Evaluating the impact of participation in school-based physical education lessons on adolescent health and wellbeing in Ontario: Findings from the COMPASS study

by

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Author's Declaration

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

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

Statement of Contributions

This thesis contains three manuscripts which have been published or submitted for publication. Exceptions to sole authorship are:

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As lead author for Chapters 4, 5, and 6, I was responsible for the development of the research questions, conducting the literature review, planning and implementation of statistical analyses, interpretation of findings, and drafting all sections of each manuscript. My co-authors, Drs Richmond, Skinner, and Leatherdale provided guidance throughout each step, gave feedback on manuscripts drafts, and approved each final manuscript for submission to academic journals. Under the supervision of Dr. Leatherdale, I also prepared the remaining chapters of this thesis, which were not written for publication.

Abstract

Physical activity rates among adolescents in Canada are critically low; only about one in every three grade 9 students are meeting the recommended 60 minutes per day of moderate to vigorous physical activity (MVPA). These high rates of physical inactivity among youth are alarming, as physical activity is essential for both physical and mental wellbeing, and it sets the foundation for healthy habits in adulthood. School-based physical activities including physical education (PE) classes, and intramural and varsity sport programs are ideally situated for the promotion of physical activity as they can reach a large number of youth and overcome many of the barriers associated with extracurricular activities.

PE is designed to provide opportunity for youth of all ages to engage in physical activity that is structured into their weekly routine. However, in secondary school, a period that is critical for establishing healthy behaviour patterns for later in life, PE becomes non-mandatory for students in many provinces and territories across Canada, resulting in a missed opportunity to engage adolescents in regular physical activity. Ontario currently has the most lenient PE policy in Canada, with students only required to complete one secondary school-level PE course. To date, only four studies have examined the impact of PE programming in Canada on physical activity levels, only one of which included students from the province of Ontario. No published studies to date have explored the impact of PE participation on mental health outcomes among adolescents in Canada. The lack of evidence in this domain renders it challenging to determine the effectiveness of PE or make recommendations to enhance PE programs to maximize their impact on student health and wellbeing.

This dissertation aimed to provide a deeper understanding of the patterns of physical activity behaviours and the impacts of participating in non-mandatory secondary school PE on physical activity and mental health outcomes among adolescents in Ontario. Specifically, Study 1 characterized longitudinal physical activity profiles of non-mandatory PE participation, adherence to physical activity guidelines, and sport participation throughout secondary school. Study 2 quantified the impact of participation in PE on physical activity levels, over time. Study 3 quantified the impact of PE participation on student mental health, over time. This dissertation utilized linked longitudinal data from students in Ontario who participated in four consecutive years of the COMPASS Study (Time 1: 2015-16; Time 2: 2016-17; Time 3: 2017-18; Time 4: 2018-19). The COMPASS Study is a school-based prospective cohort study (2012-2027) that collects demographic, behavioural, and mental health data from students annually across Canada. Study 1 utilized a repeated measures latent class analysis

to identify longitudinal physical activity profiles of adolescents in Ontario. Studies 2 and 3 utilized linear mixed models to estimate the average effect of PE participation on (a) minutes of MVPA (Study 2) and (b) symptoms of anxiety, (c) symptoms of depression, and (d) psychological wellbeing (Study 3), over time. Models in Studies 2 and 3 were adjusted using doubly robust propensity score methodology to account for self-selection biases that may influence PE participation.

Findings from Study 1 illustrated that there are distinct, clustered physical activity profiles among adolescents which vary by sex; three physical activity profiles were identified among both female and male students: Guidelines, PE & Sports, and Guidelines & Sports. A fourth profile was identified among male students only: Inactive. Study 2 demonstrated that participation in secondary school PE had a significant positive impact on MVPA levels over time, and effects were most pronounced for male students and during the semester of PE participation. Study 2 also illustrated that the benefits of PE remained present in the semester opposite to PE participation, suggesting that the benefits of PE extended beyond the MVPA accumulated during class-time. In Study 3, PE participation was not associated with symptoms of anxiety or depression, over time. Study 3 also found that male students enrolled (but not currently participating) in PE were found to have higher psychological wellbeing compared to those not enrolled in PE within the academic year.

This dissertation fills an important gap with respect to our understanding of PE programming in Ontario secondary schools. Findings from this dissertation revealed that many students are choosing not to enroll in PE, with a particularly high-risk subgroup of male adolescents showing low participation across several physical activity behaviours during secondary school. Among male students who elect to participate, PE was found to positively impact time spent in MVPA and psychological wellbeing. These results highlight the potential of PE for improving the health and wellbeing of adolescents, although low participation rates limit these benefits being experienced at the population-level. Importantly, all three studies identified sex-based differences in the physical activity profiles and the impact of PE on health outcomes; female students were found to have lower PE participation rates and experienced reduced benefits compared to male students. These result underscore the importance of promoting inclusive environments in PE to ensure health benefits are experienced by all adolescents, regardless of sex and other key characteristics. Findings from this dissertation offer valuable insights for public health programming, particularly within the school context; decision-makers in Canada should explore ways to increase PE participation across secondary schools, paying particular attention to female students and those not participating in other forms of physical activity.

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List of Abbreviations

AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
BMI	Body Mass Index
CESD-R-10	Center for Epidemiological Studies Depression (Revised) 10-item scale
CI	Confidence interval
COMPASS	Cannabis use, Obesity, Mental health, Physical activity, Alcohol use, Smoking, Sedentary behaviour study
CSEP	Canadian Society of Exercise Physiology
GAD-7	Generalized Anxiety Disorder 7-item scale
IPTW	Inverse probability of treatment weighting
IQR	Inter quartile range
LMM	Linear mixed models
LMRT	Lo–Mendell–Rubin Adjusted Likelihood Ratio Test
LTA	Latent transition analysis
MVPA	Moderate-to-vigorous physical activity
OR	Odds ratio
PE	Physical education
RCT	Randomized controlled trial
RMLCA	Repeated measures latent class analysis
SHAPES	School Health Action Planning and Evaluation System
SMD	Standardized mean differences
WHO	World Health Organization

Chapter 1:
Introduction

Adolescence is a critical developmental period during which individual behavioural patterns are established [1]. Currently, less than one in three Canadian youth meet the physical activity recommendations, and this proportion has been shown to decrease with age [2, 3]. This is a key area of concern given that health behaviours, including physical activity patterns, are mostly established during adolescence and subsequently track into adulthood [4]. Identifying and evaluating strategies that increase physical activity levels and build healthy behaviour patterns during adolescence is a public health imperative.

1.1 Physical activity among youth

Physical activity plays an important role in health and wellbeing throughout the lifespan [5, 6], with adolescence being a particularly critical window for establishing healthy behavior patterns [4, 7]. Scientific literature has demonstrated that the health-related benefits of physical activity participation are more pronounced among youth (relative to adults) and consistent participation decreases the risk of poor health later in life [7]. Despite the multitude of health benefits, physical activity engagement is relatively low among adolescents [3, 8]. The Canadian Society for Exercise Physiology (CSEP) and the World Health Organization (WHO) currently recommend that youth spend at least 60 minutes per day engaging in moderate-to-vigorous physical activity (MVPA) and incorporate both vigorous physical activities and muscle and bone strengthening activities at least 3 days per week [9, 10]. Evidence suggests that youth are not meeting this daily recommended 60 minutes and have become increasingly sedentary in the last decade [11]. Insufficient physical activity can lead to a variety of negative health outcomes later in life, including obesity, cardiovascular disease, and poor mental health [12]. Recognizing the significance of consistent engagement throughout adolescence, programs and strategies that increase physical activity participation among youth can have profound, lifelong impacts [11].

1.1.1 Physical activity and physical health

Physical activity is one of the most well-established modifiable risk factors of premature mortality and chronic disease [7]. Existing evidence has outlined a clear dose-response relationship between increased physical activity and increases in positive health outcomes (e.g., lower risk of diabetes, hypertension, cardiovascular disease, and all-cancer mortality) [7, 13–17]. While many of the negative

health outcomes associated with physical inactivity are chronic diseases that arise in adulthood, the risk of these conditions is known to be reduced with consistent physical activity throughout childhood and adolescence [7, 18]. Compared to persistent inactivity, modest increases in physical activity from adolescence through to adulthood have been found to result in improvements in cardiometabolic risk profiles [19], providing further justification for increasing physical activity levels (of any magnitude) throughout childhood and adolescence.

