○ 0-10%

9. Since September, how many classes or lectures did you have that talked about <u>cigarette smoking</u>?
- ○ No classes
- ○ 1 or 2 classes
- ○ 3 or 4 classes
- ○ 5 or 6 classes
- ○ 7 or more classes

10. Since September, have you taken part in any other anti-smoking activities or events at your school?
- ○ Yes
- ○ No
- ○ I don't know

11. Have you seen or heard any anti-smoking campaigns in the last year?
- ○ Yes
- ○ No
- ○ I don't know

12. In the last year have you seen or heard any anti-smoking campaigns with the slogan *stupid.ca*?
- ○ Yes
- ○ No
- ○ I don't know

13. If you have heard of *stupid.ca*, did you visit the web site?
- ○ Yes
- ○ No
- ○ I have not heard of *stupid.ca*

PLEASE DO NOT WRITE IN THIS AREA

14. **Are you exposed to smoking at your job?**
- ○ Yes
- ○ No
- ○ I do not have a job outside of school

15. **Have you ever been curious about smoking a cigarette?**
- ○ Yes
- ○ No

16. **Have you ever smoked a cigarette, even just a few puffs?**
- ○ Yes
- ○ No

17. **Have you ever smoked a whole cigarette?**
- ○ Yes
- ○ No
- ○ I have never smoked

18. **Have you smoked 100 or more whole cigarettes in your life?**
- ○ Yes
- ○ No
- ○ I have never smoked

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

20. **Think about the last 30 days. On the days that you smoked, how many cigarettes did you usually smoke?**
- ○ I did not smoke at all
- ○ A few puffs in a day
- ○ 1-2 cigarettes in a day
- ○ 3-5 cigarettes in a day
- ○ 6-10 cigarettes in a day
- ○ 11-19 cigarettes in a day
- ○ 20 or more cigarettes in a day

21. **In the last 12 months, how often did you smoke?**
- ○ I have never smoked
- ○ I have smoked, but not in the last 12 months
- ○ I have tried one cigarette in the last 12 months
- ○ I have had more than one cigarette in the last 12 months

22. **Are you a smoker?**
- ○ Yes
- ○ No

23. **Do you think in the future you might try smoking cigarettes?**
- ○ I already smoke
- ○ Definitely yes
- ○ Probably yes
- ○ Probably not
- ○ Definitely not

24. **If one of your best friends was to offer you a cigarette, would you smoke it?**
- ○ Definitely yes
- ○ Probably yes
- ○ Probably not
- ○ Definitely not

25. **At any time during the next year do you think that you will smoke a cigarette?**
- ○ Definitely yes
- ○ Probably yes
- ○ Probably not
- ○ Definitely not

26. **Do you plan to quit smoking cigarettes?**
- ○ I have never smoked
- ○ I have only smoked a few times
- ○ I have already quit
- ○ Yes, within one week
- ○ Yes, within 30 days
- ○ Yes, within six months
- ○ Yes, within one year
- ○ Yes, but I'm not sure when
- ○ No, I do not plan to quit smoking

27. **How long ago did you quit smoking?**
- ○ I have never smoked
- ○ I have only smoked a few times
- ○ I am still smoking
- ○ I quit less than 2 weeks ago
- ○ I quit between 2 weeks and 6 months ago
- ○ I quit between 6 months and one year ago
- ○ I quit more than one year ago

28. **How many times in the past year have you tried to quit smoking?**
- ○ I have not smoked in the last year
- ○ I have only smoked a few times in the last year
- ○ I have not tried to quit in the last year
- ○ I have tried to quit once in the last year
- ○ I have tried to quit 2 times in the last year
- ○ I have tried to quit 3 times in the last year
- ○ I have tried to quit 4 or more times in the last year

29. **How sure are you that you could quit smoking if you wanted to?**
- ○ Very sure
- ○ Sure
- ○ Unsure
- ○ Very unsure
- ○ I do not smoke
- ○ I have only smoked a few times
- ○ I do not want to quit

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

31. **Is there help available at this school for students who want to quit smoking?**
- ○ Yes
- ○ No
- ○ I don't know

32. **Would you join a program to help you quit smoking if one was offered at your school?**
- ○ Yes
- ○ No
- ○ I do not smoke cigarettes anymore
- ○ I have never smoked

33. **Do you think all public places (e.g., restaurants, malls, arcades, etc.) should be smoke-free?**
- ○ Definitely yes
- ○ Probably yes
- ○ Probably not
- ○ Definitely not

34. How often do you smoke in each of the following places?

	Often	Sometimes	Never	I don't smoke	
a) At home	○	○	○	○	61
b) Walking to and/or from school	○	○	○	○	60
c) At school but off school property	○	○	○	○	59
d) At school on school property	○	○	○	○	58
e) At concerts/dances/clubs	○	○	○	○	57
f) In restaurants/coffee shops	○	○	○	○	56
g) At parties	○	○	○	○	55
h) Other:______________	○	○	○	○	54

35. How often do you smoke at the following times?

	Often	Sometimes	Never	I don't smoke	
a) Before school	○	○	○	○	50
b) During the school day	○	○	○	○	49
c) After school	○	○	○	○	48
d) In the evening	○	○	○	○	47
e) On weekends	○	○	○	○	46
f) Other:______________	○	○	○	○	45

36. How often do you smoke with the following people?

	Often	Sometimes	Never	I don't smoke	
a) By myself	○	○	○	○	41
b) With my parents	○	○	○	○	40
c) With other family members	○	○	○	○	39
d) With friends	○	○	○	○	38
e) Other:______________	○	○	○	○	37

37. If you were thinking about quitting smoking, rate whether you might use the following ways to quit.

	I don't smoke	Definitely	Maybe	Never	
a) A self-help booklet	○	○	○	○	32
b) Group meetings at school	○	○	○	○	31
c) My doctor	○	○	○	○	30
d) Chat room on the Internet	○	○	○	○	29
e) Information site on the Internet	○	○	○	○	28
f) Teacher, guidance counsellor, or school nurse	○	○	○	○	27
g) Free telephone quit line	○	○	○	○	26
h) Friend's advice	○	○	○	○	25
i) Quit on my own	○	○	○	○	24
j) Nicotine gum or nicotine patch	○	○	○	○	23
k) Other:______________	○	○	○	○	22

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

	Strongly Agree	Agree	Disagree	Strongly Disagree	
a) I feel close to people at my school.	○	○	○	○	17
b) I feel I am part of my school.	○	○	○	○	16
c) I am happy to be at my school.	○	○	○	○	15
d) I feel the teachers at my school treat me fairly.	○	○	○	○	14
e) I feel safe in my school.	○	○	○	○	13

39. How many students at this school smoke where they are not allowed to?

○ A lot ○ A few
○ Some ○ None

40. This school has a clear set of rules about smoking for students to follow.

○ True ○ False
○ Usually true ○ I don't know
○ Usually false

41 I often see students smoking near this school.

○ True ○ Usually false 10
○ Usually true ○ False 9
8

42. If students are caught breaking the smoking rules at this school, they get into trouble.

○ True ○ False 5
○ Usually true ○ I don't know 4
○ Usually false 3
2
1

43. **In the last 30 days, how often have you noticed cigarette packs displayed <u>behind the counter</u> at convenience stores, corner stores, or gas stations?**
- ◯ Never
- ◯ Sometimes
- ◯ Always
- ◯ Haven't been to one of these stores in the last 30 days

44. **In the last 30 days, how often have you noticed cigarette packs displayed <u>on the counter</u> at convenience stores, corner stores, or gas stations?**
- ◯ Never
- ◯ Sometimes
- ◯ Always
- ◯ Haven't been to one of these stores in the last 30 days

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

"My height is ________________"

Example: 5 ft 7in

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

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

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

"My weight is ________________"

Example: 127lbs

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix G

Fully Unconditional Model

Fully Unconditional Model (One-way ANOVA with Random Effects)

Level 1 Model

$Y_{ij} = \beta_{0j} + r_{ij}$, var $(r_{ij}) = \sigma^2$

Level 2 Model

$\beta_{0j} = \gamma_{00} + u_{0j}$, var $(\beta_{0j}) = \tau^2_{00}$

Combined Model

$Y_{ij} = \gamma_{00} + u_{0j} + r_{ij}$

where

Y_{ij} = outcome of interest
β_{0j} = level-1 coefficient
γ_{00} = level-2 coefficient
r_{ij} = level-1 random effect, unique effect associated with student *i*
u_{0j} = level-2 random effect; unique effect associated with school *j*
σ^2 = variance among the students; within-group variability
τ^2_{00} = variance among the intercepts, between-group variability

Intraclass Correlation (ρ)

$\rho = \tau^2_{00} / (\tau^2_{00} + \sigma^2)$

where var $(\beta_{0j}) = \tau^2_{00}$

var $(r_{ij}) = \sigma^2$

Appendix H

Random Coefficient Model

Random Coefficient Model

Level 1 Model

$Y_{ij} = \beta_{0j} + \beta_{1j} (X_{ij}) + r_{ij}$, var $(r_{ij}) = \sigma^2$

Level 2 Model

$\beta_{0j} = \gamma_{00} + u_{0j}$, var $(\beta_{0j}) = \tau^2_{00}$

$\beta_{1j} = \gamma_{10} + u_{1j}$, var $(\beta_{1j}) = \tau^2_{11}$

Cov $(\beta_{0j}, \beta_{1j}) = \tau^2_{01}$

Combined Model

$Y_{ij} = \gamma_{00} + \gamma_{10} (X_{ij}) + u_{1j} (X_{ij}) + u_{0j} + r_{ij}$

where

Y_{ij} = outcome of interest
β_{0j} = level-1 coefficient
β_{1j} = level-1 coefficient
X_{ij} = level-1 predictor, e.g. age
γ_{00} = level-2 coefficient
γ_{10} = level-2 coefficient
r_{ij} = level-1 random effect; unique effect associated with student *i*
u_{0j} = level-2 random effect; unique effect associated with school *j*
u_{1j} = level-2 random effect; unique effect associated with school *j*
σ^2 = level-1 variance component
τ^2_{00} = level-2 variance component
τ^2_{11} = level-2 variance component
τ^2_{01} = level-2 covariance component