In addition to the benefits of physical activity participation for the prevention of chronic disease, consistent participation in physical activity throughout childhood and adolescence is essential for healthy growth and development [20]. Regular physical activity during adolescence leads to a variety of favourable health outcomes, including better musculoskeletal [20, 21], respiratory [22], and cardiovascular [5, 7, 23] health, as well as improved body composition [24]. Engagement in physical activity is also reported to be associated with other health behaviours such as sleeping and sedentary behaviour; active adolescents have been shown to have better sleeping patterns [25] and some research suggests a small positive effect on time spent engaging in sedentary activities [26, 27] compared to their inactive counterparts. Preliminary evidence indicates that physical activity engagement of any magnitude is associated with self-perceived health in adolescence [28], a strong predictor of mortality [29].

1.1.2 Physical activity and mental health

Depression and anxiety are the most common mental disorders among youth [30]. Nearly half (44%) of secondary school-aged youth in Ontario report a moderate-to-severe level of psychological distress [31], and an estimated 8% and 13% of youth in Canada have a diagnosis for an anxiety or mood disorder, respectively [32]. Without appropriate support and treatment, poor mental health can lead to a variety of adverse outcomes including poor academic outcomes, substance use, self-harm, and suicidal behaviour [33–35]. Moreover, mental disorders experienced during adolescence have a high risk of chronicity, which may lead to the emergence of more severe mental disorders later in life [36, 37].

There is substantial evidence suggesting that physical activity is positively associated with mental health among youth, including lower symptoms of depression [38, 39], higher physical self-concept [39], and small-to-moderate positive effects on anxiety [6, 40]. Engagement in physical activity provides youth the opportunity to develop both personal and social skills, which can reinforce their

self-esteem [41], self-efficacy [42], and self-control [43]. Positive mental health reflects a state of positive wellbeing extending beyond the absence of mental disorders and can be reflected through strong self-efficacy and self-esteem, satisfying personal relationships, and resilience [44]. Some evidence even suggests that physical activity participation during childhood or adolescence decreases the risk of poor mental health in adulthood [45–47].

Engagement in physical activity has also been linked to improvements in memory [45, 46], attention [47], and academic achievement [48–50]. The existing literature in this space has led to general consensus that consistent engagement in physical activity has a protective and positive effect on mental health and wellbeing among adolescents. While much of the existing research examining the association between physical activity and mental health among adolescents is cross-sectional in nature, the longitudinal evidence base is growing [39, 51].

1.1.2.1 Physical activity and anxiety

The published literature to date indicates that there is evidence of a small-to-moderate positive association between physical activity engagement and symptoms of anxiety among youth [6, 52]; however, evidence of a causal association and the mechanisms through which physical activity may influence symptoms of anxiety remain not well understood [6]. Some research suggests that the odds of reporting moderate and severe symptoms of anxiety are nearly two times higher among inactive youth compared to their active counterparts [53]. However, a recent study examining the bidirectional association between physical activity and symptoms of generalized anxiety found that greater physical activity was associated with lower symptoms among boys, but greater symptoms among girls, one year later [54]. Varying findings between studies could be the result of the differing types of physical activity, study methodology, rigor, and populations evaluated [6]. Further research is necessary to clarify the association between physical activity and anxiety and delineate any sex-based differences in this association. Despite the somewhat inconsistent findings between studies, there is evidence to support the promotion of physical activity as an approach to reducing symptoms of anxiety among youth [52].

1.1.2.2 Physical activity and depression

Research surrounding physical activity and depression is more established compared to anxiety; physical activity has been shown to reduce symptoms of depression among adolescents, with the

magnitude of association often being stronger in boys than girls [6, 54]. The mechanisms through which physical activity could reduce symptoms of depression remain poorly understood [6]; possible mechanisms including increased autonomy, competence, and relatedness [55], as well as increased self-concept [56, 57] have been reported among youth populations. Compared to those who meet current guidelines, youth who do not meet the guidelines have a 1.5-times greater odds of reporting moderate and severe symptoms of depression [53]. Another study found that 1 hour increases in physical activity per week was associated with an 8% decrease in the odds of reporting depressive symptoms in both girls and boys [38]. While there are research foundations exploring associations between physical activity and depression, there is a need for additional research exploring the differential impact of types of physical activity and contexts for physical activity on symptoms of depression among youth [6].

1.1.2.3 Physical activity and psychological wellbeing

Research exploring the association between physical activity participation and measures of positive mental health (e.g., flourishing) is still in the early stages, particularly among youth populations [58]. Flourishing represents a state of overall psychological wellbeing, capturing elements of both emotional and social wellbeing [59]. Findings from recent cross-sectional studies [60, 61], demonstrate that greater levels of physical activity were associated with higher psychological wellbeing. Similarly, among a nationally representative sample of adolescents in the United States, adolescents meeting the physical activity guidelines on 3 or less days per week were significantly less likely to "flourish" compared with adolescents who met the guidelines on each day of the week [62]. Similar to the relationship between physical activity and anxiety and depression, there appear to be sex-based differences in the relationship between physical activity and psychological wellbeing. Male, but not female, adolescents who meet the recommended 60 minutes of daily activity are more likely to experience better psychosocial wellbeing compared to those not meeting the recommendations [58]. Much of the literature examining the relationship between physical activity and psychological wellbeing to date has been cross-sectional in nature and has not explored the differential impact among female and male adolescents; robust sex-stratified analyses using longitudinal data are needed to further elucidate the impact of physical activity on psychological wellbeing among adolescents.

1.2 Physical activity patterns among youth in Canada

Physical inactivity remains a significant public health crisis among children and adolescents both in Canada and globally [11]. Adherence to the physical activity guidelines among adolescents in Canada

is relatively poor [3], and evidence consistently demonstrates that time spent engaging in physical activity tends to decrease as children get older [3, 63–65]. Roughly one third of grade 9 students in Canada meet the physical activity recommendations, and less than half of these students continue to do so during grade 12 [2]. Recent evidence suggests that this age-related decline begins in childhood, which is earlier than previously understood, and continues throughout adolescence. While research has begun to explore possible causal associations as to why physical activity declines throughout childhood and adolescence (e.g., displaced time with sedentary behaviour) or mediating and moderating factors (e.g., enjoyment of physical activity, access to physical activity resources) [66, 67], it is likely that there are a multitude of factors influencing this age-related decline. Further research is needed to elucidate the reasons for which youth alter their physical activity patterns over time.

There appear to be sex-based differences in the age-related decline in physical activity levels, however the timing, magnitude, and directionality of these differences remains somewhat unclear. A recent systematic review of longitudinal studies identified that the age-related decline appears to begin as early as the age of 6 years among girls and the age of 9 years among boys [65, 68, 69]. Some research has observed a greater decline among girls compared to boys [70, 71]; however, a recent review of published longitudinal data found a slightly larger decline in physical activity from adolescence to adulthood in boys compared to girls [26, 72]. The varying findings from these systematic reviews suggest that there may be nuances in this relationship that may be unaccounted for in previous studies [72]. Overall, these data indicate that youth may be choosing to engage in more sedentary activities (e.g., screen-based behaviours) rather than physical activity during their leisure-time [3, 73]. Further research is required to better understand the role that sex plays in adolescent movement behaviour patterns.

1.3 Correlates of physical activity among youth

Physical activity levels are known to differ between youth, with a wide range of physical activity levels reported among adolescents [74]. At an individual level, various demographic, behavioural, and psychological characteristics are associated with physical activity levels among adolescents.

Demographic characteristics (e.g., race, gender, socio-economic status) can play a key role in shaping an individual's access, experience, and attitudes towards physical education (PE), physical activity, and sport [75], ultimately impacting their engagement in physical activity. Adolescents who are younger [2, 76, 77], male [2, 76, 77], white [78–80], and come from homes with higher socioeconomic status

and higher parental education attainment [78, 80] are often found to report higher levels of physical activity. In terms of body composition and body image, lower BMI among adolescent girls [78], and perceiving one's weight as "about right" among all adolescents [81], have been reported to be positively associated with physical activity. Key indicators of academic achievement, including higher desired educational attainment [82], and higher English and math grades [83] are also associated with more favourable physical activity engagement.