Appendix I

Intercepts and Slopes as Outcomes Model

Intercepts and Slopes as Outcomes Model

Level 1 Model

$Y_{ij} = \beta_{0j} + \beta_{1j} (X_{1ij}) + \beta_{2j} (X_{2ij}) + r_{ij,}$, var $(r_{ij}) = \sigma^2$

Level 2 Model

$\beta_{0j} = \gamma_{00} + \gamma_{01} (W_1) + \gamma_{02} (W_2) + u_{0j}$, var $(\beta_{0j}) = \tau^2_{00}$

$\beta_{1j} = \gamma_{10} + \gamma_{11} (W_1) + \gamma_{12} (W_2) + u_{1j}$, var $(\beta_{1j}) = \tau^2_{11}$

$\beta_{2j} = \gamma_{20} + \gamma_{21} (W_1) + \gamma_{22} (W_2) + u_{2j}$, var $(\beta_{2j}) = \tau^2_{22}$

Combined Model

$Y_{ij} = \gamma_{00} + \gamma_{01} (W_1) + \gamma_{02} (W_2) + \gamma_{10} (X_{1ij}) + \gamma_{20} (X_{2ij})$

$+ \gamma_{11} (W_1) (X_{1ij}) + \gamma_{12} (W_2) (X_{1ij}) + \gamma_{21} (W_1) (X_{2ij})$

$+ \gamma_{22} (W_2) (X_{2ij}) + u_{1j} (X_{1ij}) + u_{2j} (X_{2ij}) + u_{0j} + r_{ij}$

Cov $(\beta_{0j}, \beta_{1j}) = \tau^2_{01}$

Cov $(\beta_{0j}, \beta_{2j}) = \tau^2_{02}$

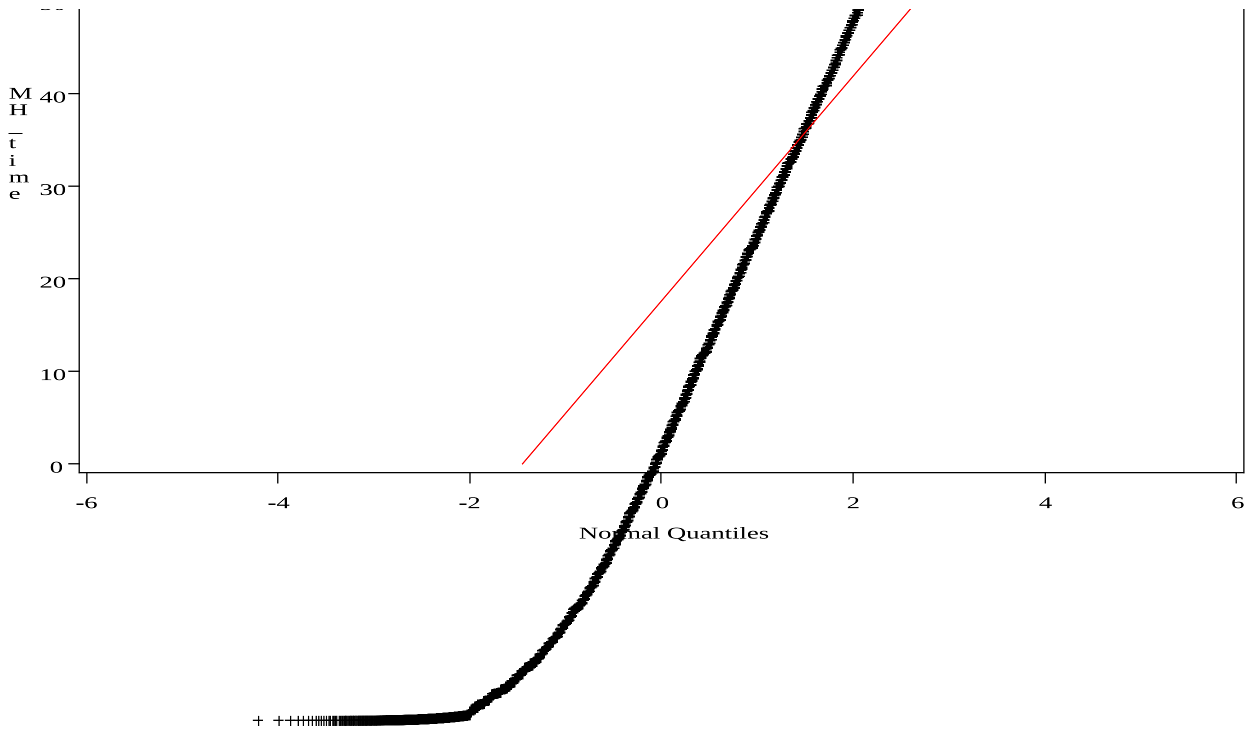
where

Y_{ij}	= outcome of interest
$\beta_{0j} \ldots \beta_{2j}$	= level-1 coefficient
$X_{1ij} \ldots X_{2ij}$	= level-1 predictor, e.g. age
$\gamma_{00} \ldots \gamma_{22}$	= level-2 coefficient
r_{ij}	= level-1 random effect; unique effect associated with student *i*
$u_{0j} \ldots u_{2j}$	= level-2 random effect; unique effect associated with school *j*
σ^2	= level-1 variance component
$\tau^2_{00} \ldots \tau^2_{22}$	= level-2 variance component
$\tau^2_{01} \ldots \tau^2_{02}$	= level-2 covariance component

Appendix J

Data Cleaning

A Q-Q plot of MVPA indicated floor and ceiling effects at 0 and 66.5 hr/wk.



Participants who reported MVPA=66.5 hr/wk were not significantly different in age, grade or BMI compared to those who reported other values of MVPA, but they were significantly different in gender (p<0.0001). In addition, there was a substantially greater percentage of participants with missing BMI values and reported MVPA=66.5 hr/wk (34.8%) compared to those who reported other values for MVPA (13.0%).

	MVPA (N = 51222)		MVPA=66.5 (N=204)	
Age	15.5 (1.3)	51139 (99.8%)	15.5 (1.4)	202 (99.0%)
Grade	10.4 (1.1)	51222 (100.0%)	10.3 (1.1)	204 (100%)
BMI	21.7 (3.4)	44562 (87.0%)	22.0 (3.4)	133 (65.2%)
Gender	50.9% male		87.6% male	

Due to the large number of hours per week that can reasonably be attributed to sleep and being sedentary at school, it seems unlikely that the observed ceiling effects were because participants had actually performed more than 66.5 hr of MVPA in the week prior to the survey (i.e. an average of 9.5 hr/day) but the response options limited them to responding 66.5 hr/wk. It seems more likely that these participants were not attempting to answer the questions honestly. Thus, these participants were excluded from the analyses (N=204).

Since it is not possible to perform less than 0 hr/wk of MVPA, the observed floor effects were not because the response options did not provide the option of reporting less MVPA. However, it is plausible that participants performed no MVPA in the week prior to the survey. Indeed, in a previous study (Wong et al., 2006), 2 of 67 students (3.0%) performed 0 hr/wk of MVPA as measured by accelerometers (unpublished results). In the current study, a similar percentage of students (2.2%, or 1108 of 51222) reported 0 hr/wk of MVPA. Thus, these participants were included in the analyses.

Appendix K

Results of fully unconditional models of physical activity for 76 secondary schools

Table K1. Results of fully unconditional models of physical activity for 76 secondary schools; overall and by module

Model	N	Intercept	p value	Between-School Variance	p value	Within-School Variance	p value	Intraclass Correlation
Overall								
Both Modules	49037	17.3754	<.0001	2.6345	<.0001	135.05	<.0001	0.019
Tobacco Module	24482	17.2725	<.0001	2.5595	<.0001	147.31	<.0001	0.017
PA Module	24555	17.4555	<.0001	3.0530	<.0001	122.54	<.0001	0.024

PA = physical activity

Table K2. Results of fully unconditional models of physical activity for 76 secondary schools by gender; overall and by module

Model	N	Intercept	p value	Between-School Variance	p value	Within-School Variance	p value	Intraclass Correlation
Both Modules								
Males	24628	19.4730	<.0001	3.1448	<.0001	152.27	<.0001	0.020
Females	24165	15.1783	<.0001	1.9384	<.0001	108.43	<.0001	0.018
Tobacco Module								
Males	12163	19.7575	<.0001	3.0791	<.0001	169.54	<.0001	0.018
Females	12176	14.7311	<.0001	2.1991	<.0001	112.82	<.0001	0.019
PA Module								
Males	12465	19.1579	<.0001	3.3878	<.0001	135.05	<.0001	0.025
Females	11989	15.6011	<.0001	2.1283	<.0001	103.35	<.0001	0.020

PA = physical activity

Table K3. Results of fully unconditional models of physical activity for 76 secondary schools by grade; overall and by module

Model	N	Intercept	p value	Between-School Variance	p value	Within-School Variance	p value	Intraclass Correlation
Both Modules								
Grade 9	13721	18.8242	<.0001	2.8513	<.0001	137.99	<.0001	0.020
Grade 10	13115	17.6189	<.0001	3.2991	<.0001	137.34	<.0001	0.024
Grade 11	11393	16.7408	<.0001	2.5658	<.0001	128.73	<.0001	0.020
Grade 12	10808	15.7614	<.0001	2.5273	<.0001	128.64	<.0001	0.019
Tobacco Module								
Grade 9	6782	18.4021	<.0001	3.8224	<.0001	149.53	<.0001	0.025
Grade 10	6563	17.5142	<.0001	3.6534	<.0001	149.10	<.0001	0.024
Grade 11	5843	16.7209	<.0001	2.5865	0.0006	138.75	<.0001	0.018
Grade 12	5294	16.0742	<.0001	2.7994	0.0001	145.05	<.0001	0.019
PA Module								
Grade 9	6939	19.2120	<.0001	3.1184	<.0001	125.31	<.0001	0.024
Grade 10	6552	17.7533	<.0001	3.9562	<.0001	124.80	<.0001	0.031
Grade 11	5550	16.7392	<.0001	3.1287	<.0001	117.52	<.0001	0.026
Grade 12	5514	15.5167	<.0001	3.6821	0.0001	111.28	0.0001	0.032