Physical activity behaviours are known to be highly correlated; existing studies have demonstrated that previous physical activity [77] and community sports [78–80] participation are positively associated with current physical activity patterns in adolescence. Adolescents who participate in one type of physical activity (e.g., PE) have a greater likelihood of participating in other physical activities (e.g., organized sports) [84]. Further, diverse participation in physical activity during adolescence is associated with higher levels of physical activity in adulthood [85–87].

Other behavioural correlates of physical activity participation, including sedentary behaviour [3, 78, 88, 89] and substance use [2, 76, 90, 91], have been somewhat inconsistently correlated with physical activity participation. The relationship between physical activity and sedentary behaviour has been widely studied in the literature [27, 78, 80], and contrary to what might be expected (that increased sedentary behaviour hinders physical activity participation), recent systematic reviews and meta-analyses have observed a weak association between the health behaviours [27, 78, 80]. A small negative association was identified between physical activity and sedentary behaviour, suggesting that these behaviours do not directly displace each other [27, 78, 80]. Measures of substance use are found to demonstrate a less clear relationship with physical activity; binge drinking has been tied to increased physical activity participation [2, 76, 90, 91], likely as a result of the social and contextual factors associated with recreational sport participation [92]. Scientific literature on cigarette [76, 90, 93] and cannabis use [90, 94–96] demonstrates mixed findings in independent associations with physical activity, and further research is needed to better understand these relationships.

Perceived competence and intention for physical activity have been found to be positively associated with physical activity in adolescence [78–80], while perceived barriers to physical activity participation [78] appear to be negatively associated with engagement. Intrinsic factors including enjoyment of and motivation for physical activity are strong predictors of physical activity engagement [97–99]; individuals who enjoy participating in physical activity are more likely to continue engaging in physical

activity [97]. Similarly, individuals with high rates of autonomous motivation (i.e., self-directed or intrinsic motivation) are found to engage in greater quantities of physical activity [98, 99]. In addition to the intrinsic factors, extrinsic motivators including physical activity encouragement from friends [78, 80] and family [78–80] are reported to be positively associated with physical activity engagement among youth.

1.4 Settings for physical activity

Structured physical activity represents activities that are planned, organized, and carried out with the intention of being active [100]. Common settings in which youth have the opportunity participate in structured physical activity, include organized sports, swimming lessons, and/or exercise classes [101]. Organized sport participation typically makes up a large proportion of structured physical activity in childhood, however participation in these activities tends to decrease throughout adolescence [73, 102]. Sport participation can occur both in community settings as well as within the school setting (e.g., intramural and varsity programs). Among youth who join organized sport programs, anywhere from 44-76% are reported to discontinue participation at some point during childhood or adolescence [103, 104]. Declines in community sport participation tend to begin around ages 11-14 years [102] and participation is reported to be a strong predictor of physical activity engagement in adulthood, however this association appears to be stronger among boys compared with girls [105, 106].

Schools are suggested to be an ideal setting for the promotion of physical activity in youth as they provide numerous opportunities to participate via PE classes, intramural and varsity sport programs, physical activity breaks, and/or active transportation to and from school [1, 107]. Familial socio-economic status may prevent some youth from participating in extra-curricular organized sports, limiting their opportunities for structured physical activity outside of the school setting [108]. In comparison to other sources of physical activity, such as community sports, school-based physical activity programs have large reach (irrespective of backgrounds or circumstances), given that nearly all children attend school [1]. Elements of the school environment are shown to influence student engagement in physical activity. Positive associations have been reported between access to programs and facilities [78, 80], time spent outdoors [78], and school-level policies that support active transportation and prioritize physical activity [109]. School connectedness has also been found to be positively associated with physical activity participation [110].

1.5 Physical education

PE is a core component of the school curriculum aimed at promoting physical activity and overall wellbeing among youth [1, 111]. PE is one of the primary environments in which youth can develop and refine many of the skills required to lead physically active lives [1, 112]. Many PE programs are developed with the intention that the knowledge and abilities fostered in PE, translate into active youth both inside and outside of the school setting [113]. Curricula are designed in a developmental manner, such that every year youth are building upon and reinforcing the knowledge and skills from previous years.

Children spend a majority of their waking hours at school; therefore, embedding physical activity programming, such as compulsory PE classes, into the school curriculum can be considered a population-level intervention [1]. PE provides structured learning and exposure to physical activity for all youth [108], including those who may not be able to participate in structured physical activity outside of school [114]. The pre-existing infrastructure of PE positions it to be one of the most cost-effective population-level health-promotion strategies targeting youth [20]. Most countries globally (>90%) have legislation or have implemented best practices to provide some level of PE administration throughout compulsory schooling [115]; however, the frequency, quantity, and duration of these programs differ across countries, by school board, and even between schools [115]. Moreover, many countries are found not to comply with PE regulations or expectations [115].

1.5.1 Canadian PE system

In Canada, PE is provincially developed and implemented. Provincial and territorial Ministries of Education are responsible for overseeing the policies, funding, curriculum development, and operation of public education across each province and territory [116]. While each province and territory regulate their own individual programs, they share several commonalities in their PE participation requirements [117]. Throughout elementary (grades 1-6) and middle school (grades 7-8), PE is compulsory for all students. In secondary school (grades 9-12) however, many students across Canada are given the opportunity to opt-out of yearly PE courses. Most Canadian provinces and territories require two PE course credits for graduation [111, 118–120]. Quebec and Manitoba currently have the most comprehensive PE programming in Canada, as both provinces have recently implemented policies mandating PE participation in each year of secondary school [121–123]. Ontario currently has the most lenient PE policy, with students only required to complete one secondary school-level PE course [111].

A graphical representation of the PE requirements throughout secondary school across the provinces and territories in Canada is presented in **Figure 1-1**.

	Grade 9	Grade 10	Grade 11	Grade 12
Alberta	✓	✓		
British Columbia	✓	✓		
Manitoba	✓	✓	✓	✓
New Brunswick	✓	✓		
Newfoundland and Labrador	✓	✓		
Northwest Territories	✓	✓		
Nova Scotia	✓	✓		
Nunavut	✓	✓		
Ontario	✓			
Prince Edward Island	✓	✓		
Quebec†	✓	✓	✓	-
Saskatchewan	✓	✓		
Yukon	✓	✓		

Figure 1-1 Secondary school physical education graduation requirements across provinces and territories in Canada

† Grades 9-11 correspond to secondaire III-V in the province of Quebec. Checks denotes grades for which PE enrollment is compulsory within provincial or territorial policy guidelines.

In Canada, children begin school, and therefore PE, at a young age and progress through the curriculum until they reach late adolescence [1]. This consistent engagement and incremental progression allow for youth to develop and refine physical and health literacy (i.e., movement

competency, and the appreciation and enjoyment of physical activity), required to foster lifetime engagement in physical activity [1, 124].

1.5.1.1 Ontario PE program

The Ontario Ministry of Education aims to provide a "coordinated and comprehensive education plan" to ensure that students across the province receive the highest quality education and programming possible [111]. As outlined in the curriculum, the goal of PE is to foster the knowledge and skills required for students to develop the comprehension, capacity, and commitment they need to lead healthy and active lives (i.e., develop physical and health literacy) [111]. The current Ontario secondary school PE program includes "traditional" PE courses (titled *Healthy Active Living Education*), that are offered across all grades in secondary school. These grade-specific courses are an extension of the elementary school PE courses and aim to develop the movement competence and personal fitness needed for healthy living. Most provinces offer specialized PE courses in the upper years of secondary school, but availability varies by province, school board, and ultimately by school. "Destination" PE courses are specialized courses designed to equip students with foundational knowledge and skills in fields that they can pursue in postsecondary education or occupations [111]. Examples of specialized PE courses offered by secondary schools in Ontario include: "Health for Life", "Introductory Kinesiology", and "Recreation and Healthy Active Living Leadership" [111]. Secondary school students in Ontario are currently only required to enroll in one traditional PE course to meet the graduation requirements outlined by the Ministry of Education [111]. Ontario currently offers sex- or gender-specific PE courses in most secondary schools across the province, however, schools who experience challenges developing a workable timetable for students have reported establishing co-ed PE courses [125].

1.6 Participation in PE

Evidence suggests that anywhere from 20-65% of secondary school students globally are not enrolled in regular PE classes past grade 9 [126–128]. Similar to physical activity participation more generally, a rather substantial age-related decline is seen in rates of participation in secondary school PE [129]. Since many policies across Canada and the United States require participation in only 1 or 2 years of secondary school [129]; enrollment rates are typically high among grade 9 students and decline across the remainder of secondary school. According to a 2014 report published by the Center for Disease Control in the United States, fewer than 10% of students are enrolled in PE in grades 11 and 12 [130].

Girls are often found to make up a larger proportion of the students not enrolling in PE compared to boys [126, 131, 132].

Research examining participation rates in secondary school PE in Canada is scarce [133, 134]. Data from Statistics Canada suggests that enrollment in PE among secondary school students in Ontario has decreased consistently since the turn of the 21st century [133], with a recent study reporting that by grade 12, only 24% of secondary school students in Ontario and Alberta were enrolled in PE [134]. Similar rates of participation were reported in a 1999 study from British Columbia, with only 10% of female and 22% of male students participating in PE in grade 11 (the grade in which PE becomes non-mandatory for students in British Columbia) [135]. Given the volitional nature of most PE programs across Canada, there is a need for up-to-date evidence surrounding the current enrollment rates in secondary school PE across Canada.

1.6.1 Correlates of PE participation

Previous research globally has established that participation in elective PE is not random and numerous student- and school-level variables influence enrollment among adolescents [126, 132, 136]. Similar to those reported for other physical activity behaviours, reported correlates of PE enrollment include sex, age, geographical region, parental education and employment status, school size, and school grade [126, 132]. While most studies report higher rates of PE participation among male students [126, 131, 132, 137], some studies have found no significant differences in participation rates by sex or gender [84, 138]. Physical activity behaviours have also been identified as significant correlates of PE participation; a study among secondary school students in Manitoba demonstrated that students enrolled in PE are more likely to participate in varsity sports [84]. Relatedly, a study in Brazil found that those not enrolled in PE are more likely to be insufficiently active [126]; as expected, students in this study who participated in PE reported greater enjoyment for participating in PE compared to those not enrolled [126]. At the school-level, factors such as larger school size, attending school in the evening, and higher school grade have all been negatively associated with PE participation among adolescents in Brazil [126]. Reported correlates of participation in PE vary between studies [126, 139], likely reflecting differences in populations, curricula, and implementation strategies between school boards, regions, and countries.

1.7 Effectiveness of PE programs

PE provides opportunity for youth of all ages and backgrounds to engage in physical activity that is structured into their weekly routine [133]. PE has the potential to impact youth health both through direct and indirect effects [140]. Direct effects can be seen through engagement in physical activity during PE lessons themselves [140], contributing to the recommended minutes of daily physical activity. Indirectly, PE aims to encourage youth to continue engaging in physical activity during their leisure-time, ideally over the life course [140]. However, research within this field indicates that only about 40% of PE class time is actually spent engaging in physical activity [141], minimizing the potential direct effects. The indirect effects of PE participation are difficult to study, as they represent longer-term behaviours and are context-dependent which likely vary by population, geographic region, and by school board or PE curricula.

1.7.1 Association between PE participation and physical activity levels

International research demonstrates that enrollment in PE is associated with spending greater amounts of time engaging in physical activity [128, 131, 132, 137, 139, 142, 143]. A recent study looking at the impacts of PE participation on physical activity levels among adolescents in the United States found that students who were enrolled in daily PE engaged in more days of being physically active for at least 60 minutes compared to students without daily PE [144]. Similarly, a study in Brazil found that adolescents enrolled in at least two PE classes per week were 27% more likely to meet the current physical activity recommendations compared with those without weekly PE [126]. The effectiveness of PE participation at increasing PA participation is particularly important to explore within a real-world context, taking into consideration the numerous variables that may influence this association. For example, a recent study among grades 8, 9, and 12 girls in the United States found that those enrolled in PE reported greater MVPA and a higher proportion reported a daily average of ≥30min of vigorous physical activity at all grade levels [128]. When the physical activity obtained in PE was removed, differences in physical activity engagement between the 8th- and 9th-grade girls enrolled in PE and those who were not became non-significant, suggesting that the association was primarily driven by the physical activity gained during the PE lesson itself. By contrast, when the physical activity obtained in PE was removed, grade 12 girls enrolled in PE were still substantially more physically active than those who were not enrolled, suggesting that those who choose to participate in PE might be inherently more active than those who opt-out.

Very few studies have evaluated the impact of participation in PE programs on physical activity levels across Canadian provinces and territories; the majority of which were conducted among students in Manitoba following implementation of their revised secondary school PE policy [84, 123, 145]. In 2008, the Ministry of Education in Manitoba implemented a province-wide policy mandating PE participation across all four years of secondary school [84]. As part of this mandate, students in grades 11 and 12 were required to participate in (i) 30 hours of in-class health and personal planning, (ii) ≤27.5 flexible hours students can reallocate to component i or iii, and (iii) 55 hours of physical activity, either in-class or out-of-class time [123]. The 55 hours of physical activity was selected for this policy as it required students to participate in ≥30 minutes of physical activity daily at least 5 days a week [123]. Three evaluations of this policy have been conducted to date; one cross-sectional study demonstrated that enrollment in PE during the semester of data collection was associated with 70% increased odds of achieving an average of 60 minutes of MVPA per day, compared to students not enrolled during the semester of data collection [84]. A longitudinal evaluation of this policy, however, found that the majority of students included in this study were found to meet the 30 minutes of daily MVPA both at baseline and at follow-up, indicating that this policy did not have a significant impact on student physical activity levels in grade 11 or 12 [123].

To date, only one study has examined the impacts of participation in Ontario's secondary school PE program on physical activity levels [134]. This study identified a 30-minute per day benefit of PE participation among students enrolled in PE in both grade 9 and in grade 12 relative to students enrolled in grade 9 but not in grade 12, among a sample of students in Ontario and Alberta [134]. No significant differences in the association between PE participation and minutes of daily MVPA were identified between female and male students. Findings from this study are limited in that data was pooled from schools in Ontario and Alberta, limiting the interpretability of the results for provincial policy makers. Additionally, while data was linked between grades 9 and 12, student behaviours in grades 10 and 11 were not taken into consideration. Previous research suggests that previous physical activity participation is one of the strongest predictors of future physical activity participation [77], and as a result this may have significantly influenced the findings from this study. Further research is needed to better understand the longitudinal impact of participation in secondary school PE programs in Ontario, while also considering many of the student-level factors that could influence physical activity behaviours.

1.7.1.1 Sex-based differences in PE effectiveness

Research suggests that there are sex-based differences in the effectiveness of PE programming for increasing physical activity among adolescents, but the magnitude and directionality of this association remain somewhat unclear. Most of the published literature to date suggests that PE participation results in greater increases in physical activity among males compared to female adolescents [84, 146]. In a recent study examining the association between PE participation and physical activity among adolescents in Manitoba, benefits to MVPA appeared to be heightened among male students relative to their female counterparts [84]. Similarly, a study among adolescents in the Czech Republic concluded that male students participating in PE had a greater likelihood of accumulating 200 minutes of school-based MPVA per day relative to female adolescents [146]. There are some studies, however, that report greater effectiveness among female adolescent samples [131, 143, 147]; a study conducted among German adolescents, determined that PE participation was significantly associated with additional minutes of MVPA and a greater number of days meeting the recommended 60 minutes of MVPA per day among female adolescents only [143]. Finally, some studies have either reported no significant differences by sex [134] or have not examined the sex-based differences of participation [144]. It is possible that these varying associations are due to differing programs or types of activities offered in PE, as previous research indicates that preferences for certain physical activity types appear to differ by sex [148, 149]. It is also possible that some schools examined in these studies provide sex- or gender-specific PE courses (such as Ontario) and the provision of sex-specific courses may significantly influence this association.

1.7.2 Association between PE participation and mental health outcomes

There is a growing body of literature exploring the impact of physical activity on mental health, however, studies specifically examining the impact of PE programming on youth mental health remain scarce [150, 151]. Engaging in regular physical activity through PE classes is believed to have a positive impact on mental wellbeing as a result of the dose of physical activity it provides [152]. Additionally, PE provides a structured environment for students to develop social connections and build a sense of community, which has demonstrated protective effects for the prevention of isolation and loneliness [153, 154]. Moreover, the physical challenges and accomplishments experienced in PE can boost self-confidence and resilience, contributing to a sense of personal achievement and wellbeing [111, 155].