PA = physical activity

Appendix L

Results of nine multilevel models,
each with a single school-level predictor entered as a fixed effect

Table L1. Results of nine multilevel models, each with a single school-level predictor entered as a fixed effect

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Model 1				
Random				
Intercept	2.5743	0.4674		<.0001
Residual	135.05	0.8631		<.0001
Fixed				
Intercept	16.8255	0.3783	74	<.0001
Commute1	2.6958	1.5951	74	0.0952
Model 2				
Random				
Intercept	2.5885	0.4707		<.0001
Residual	135.05	0.8632		<.0001
Fixed				
Intercept	18.1621	0.6309	74	<.0001
Commute2	-3.6600	2.7923	74	0.1940
Model 3				
Random				
Intercept	2.4220	0.4413		<.0001
Residual	135.05	0.8631		<.0001
Fixed				
Intercept	14.7566	0.9730	74	<.0001
Intramurals	7.8034	2.8463	74	<.0077
Model 4				
Random				
Intercept	2.6248	0.4766		<.0001
Residual	135.05	0.8631		<.0001
Fixed				
Intercept	15.9784	1.1501	74	<.0001
Varsity	3.3784	2.7411	74	0.2217
Model 5				
Random				
Intercept	2.0041	0.3729		<.0001
Residual	135.05	0.8631		<.0001
Fixed				
Intercept	10.5919	1.4555	74	<.0001
Other	10.9721	2.3395	74	<.0001

Model 6				
Random				
Intercept	1.8530	0.3493		<.0001
Residual	135.05	.8631		<.0001
Fixed				
Intercept	21.5181	0.7968	74	<.0001
PE	-11.0531	2.0752	74	<.0001
Model 7				
Random				
Intercept	2.5327	0.4650		<.0001
Residual	135.05	0.8632		<.0001
Fixed				
Intercept	16.2260	0.6556	74	<.0001
Fac-Indoor	5.6013	3.0566	74	0.0709
Model 8				
Random				
Intercept	2.4637	0.4536		<.0001
Residual	135.05	0.8632		<.0001
Fixed				
Intercept	15.9536	0.6454	74	<.0001
Fac-Outdoor	7.9575	3.4559	74	0.0241
Model 9				
Random				
Intercept	2.6559	0.4847		<.0001
Residual	135.05	0.8632		<.0001
Fixed				
Intercept	17.0843	0.5929	74	<.0001
Fac-Accom	1.4169	2.7220	74	0.6042

Appendix M

Results of four multilevel models,
each with a single school-level predictor,
controlled for age, gender and interactions with age and gender

Table M1. Results of four multilevel models, each with a single school-level predictor, controlled for age, gender and interactions with age and gender

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Model 1				
Random				
Age				
Intercept	2.9423	0.5620		<.0001
Slope	0.0746	0.0344		0.0151
Covariance	-0.1037	0.1007		0.3028
Gender				
Intercept	-0.7794	0.2885		0.0069
Slope	0.4863	0.2243		0.0151
Covariance	0.1183	0.0636		0.0629
Residual	129.35	0.8306		<.0001
Fixed				
Intercept	16.3058	1.1053	74	<.0001
Age	-0.5910	0.2958	>49,000	0.0457
Gender	-2.5809	0.7338	>49,000	0.0004
Intramurals	9.4439	3.2372	74	0.0047
Age*Intramurals	-0.6634	0.8844	>49,000	0.4532
Gender*Intramurals	-5.0121	2.1966	>49,000	0.0225
Model 2				
Random				
Age				
Intercept	2.4625	0.4840		<.0001
Slope	0.0682	0.0338		0.0218
Covariance	-0.0544	0.0921		0.5551
Gender				
Intercept	-0.6715	0.2679		0.0122
Slope	0.4760	0.2239		0.0168
Covariance	0.1021	0.6274		0.1038
Residual	129.35	0.8306		<.0001
Fixed				
Intercept	11.8680	1.6774	74	<.0001
Age	-0.0931	0.4974	>49,000	0.8516
Gender	-1.6654	1.2370	>49,000	0.1728
Other	12.2914	2.6963	74	<.0001
Age*Other	-1.1651	0.8040	>49,000	0.1473
Gender*Other	-4.1700	2.0012	>49,000	0.0372