Much of the published literature linking participation in PE with anxiety, depression, or psychological wellbeing has evaluated the impact of specific interventions (e.g., teacher workshops or high intensity interval training programmes [156–158]) or specific elements of the PE environment (e.g., assessment styles or teaching styles [159, 160]), with few studies examining the impact of PE participation more generally [150, 151, 161]. Among the studies identified in recent systematic and scoping reviews, none examined the impact of PE participation on depression nor psychological wellbeing, one examined the impact of PE participation on positive mental health longitudinally, and one study examined the differential impact of varying assessment styles in PE on anxiety levels of secondary school students [150]. Findings from these reviews highlight the current gaps in the literature pertaining to the impact of PE participation on mental health and wellbeing; there is a need for more rigorous studies to evaluate the impact of PE participation longitudinally and to explore how these associations differ by sex [150, 151].

While PE holds the potential to be an opportunity for adolescents to develop and strengthen behaviors that promote life-long physical activity, some research has speculated that the complex dynamics of PE programming and environment (e.g., social dynamics, teachers, curricula, and assessment and evaluation) may inhibit the mental health benefits often associated with physical activity participation [151]. As previously described, enrollment in voluntary PE is believed to be biased, whereby certain students (for example, athletes and students with a higher social standing) may be more likely to enrol [162]. This may lead to a competitive environment both in terms of athletic ability and social confidence, ultimately creating a non-inclusive environment. Such environments may heighten anxiety and depression due to performance pressure and complex social dynamics, particularly among students who are less physically or socially confident [151]; negative feelings and experiences in PE, including feelings of embarrassment, peer comparisons, body image concerns, and bullying are identified barriers to PE (and ultimately physical activity) participation [162–166]. Coupled with the limited research in this field, these concerns underscore the need for additional research determining whether (and how) PE participation is associated with mental health outcomes among adolescents over time.

1.8 Considerations for evaluating PE programs

One of the key considerations when developing public health programs is to use an evidence-informed decision-making process [167]. This process requires identifying evidence of effectiveness for policies and programs, translating that evidence into recommendations, and increasing the extent to

which that evidence is used in public health practice [168]. Many programs and policies; however, are not founded in evidence and/or lack thorough evaluation which poses difficulty in assessing their true effectiveness. Further, programs that are evidence-informed, may be poorly implemented. It is possible that the guidelines surrounding PE implementation (i.e., frequency, quality, or vigour of classes) or features of the PE environment (e.g., teaching style or social dynamics) are diminishing the potential health benefits. While the fundamentals of the PE curriculum are evidence-informed, there has yet to be a rigorous evaluation of the effectiveness of PE programs in Ontario.

While the evidence generated from evaluations are essential for the development and enhancement of public health programs and policies, it can be challenging to conduct such evaluations within a real-world context [169]. This may be particularly true for PE programming, where there are a wide range of potential challenges, from data-related challenges (e.g., data availability, reliability, or sample size), methodological challenges (e.g., study design), or even participant-related challenges (e.g., individual characteristics that influence one's desire to enroll in PE or one's experience in PE) confounding the true effectiveness of programs [170–172]. These challenges likely all contribute to the limited evidence base surrounding PE effectiveness.

Randomized controlled trials are considered the gold standard when generating causal evidence [173]; randomization aims to reduce selection biases by ensuring that participants between two (or more) treatment conditions do not differ significantly on any observed or unobserved characteristics or covariates which may impact their outcome [173]. Studies without randomization, such as observational or cohort studies, are at risk for selection biases [173]. For example, individuals volunteering to participate in a given study may be systematically different from those who do not elect to participate. Randomization, however, is not always feasible nor ethical, particularly when conducting research involving youth or other at-risk populations [168]. One of the challenges in evaluating voluntary PE programs lies in the fact that enrollment is optional. As previously described, numerous student- and school-level factors may influence one's decision to enroll in PE, and mandating participation is likely not practically, ethically, or logistically feasible; mandating participation may conflict with students' preferences for course selection or interests, pose challenges for academic timetables, and interfere with extracurricular commitments [117]. Additionally, mandating enrollment solely for evaluation purposes would introduce bias, as it would no longer assess a genuinely voluntary program.

Quasi-experimental study designs leverage pre-existing or self-selected exposure groups (non-randomized) to evaluate the effectiveness of interventions or programs [168]. Quasi-experimental designs offer an ethical and practical approach to the evaluation of programs and policies within the real-world context in which they're delivered, increasing their generalizability [168, 174]. One of the primary criticisms for quasi-experimental designs is their internal validity [174]. In other words, identifying a control group that is comparable to the intervention group can pose a challenge within a real-world scenario [168]. In the context of the evaluation of a non-mandatory PE program, this represents the cohort of students who opt-out of PE; existing research in this field indicates that these groups should not be considered comparable due to self-selection bias (in terms of demographic, behavioural, and psychological characteristics), limiting the internal validity of the evaluation [170–172]. However, there are a number of methodological strategies that can help increase the rigor of quasi-experimental designs, including adjusting for confounding variables, utilizing multiple control groups, or increasing the comparability of control groups through innovative methodological techniques [168, 174]. In fact, quasi-experimental designs that implement strategies to minimize selection bias and threats to internal validity have been considered the "next best" study design (behind RCTs) for generating causal evidence [175].

Chapter 2:
Research Questions and Rationale

The aim of this dissertation is to improve current understanding of longitudinal patterns of physical activity behaviours of Ontario adolescents, namely non-mandatory physical education (PE), and to examine the impact of PE participation on physical activity and mental health outcomes. This dissertation is divided into three separate studies, presented as manuscripts for academic publication.

2.1 Study 1: Identifying latent classes of physical activity profiles over time among adolescents in Ontario, Canada

2.1.1 Rationale

It is well established that physical activity behaviours are highly correlated [85–87], and research has started to explore concurrent participation in common types of physical activity and movement behaviours (e.g., moderate-to-vigorous physical activity (MVPA), sport participation sedentary behaviour, sleep) [74, 176]. PE participation has been linked to other forms of physical activity (e.g., sport participation), however, most of the PE participation research to date has examined PE participation in isolation, without consideration of other co-occurring physical activity behaviours [84, 126, 147, 177]. Moreover, PE research within the Canadian context is scarce; it remains unknown how adolescents in Ontario are engaging with other physical activity behaviours alongside participation in elective PE. Therefore, the objective of Study 1 was to investigate longitudinal physical activity profiles, examining non-mandatory PE participation alongside other physical activity behaviours, among a large sample of secondary students in Ontario, Canada using a repeated measures latent class analysis (RMLCA).

Data-driven statistical methods, such as latent class analysis and cluster analysis, are becoming increasingly common approaches to identifying connections between health behaviours [74, 176, 178–181]. Latent class analysis is a person-centred statistical approach that identifies clusters of participants that share common characteristics [180]. Repeated measures latent class analysis is an extension of the traditional latent class analysis, permitting the examination of class indicators over multiple time points [182]. In the context of PE and physical activity research, RMLCA allows for the identification of

common patterns of behaviour change (i.e., physical activity profiles), and the probability of engaging in those behaviours over time.

Deepening our understanding of concurrent, longitudinal participation in multiple physical activity behaviours (including participation in non-mandatory PE) would provide a more holistic view of adolescent physical activity patterns over time. By examining patterns of PE participation alongside other physical activity behaviours using an RMLCA approach, it enables us to better understand how students are participating in specific clusters of physical activity behaviours, and acknowledges that PE, sport participation, and MVPA are not necessarily independent. Moreover, it is also important to explore these physical activity profiles separately for female and male students as evidence indicates that there are sex-based differences in the preferences for certain physical activity behaviours [148, 149]. Identification of these profiles and understanding the key characteristics of students belonging to each profile fills a knowledge gap with respect to physical activity engagement of Ontario youth, and could allow for the development of programs, curricula, and policies tailored to these subgroups.

2.1.2 Research Questions

1. Among students in Ontario who participated in four consecutive waves (2015/16-2018/19) of the COMPASS study, what are the latent classes of physical activity profiles from grade 9 to 12?
    1.1. How do the identified latent classes differ between female and male students?
    1.2. Which individual or behavioural characteristics differentiate the latent classes of physical activity profiles?

2.2 Study 2: Examining the longitudinal impact of participation in school-based physical education lessons on physical activity levels among a large sample of adolescents in Ontario, Canada

2.2.1 Rationale

There is a paucity of research evaluating PE programming in Canada [84], where PE programming throughout secondary school is for the most part non-mandatory [111, 118–120]. The extent to which PE participation impacts time spent engaging in MVPA has yet to be rigorously investigated, particularly in Ontario. In addition to the overall need for more research to better understand the impact

of volitional PE participation, there is also a need to adjust for inherent self-selection bias. Since there are many factors that influence a student's choice to enroll in PE, and these factors can confound the relationship between PE and other behaviours, this makes determining the effectiveness of PE more challenging. Many studies in this area utilize regression analyses to examine the impact of PE participation on MVPA [84, 128, 183]; however, this can limit the ability to control for numerous covariates (and thus the number of potential confounders) within a single model [184]. As such, the purpose of study 2 was to quantify the impact that PE participation had on MVPA levels over time, among secondary school students in Ontario, Canada, while controlling for potential self-selection bias differences in observed individual characteristics using propensity scores.

Propensity scoring is a statistical technique that helps reduce the impact of confounding in observational studies. Propensity scores represent the conditional probability of assignment to a particular exposure (e.g., treatment, intervention) given a set of observed covariates [185]. In practice, propensity scores act as a balancing measure that take into consideration a set of observed covariates that are believed to influence either (or both) the treatment assignment or outcome variable, in a real-world setting. Propensity scores aggregate covariates into a single score [184]; this is in contrast to regression where studies are limited in the number of covariates they can include by their sample size. For example, in a study with 50 available potential covariates without a sufficiently large sample size, including all variables in a regression model may limit interpretability and lead to overfitting. In contrast, when using propensity scores, any number of observed covariates can be included, and participants that share scores are assumed to have similar characteristics, regardless of treatment assignment [186]. As such, if one can have a similar distribution of propensity scores across groups, this helps observational studies more closely reflect the strong internal validity given by randomization in experimental type studies, strengthening confidence in the findings.

Findings from this research will provide insights into the extent to which participation in secondary school PE in Ontario impacts adolescent physical activity, by quantifying both the direct and the indirect effects of participation. Further, by leveraging methods that adjust for self-selection bias, this research provides a sex-stratified examination of the effectiveness of PE in Ontario over time. Findings from this study will provide either preliminary justification for increasing enrollment in PE programs across the province and/or the justification needed for the redesign or reimplementation of the provincial curriculum.

2.2.2 Research questions

1. Among students in Ontario who participated in four consecutive waves (2015/16-2018/19) of the COMPASS study, controlling for differences in observed individual characteristics using propensity scores, what is the impact of participation in PE in grades 9 to 12 on daily MVPA over time?

    1.1. How does the impact of participation in PE in grades 9 to 12 on daily MVPA differ between female and male students?

2.3 Study 3: The longitudinal impacts of physical education participation on adolescent mental health: a sex-stratified propensity score analysis

2.3.1 Rationale

Identifying modifiable factors that promote positive mental health and reduce the risk of mental disorder during adolescence can have long-term positive impacts on population health and wellbeing [11, 187]. Fostering positive mental health and promoting resilience are key objectives of PE curricula across Canada [111, 118, 119, 188]. Much of the published literature relating to PE and mental health has evaluated the impact of specific interventions (e.g., teacher workshops or high intensity interval training programmes) on mental health outcomes, rather than the impact of PE participation more generally [150]. Few observational studies have evaluated this association, and even fewer have quantified this association longitudinally or examined if there may be differential impacts on female students compared to male students [150]. The scarcity of research on this topic limits our understanding of whether PE participation is achieving its intended outcomes.

The purpose of study 3 was to examine the impact of participation in secondary school PE on (a) symptoms of anxiety, (b) symptoms of depression, and (c) psychological wellbeing among adolescents in Ontario, Canada, controlling for observed differences in individual characteristics using propensity scores. This study is the first to examine the association between secondary school PE participation and mental health outcomes in Canada. Understanding whether PE programming in Ontario is successful at fostering positive mental health among adolescents or, conversely, whether it may be diminishing the mental health benefits often associated with physical activity participation has important implications for the delivery of PE programming in Canada.

2.3.2 Research questions

1. Among students in Ontario who participated in four consecutive waves (2015/16-2018/19) of the COMPASS study, controlling for differences in observed individual characteristics using propensity scores, what is the impact of participation in PE in grades 9 to 12 on youth mental health outcomes over time?

    1.1. Specifically, what are the differences in three distinct mental health outcomes, being: i) symptoms of anxiety, ii) symptoms of depression, iii) psychological wellbeing (flourishing)?

    1.2. How does the impact of participation in PE in grades 9 to 12 on each of the three mental health outcomes differ between female and male students?

Chapter 3:
Methods

The above research questions were explored using data from years 4 (2015-16) through 7 (2018-19) of the COMPASS Study. The following sections describe the data used for the proposed studies including information about the COMPASS host study, as well as the sampling and data collection procedures and the measures collected.

3.1 The COMPASS Study

The COMPASS Study (Cannabis use, Obesity, Mental health, Physical activity, Alcohol use, Smoking, Sedentary behaviour) is a school-based prospective cohort study (2012-27) of adolescents in Canada. Data are collected from secondary schools across five provinces (Ontario, Alberta, British Columbia, Prince Edward Island, and Québec). The COMPASS Study collects student- and school-level data related to health behaviours (e.g., physical activity, substance use), mental health (e.g., depression, anxiety), substance use (e.g., binge drinking, cannabis use), and school infrastructure and policies (e.g., built environment, programs). The COMPASS Study was developed to evaluate how changes to school policies, programs, and/or the built environment influence adolescent health behaviours and outcomes over time [189]. The COMPASS Study was designed to facilitate the evaluation of natural experiments, using a quasi-experimental design, to inform school-based prevention programming. Additional information about the COMPASS Study is available online (www.COMPASS.uwaterloo.ca).

3.1.1 Research funding and ethics

The COMPASS Study was initiated in 2012-13 and is currently funding through the end of 2027. Funding details for the COMPASS Study can be found in Appendix A. Ethical approval was obtained through the University of Waterloo Office of Research Ethics (reference #30118) as well as all participating school boards.

3.1.2 Data collection

The COMPASS Study utilizes a whole-school convenience sampling approach; schools are eligible to participate if they: 1) operate under a standard classroom setting, 2) have students in grades 9 to 12 (or école secondaire I-V in Québec), 3) have at least 100 enrolled students per grade, and 4) allow for

an active-information passive-consent parental permission protocol. Passive-consent protocols require students, or their parents/guardians, to opt-out rather than opt-in, yielding higher participation rates, reduced selection bias, and more truthful self-reporting of health behaviours [190]. These protocols have been widely adopted and have been approved by ethics boards at multiple universities and the school boards themselves. Under these protocols, parents were informed of the study by schools. If parents had any questions/concerns and/or did not wish to have their child participate, these students were ineligible for participation and were not provided a questionnaire. If after two weeks parents had not contacted study staff to withdraw their child, passive consent was assumed. All students not withdrawn by their parents were considered eligible for participation. All participating students provided active assent. Participation in the COMPASS Study is entirely voluntary, and students were free to withdraw at any time. The COMPASS Study recruitment coordinator is responsible for recruiting individual schools to participate in the study following school board approval and ethics clearance.

The COMPASS Study collects data at the student-level using the COMPASS Student Questionnaire. The full 2018/19 COMPASS Student Questionnaire can be found in Appendix B. Data is collected longitudinally from a rolling cohort of students attending COMPASS schools; each year, grade 9 students newly admitted to participating schools begin data collection and are followed on an annual basis until they graduate (unless they change schools, withdraw from data collection, or are lost to follow up) [189]. To allow for longitudinal data linkage among participants in COMPASS, students are identified using a unique self-generated code which preserves anonymity [191]. These unique codes are generated from student responses to five questions on the cover page of the COMPASS student questionnaire; responses to these questions do not change over time (e.g., the name of the month in which you were born) and cannot be used to identify participants. Additional information on data linkage procedures is available [191]. In an attempt to minimize the effect of seasonality of data collected over time, the COMPASS Study aims to arrange data collection schedules for each school around the same time each year.