Model 3				
Random				
Age				
Intercept	2.2009	0.4424		<.0001
Slope	0.0756	0.0346		0.0143
Covariance	-0.1289	0.0912		0.1575
Gender				
Intercept	-0.5249	0.2466		0.0333
Slope	0.4099	0.2100		0.0255
Covariance	0.1268	0.0620		0.0410
Residual	129.35	0.8306		<.0001
Fixed				
Intercept	24.2819	0.9064	74	<.0001
Age	-0.7601	0.2805	>49,000	0.0067
Gender	-6.1600	0.6802	>49,000	<.0001
PE	-12.8589	2.3650	74	<.0001
Age*PE	-0.1375	0.7343	>49,000	0.8514
Gender*PE	5.1267	1.7753	>49,000	0.0039

Model 4				
Random				
Age				
Intercept	2.9488	0.5738		<.0001
Slope	0.0713	0.0339		0.0176
Covariance	-0.0799	0.1035		0.4406
Gender				
Intercept	-0.7693	0.6326		0.0880
Slope	0.4907	0.2263		0.0151
Covariance	0.1079	0.0633		0.0880
Residual	129.35	0.8306		<.0001
Fixed				
Intercept	17.7141	0.7257	74	<.0001
Age	-0.5845	0.1925	>49,000	0.0024
Gender	-3.3626	0.4839	>49,000	<.0001
Fac-Outdoor	9.8091	3.8853	74	0.0137
Age* Fac-Outdoor	-1.2650	1.0351	>49,000	0.2217
Gender* Fac-Outdoor	-4.9148	2.6090	>49,000	0.0596

Appendix N

Results of a multilevel model that included all significant school-level predictors, controlled for age, gender and interactions with age and gender

Table N1. Results of a multilevel model that included all significant school-level predictors, controlled for age, gender and interactions with age and gender

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Age				
Intercept	2.2273	0.4550		<.0001
Slope	0.0670	0.0343		0.0255
Covariance	-0.1018	0.9152		0.2660
Gender				
Intercept	-0.5453	0.2566		0.0336
Slope	0.4414	0.2186		0.0217
Covariance	0.1283	0.0632		0.0425
Residual	129.35	0.8306		<.0001
Fixed				
Intercept	19.7748	3.1633	71	<.0001
Age	1.1428	0.9539	>49,000	0.2309
Gender	-5.2866	2.3344	>49,000	0.0235
Intramurals	1.1182	3.7199	71	0.7646
Age*Intramurals	0.0894	1.0655	>49,000	0.9332
Gender*Intramurals	-2.6474	2.6701	>49,000	0.3215
Other	4.0610	4.1184	71	0.3274
Age*Other	-2.0298	1.2158	>49,000	0.0950
Gender*Other	1.1408	3.0078	>49,000	0.7045
PE	-9.4114	3.2642	71	0.0052
Age*PE	-1.5420	0.9781	>49,000	0.1149
Gender*PE	4.3012	2.4089	>49,000	0.0742
Fac-Outdoor	1.8724	4.0362	71	0.6441
Age* Fac-Outdoor	-0.8721	1.1902	>49,000	0.4637
Gender* Fac-Outdoor	-2.2046	2.9874	>49,000	0.4605

Appendix O

Results of a multilevel model that included all significant school-level predictors, controlled for age, gender, interactions with age and gender, and school demographics

Table O1. Results of a multilevel model that included all significant school-level predictors, controlled for age, gender, interactions with age and gender, and school demographics

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Age				
Intercept	2.5351	0.6827		0.0001
Slope	0.0715	0.0368		0.0260
Covariance	-0.2845	0.1188		0.0166
Gender				
Intercept	-0.8681	0.3644		0.0172
Slope	0.4718	0.2533		0.0313
Covariance	0.1177	0.0704		0.0946
Residual	128.12	0.9291		<.0001
Fixed				
Intercept	25.2097	1.6701	48	<.0001
Age	-0.7317	0.3165	>38,000	0.0208
Gender	-6.0005	0.7931	>38,000	<.0001
PE	-9.5147	3.0001	48	0.0026
Age*PE	-0.3951	0.8245	>38,000	0.6318
Gender*PE	4.5712	2.0586	>38,000	0.0264
School Income	-0.0530	0.0244	48	0.0351
School Board	-0.5539	0.3766	48	0.1479
School Size	0.1546	0.0544	48	0.0065
School Location	-1.4939	0.7989	48	0.0676

Table O2. The results of a multilevel model that included all significant school-level predictors, controlled for age, gender, interactions with age and gender, school demographics, and module.