3.1.3 Sample

The sample used in the three studies that make up this dissertation was generated by linking longitudinal data from students in Ontario who participated in four consecutive years of the COMPASS Study (Time 1 (TI): 2015-16; Time 2 (T2): 2016-17; Time 3 (T3): 2017-18; Time 4 (T4): 2018-19).

Among the students participating in T1 (n=37,106; 72 schools), T2 (n=34,078; 68 schools), T3 (n=31,654; 61 schools), and T4 (n=30,675; 61 schools), data from 2,036 students across 48 secondary schools in Ontario were successfully linked. Students who were not enrolled in grade 9 at T1 and those who did not report their sex at T1 were excluded from study 1, for a total sample size of 1,917 students. An additional 57 students who were missing data on their physical education (PE) participation status or who reported more than one sex over the study period were excluded from studies 2 and 3, for a total sample size of 1,860.

Data from these four years of the COMPASS Study were selected for this dissertation as they were the most recently linked dataset available at the time when this dissertation was initiated. Data from students residing in the province of Ontario were selected, as it is currently the province in Canada with the most lenient PE policy, with students only required to complete one secondary school-level PE course [111]. Ministries of Education within each province and territory are responsible for overseeing the policies, curriculum, and operation of public education throughout Canada [116]. As such, the PE policy in Ontario is distinct from that of other provinces and territories across Canada and should be examined independently.

3.1.4 Measures

COMPASS collects a wide breadth of variables at the student-level including data on student demographics, physical activity behaviours, academic indicators, substance use, and mental health.

3.1.4.1 Physical education participation

PE participation was assessed on the COMPASS questionnaire by asking students: "Are you taking a physical education class at school this year?" Students were asked to select one of the following response options: "Yes, I am taking one this term," "Yes, I will be taking one or have one this school year, but not this term," or "No, I am not taking a physical education class at school this year." For study 1, student responses were collapsed into two mutually exclusive groups depending on their participation at any point during the school year (yes=1) or not (no=0). For studies 2 and 3, student responses retained their original coding scheme (yes, this semester=2), (yes, but not this semester=1), or not (no=0), to explore the impact of the timing of their PE participation.

3.1.4.2 Sociodemographic measures

Students were asked to self-report their **age**, with yearly response options ranging from "13 years or younger" to "18 years or older," and their **sex**, with response options of "Female" or "Male." Students were asked to report their **weekly spending money**: "About how much money do you usually get each week to spend on yourself or to save?" Response options range from "Zero" to "More than $100." This measure has been previously demonstrated to be a suitable proxy for socio-economic status as it is reported to be a more accessible value for youth to report on than household income [192].

Students were also asked to self-report their **racial or ethnic background**, with response options of "White," "Black," "Asian," "Latin American/Hispanic," and "Other." Responses were recategorized as a dichotomous indicator of racialized [Black, Asian, Latin American or Hispanic, Mixed, Other] or non-racialized [White]. The ethno-racial identity question used in this dissertation was selected for inclusion in the COMPASS questionnaire in 2012 and captures the constructs of both race and ethnicity [193]. For this dissertation, the variable has been operationalized as "ethno-racial identity" to align with the recently published guidance on the reporting of race and ethnicity by the Canadian Medical Association Journal [193]. To create more inclusive and specific options for participants, the question was updated for the 2020-2021 COMPASS data collection cycle.

To measure **height**, students were asked "How tall are you without your shoes on?" Students were asked to record their height in either feet and inches or in centimetres. Students were also provided the response option "I do not know how tall I am." To measure **weight**, students were asked "How much do you weigh without your shoes on?" Students were asked to record their weight in either pounds or kilograms. Similar to height, students were provided the response option "I do not know how much I weigh." Student responses for height were converted from feet/inches to centimeters, and for weight were converted from pounds to kilograms. Height and weight data were then used to calculate students' **body mass index (BMI)** (weight/height^2). Improbable responses (heights less than 4ft or more than 6ft11 inches and weights less than 45lbs or more than 390lbs) were recoded as missing and excluded from BMI calculations.

Students were also asked about their weight perception and weight-control intentions. To measure **weight perceptions**, students were asked "How do you describe your weight?" Students were asked to select one of the following response options: "Very underweight," "Slightly underweight," "About the right weight," "Slightly overweight," "Very overweight," or "Not stated." Response options were

collapsed into “Very/Slightly underweight,” “About right,” and “Very/Slightly overweight.” To measure **weight-control intentions**, students were asked “Which of the following are you trying to do about your weight?” Students were asked to select one of the following response options: “Lose weight,” “Gain weight,” “Stay the same weight,” or “I am not trying to do anything about my weight.” Response categories for weight-control intentions were retained throughout the three studies.

3.1.4.3 Movement behaviours

Moderate-to-vigorous physical activity (MVPA) was assessed using a modified version of the physical activity measure in the School Health Action Planning and Evaluation System (SHAPES) [194]. Students were asked to report the number of hours and minutes of both moderate and hard physical activity on each of the last 7 days. Hard physical activity was defined as “activities that increase your heart rate, and that make you breathe hard and sweat (e.g., jogging, team sports, and jump-rope).” Moderate physical activity was defined as “lower intensity activities (e.g., walking, biking to school, and recreational swimming).” Students were asked to provide estimates that include physical activity during PE class, lunch, after school, evenings, and spare time. Students were asked to indicate the number of hours (0-4 h) and 15-min increments (0-45 min) they performed each activity for each day of the week. Student estimates from the two questions were totaled and averaged to provide a measure of minutes of daily MVPA. This physical activity measure has been previously validated for use among adolescents [195] and has been found to have acceptable test-retest reliability and criterion validity [196].

Physical activity guideline adherence was derived using self-reported measures of daily MVPA. Guideline adherence in this dissertation represented meeting the SWEAT (i.e., MVPA) component of the WHO and CSEP guidelines [9, 10]. Students were dichotomized into two groups dependent on their reported daily MVPA. Students were categorized as “Meeting the guidelines” if they reported ≥60 minutes of MVPA on each of the last 7 days (rather than on average). Students who reported <60 minutes on each of the last 7 days were categorized as “Not meeting the guidelines.” See Appendix C for the complete 2016 CSEP guidelines.

M**uscle strengthening exercise** by asking students: “On how many days in the last 7 days did you do exercises to strengthen or tone your muscles?”, to which students may respond: “0 days,” “1 day,” “2 days,” “3 days,” “4 days,” “5 days,” “6 days,” or “7 days.” For study 1, responses were categorized

into 0 days, 1–3 days, or 4–7 days per week. For studies 2 and 3, student responses were summed to provide a total number of days per week of muscle strengthening exercises.

Sport participation was assessed through three distinct questions: "Do you participate in before-school, noon hour, or after-school physical activities organized by your school?", "Do you participate in competitive school sports teams that compete against other schools?", and "Do you participate in league or team sports outside of school?", to provide a measure of intramural, varsity, or community sport participation, respectively. For each question, students were asked to respond "Yes," "No," or "None offered at my school." Participation in each of the three sport programs were reclassified as yes (=1) or no (=0), where "No" included students who responded, "None offered at my school." A composite variable for overall sport participation was created for study 1; students who reported participating in at least one of the three sport programs were classified as sport participators (yes=1; no=0). For studies 2 and 3, intramural, varsity, and community sport participation were included as three distinct binary (yes/no) variables.

To measure **active transportation**, students were asked to report their method of travel to and from school. Students were asked to select which of the following travel methods they typically took to get to and from school: "By car (as a passenger)," "By car (as a driver)," "By school bus," "By public bus, subway, or streetcar," "By walking," "By bicycling," or "Other." Students that used more than one method were asked to select the method in which they spent the most time using. Students were classified into two mutually exclusive groups depending on their responses. Those that reported using methods of active transportation (e.g., walk, bus, subway, or streetcar, or bicycling) to and/or from school were coded as 1 and those that reported sedentary methods of transportation (e.g., by car, school bus) both to and from school were coded as 0.