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Age				
Intercept	2.5467	0.6856		0.0001
Slope	0.0772	0.0379		0.0208
Covariance	-0.2997	0.1213		0.0134
Gender				
Intercept	-0.8561	0.3668		0.0196
Slope	0.4872	0.2560		0.0285
Covariance	0.1182	0.0717		0.0993
Residual	127.87	0.9273		<.0001
Fixed				
Intercept	25.6362	1.6809	48	<.0001
Age	-0.4558	0.3243	>38,000	0.1599
Gender	-6.8966	0.8075	>38,000	<.0001
PE	-9.6781	3.0059	48	0.0023
Age*PE	-0.4959	0.8344	>38,000	0.5523
Gender*PE	4.7536	2.0724	>38,000	0.0218
School Income	-0.0519	0.0246	48	0.0405
School Board	-0.5690	0.3795	48	0.1403
School Size	0.1541	0.0548	48	0.0071
School Location	-1.4802	0.8049	48	0.0721
Module	-0.7604	0.1638	>38,000	<.0001
Age*Module	-0.4677	0.0941	>38,000	<.0001
Gender*Module	1.6373	0.2325	>38,000	<.0001

Appendix P

Results of the final slopes-and-intercepts-as-outcomes model
with the Physical Activity Module derived school-level predictors
and the Tobacco Module derived physical activity outcome

Table P1. Results of the final slopes-and-intercepts-as-outcomes model with the Physical Activity Module derived school-level predictors and the Tobacco Module derived physical activity outcome

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Age				
Intercept	2.2143	0.6266		0.0002
Slope	0.1608	0.0845		0.0285
Covariance	-0.3022	0.1711		0.0774
Gender				
Intercept	-0.6328	0.4361		0.1468
Slope	0.6071	0.4422		0.0849
Covariance	0.1022	0.1343		0.4465
Residual	139.20	1.4358		<.0001
Fixed				
Intercept	21.7619	1.6057	50	<.0001
Age	-0.6510	0.0900	>19,000	<.0001
Gender	-6.6556	1.0569	>19,000	<.0001
PE	-7.9402	3.0248	50	0.0115
Gender*PE	4.1680	2.7407	>19,000	0.1283
School Income	-0.0359	0.0262	50	0.1759
School Size	0.1948	0.0607	50	0.0023

Table P2. Results of the final slopes-and-intercepts-as-outcomes model with school-level predictors derived from a random half of the Physical Activity Module and the outcome derived from the other half

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Age				
Intercept	2.2374	0.5907		<.0001
Slope	0.1014	0.0604		0.0467
Covariance	-0.2383	0.1400		0.0887
Gender				
Intercept	-0.5075	0.3440		0.1402
Slope	0.2236	0.3191		0.2418
Covariance	0.1382	0.1005		0.1691
Residual	116.29	1.1907		<.0001
Fixed				
Intercept	25.4402	1.5276	50	<.0001
Age	-1.1087	0.0778	>19,000	<.0001
Gender	-5.2656	0.8545	>19,000	<.0001
PE	-12.7298	2.8300	50	<.0001
Gender*PE	4.9384	2.2534	>19,000	0.0284
School Income	-0.0734	0.0262	50	0.0073
School Size	0.0686	0.0611	50	0.2673

Appendix Q

Results of a slopes-and-intercepts-as-outcomes model examining the association between physical activity, school characteristics, school demographics and module, controlled for age, gender and student physical education participation

Table Q1. Results of a slopes-and-intercepts-as-outcomes model examining the association between physical activity, school characteristics, school demographics and module, controlled for age, gender and student physical education participation

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Age				
Intercept	2.3005	0.6029		<.0001
Slope	0.1029	0.0596		0.0422
Covariance	-0.3520	0.1447		0.0150
Gender				
Intercept	-0.5227	0.3360		0.1199
Slope	0.0957	0.3012		0.3753
Covariance	0.1675	0.0965		0.0826
Residual	112.75	1.1594		<.0001
Fixed				
Intercept	21.9554	1.5701	50	<.0001
Age	-0.8364	0.0781	>19,000	<.0001
Gender	-5.1628	0.8718	>19,000	<.0001
Student PE	4.0474	0.1634	>19,000	<.0001
PE	-10.5932	2.9882	50	0.0009
Gender*PE	5.5904	2.2764	>19,000	0.0141
School Income	-0.0681	0.0252	50	0.0094
School Size	0.0571	0.0588	50	0.3364

Appendix R

Results of fully unconditional models of physical activity of students in grades 9 and 10 from 76 secondary schools; overall and by module

Table R1. Results of fully unconditional models of physical activity of students in grades 9 and 10 from 76 secondary schools; overall and by module

Model	N	Intercept	p value	Between-School Variance	p value	Within-School Variance	p value	Intraclass Correlation
Overall								
Both Modules	26836	18.2542	<.0001	2.9246	<.0001	138.13	<.0001	0.021
Tobacco Module	13345	17.9662	<.0001	3.0857	<.0001	150.10	<.0001	0.020
PA Module	13491	18.5406	<.0001	3.5448	<.0001	125.63	<.0001	0.027

PA = physical activity

Appendix S

Results of a random coefficient models examining the association between grade 9 and 10 student physical activity and age and gender, respectively

Table S1. Results of a random coefficient model examining the association between grade 9 and 10 student physical activity and age, with age as a fixed and random effect.

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Intercept	2.9409	0.5651		<.0001
Slope	0.3569	0.2093		0.0441
Covariance	0.0919	0.2441		0.7066
Residual	137.70	1.1933		<.0001
Fixed				
Intercept	18.2511	0.2126	75	<.0001
Age	-0.4248	0.1315	>27,000	0.0012

Table S2. Results of a random coefficient model examining the association between grade 9 and 10 student physical activity and gender, with gender as a fixed and random effect.

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Intercept	3.7427	0.7676		<.0001
Slope	0.9354	0.4051		0.0084
Covariance	-1.2305	0.4666		0.0084
Residual	133.95	1.1625		<.0001
Fixed				
Intercept	20.2125	0.2473	75	<.0001
Gender	-3.9545	0.1842	>27,000	<.0001

Appendix T

Results of a random coefficient model examining the association between grade 9 and 10 physical activity, age and gender, with age and gender as fixed and random effects

Table T1. Results of a random coefficient model examining the association between grade 9 and 10 physical activity, age and gender, with age and gender as fixed and random effects

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Age				
Intercept	3.7631	0.7721		<.0001
Slope	0.2789	0.1910		0.0721
Covariance	0.0036	0.2740		0.9896
Gender				
Intercept	-1.2396	0.4685		0.0081
Slope	0.9121	0.4048		0.0121
Covariance	0.0573	0.1955		0.7695
Residual	133.52	1.1615		<.0001
Fixed				
Intercept	20.2166	0.2478	75	<.0001
Age	-0.4948	0.1260	>27,000	<.0001
Gender	-3.9711	0.1832	>27,000	<.0001

Appendix U

Results of six multilevel models of grade 9 and 10 student physical activity, each with a single school-level predictor

Table U1. Results of six multilevel models of grade 9 and 10 student physical activity, each with a single school-level predictor

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Model 1				
Random				
Intercept	2.9381	0.5652		<.0001
Residual	138.13	1.1942		<.0001
Fixed				
Intercept	17.9620	0.4002	74	<.0001
Commute1	1.5876	1.8414	74	0.3914
Model 2				
Random				
Intercept	2.9740	0.5737		<.0001
Residual	138.13	1.1942		<.0001
Fixed				
Intercept	18.3146	0.8260	74	<.0001
Commute2	-0.09921	1.3195	74	0.9403
Model 3				
Random				
Intercept	2.8870	0.5571		<.0001
Residual	138.08	1.1962		<.0001
Fixed				
Intercept	17.2894	0.6150	73	<.0001
Intramurals	3.0677	1.8619	73	0.1037
Model 4				
Random				
Intercept	2.9396	0.5664		<.0001
Residual	138.08	1.1962		<.0001
Fixed				
Intercept	17.3835	0.7070	73	<.0001
Varsity	2.1708	1.7059	73	0.2072
Model 5				
Random				
Intercept	2.5960	0.5079		<.0001
Residual	138.08	1.1962		<.0001
Fixed				
Intercept	15.4656	0.8991	73	<.0001
Other	5.4031	1.7072	73	0.0023

Model 6				
Random				
Intercept	2.6578	0.5157		<.0001
Residual	137.94	1.1975		<.0001
Fixed				
Intercept	16.9489	0.8823	72	<.0001
PE	2.4428	1.7078	72	0.1569

Appendix V

Results of a multilevel model of grade 9 and 10 student physical activity
that included all significant school-level predictors,
controlled for age, gender and interactions with age and gender

Table V1. Results of a multilevel model of grade 9 and 10 student physical activity that included all significant school-level predictors, controlled for age, gender and interactions with age and gender

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Gender				
Intercept	3.3060	0.6982		<.0001
Slope	0.8271	0.3887		0.0167
Covariance	-1.0307	0.4319		0.0170
Residual	133.58	1.1629		<.0001
Fixed				
Intercept	16.8662	1.0599	73	<.0001
Age	-0.0695	0.5353	>26,000	0.8967
Gender	-2.4796	0.8687	>26,000	0.0043
Other	6.5053	2.0166	73	0.0019
Age*Other	-0.8430	1.0453	>26,000	0.4200
Gender*Other	-2.9163	1.6929	>26,000	0.0850

Appendix W

Results of a multilevel model of grade 9 and 10 student physical activity that included school-level predictors, controlled for age, gender, interactions with age and gender, school demographics, and module

Table W1. Results of a multilevel model of grade 9 and 10 student physical activity that included school-level predictors, controlled for age, gender, interactions with age and gender, school demographics, and module

	Parameter Estimate	Standard Error	Degrees of Freedom	p value
Random				
Gender				
Intercept	2.5927	0.6996		0.0001
Slope	0.6430	0.4014		0.0546
Covariance	-0.8845	0.4494		0.0491
Residual	132.46	1.3003		<.0001
Fixed				
Intercept	17.4959	2.1256	48	<.0001
Age	-0.0602	0.6072	>21,000	0.9210
Gender	-2.6715	0.9649	>21,000	0.0056
Other	6.2936	2.4261	48	0.0125
Age*Other	-0.8969	1.2106	>21,000	0.4588
Gender*Other	-2.9682	1.9293	>21,000	0.1239
School Income	-0.5508	0.0292	48	0.0655
School Board	0.3824	0.4563	48	0.4062
School Size	0.1811	0.0659	48	0.0084
School Location	-0.5504	0.9353	48	0.5590
Module	-0.1981	0.0602	>21,000	0.0010