To measure **sedentary behaviour**, students were asked to self-report the number of hours (0-9) and 15-min increments (0-45min) they spent engaging in the following sedentary activities: "watching/streaming TV shows or movies," "playing video/computer games," "doing homework," "talking on the phone," "surfing the internet," "texting, messaging, emailing," and "sleeping." Student estimates across each category, except "doing homework" were totaled and averaged to provide a measure of minutes of daily screen-based sedentary behaviour. The CSEP guidelines [10] recommend no more than 2 hours of daily recreational screen time and limited sitting for extended periods of time.

Previous research within this sample leads us to believe that most students will not meet this recommendation [2] and as such, sedentary behaviour was modelled as a continuous variable.

Sleep was assessed by asking students to report the number of hours (0-4 h) and 15-min increments (0-45 min) they typically sleep each night. The CSEP guidelines [10] recommend 8-10 hours of sleep per night for adolescents aged 14-17 years. For study 1, student responses were totalled, averaged, and reported as a binary indicator of the CSEP sleep guideline adherence, with students who reported ≥ 8 hours per night, categorized as "Meeting the guidelines" [10]. Sleep was included as a continuous measure for studies 2 and 3. Student responses were totalled and averaged to generate an estimate of average sleep duration, ranging from 0 to 9.75 hours per night.

3.1.4.4 Academic indicators

Students were asked to report their approximate overall mark in their current or most recent **English** and **Math courses** as academic indicators. Students were asked "In your current or most recent English course, what is your approximate overall mark?" Response options included: "90% - 100%," "80% - 89%," "70% - 79%," "60% - 69%," "55% - 59%," "50% - 54%," and "Less than 50%." If students were not enrolled in an English course this year, they were asked to report their grade from the previous year. The same question was asked for students' most recent Math course. Responses for each course were recategorized into: "< 60%," "60–80%," "80–90%," and "> 90%."

Educational aspirations were assessed by asking students "What is the highest level of education you would like to get?" Response options included: "Some high school or less," "High school diploma or graduation equivalency," "College/trade/vocational certificate," "University Bachelor's degree," "University Mater's / PhD / law school / medical school / teachers' college degree," or "I don't know." Student response categories were retained in all three studies, however the response option "University Mater's / PhD / law school / medical school / teachers' college degree," was relabeled "Graduate school."

Students were asked "In the last 4 weeks, how many classes did you skip when you were not supposed to?" to assess the number of **classes skipped** in the past month. Response options included "0 classes," "1 or 2 classes," "3 to 5 classes," "6 to 10 classes," "and "More than 20 classes." Student responses were recategorized into the following groups "0 classes," "1-5 classes," and "≥6 classes."

Bullying victimization was assessed by asking students “In the last 30 days, how often have you been bullied by other students?” Response options included “I have not been bullied by other students in the last 30 days,” “Less than once a week,” “About once a week,” “2 or 3 times a week,” and “Daily or almost daily.” Similarly, **bullying perpetration** was assessed by asking students “In the last 30 days, how often have you taken part in bullying other students?” Response options included “I did not bully other students in the last 30 days,” “Less than once a week,” “About once a week,” “2 or 3 times a week,” and “Daily or almost daily.” Student responses for each question were dichotomized into two groups dependent on their reported bullying behaviours in the past 30 days (yes=1) or not (no=0).

3.1.4.5 Substance Use

To measure **current binge drinking**, students were asked: “In the last 12 months, how often did you have 5 drinks of alcohol or more on one occasion?" Response options included: “I have never done this,” “I did not have 5 or more drinks on one occasion in the last 12 months,” “Less than once a month,” “Once a month,” “2 to 3 times a month,” “Once a week,” “2 to 5 times a week,” and “Daily or almost daily.” Student responses were dichotomized into two groups dependent on their reported binge drinking in the past year (yes=1) or not (no=0).

To measure **current cannabis use**, students were asked: “In the last 12 months, how often did you use marijuana or cannabis? (a joint, pot, weed, hash).” Response options included: “I have never used marijuana,” “I have used marijuana but not in the last 12 months,” “Less than once a month,” “Once a month,” “2 or 3 times a week,” “4 to 6 times a week,” and “Every day.” Student responses were dichotomized into two groups dependent on their reported cannabis use of at least once a month (yes=1) or not (no=0).

To measure **current cigarette** and **current e-cigarette use**, students were asked the questions: “On how many of the last 30 days did you smoke one or more cigarettes?” and “On how many of the last 30 days did you use an e-cigarette?” Response options for each question included: “None,” “1 day,” “2 to 3 days,” “4 to 5 days,” “6 to 10 days,” “11 to 20 days,” “21 to 29 days,” and “30 days (every day).” Student responses for each question were dichotomized into two groups dependent on their reported cigarette or e-cigarette use in the past 30 days (yes=1) or not (no=0).

3.1.4.6 Mental Health

The COMPASS Study developed and piloted a mental health module in the student questionnaire in 14 schools in Ontario and British Columbia in the 2016-17 data collection cycle [197, 198]. Following the pilot study, the mental health module was included in all COMPASS student questionnaires across all COMPASS Study schools in the 2017-18 data collection cycle [197, 198]. As such, mental health data were only available in the final two years of data included in this dissertation.

COMPASS used a shortened version of the Center for Epidemiologic Studies Depression Revised (CESD-R-10) scale [199, 200] to assess **risk of major depression**. Students were asked to self-report how often they experienced various depressive symptoms (e.g., sadness, loneliness, trouble concentrating or sleeping) in the previous week. Response options were provided on a 4-point Likert scale (0 = "None or less than 1 day," 1 = "1-2 days," 2 = "3-4 days," 3 = "5-7 days") with individual sum scores ranging from 0 to 30 (higher scores indicating greater symptoms). The CESD-R-10 has been previously validated for use among adolescents [201, 202].

COMPASS used the Generalized Anxiety Disorder 7-item scale (GAD-7) [203] to assess **risk of generalized anxiety**. Students were asked to self-report how often they experienced various symptoms of anxiety (e.g., worrying, nervousness, irritability) over the previous 2 weeks. Response options were provided on a 4-point Likert scale (0 = "Not at all," 1 = "Several days," 2 = "Over half the days," 3 = "Nearly every day") with individual sum scores ranging from 0 to 21 (higher scores indicating greater symptoms). The GAD-7 has been previously validated for use among adolescents [204–206].

COMPASS used the Flourishing scale [207] to measure self-perceived **psychological wellbeing**. Students were asked to report their self-perceived success in various areas of wellbeing (e.g., relationships, self-esteem, life purpose, optimism). Response options were provided on a 5-point Likert scale (1 = "Strongly disagree," 2 = "Disagree," 3 = "Neither agree nor disagree," 4 = "Agree," 5 = "Strongly agree") with individual sum scores ranging from 8 to 40 (higher scores indicating greater wellbeing). The Flourishing Scale has been previously validated for use among Canadian adolescents using COMPASS data [208].

3.2 Statistical analyses

Descriptive statistics were examined for the entire sample and stratified by sex. Differences in baseline characteristics between females and males were compared using chi-square test for

independence and t-tests, where appropriate. What was considered baseline varied by study; T1 (grade 9; 2015-16) for study 1, T2 (grade 10; 2016-17) for study 2, and T3 (grade 11; 2017-18) for study 3. T2 was selected as the baseline timepoint for study 2 as it represents the time at which PE enrollment becomes non-mandatory. T3 represented the baseline timepoint for study 3 as it was the first year that mental health outcomes were available in the COMPASS Study.

3.2.1 Study 1

A repeated measures latent class analysis (RMLCA) was used to identify latent classes characterized by different longitudinal patterns of physical activity indicators across four consecutive years (grades 9 through 12) of secondary school. An RMLCA was selected for this analysis rather than a latent transition analysis (LTA) as patterns of responses across all time points could be characterized in the latent classes; by contrast, an LTA examines the probabilities of transitioning from one latent class at time 1 to another latent class at time 2 (time points must be adjacent) [180]. Selection of an RMLCA also permitted a larger number of time points (i.e., all 4 years of secondary school) to be examined [180]. The objective of this study was to identify subgroups characterized by their patterns of physical activity behaviours over a four-year period (rather than the probability of changing physical activity behaviours from T1 to T2), therefore an RMLCA was selected as the most appropriate model.

Categorical indicators of PE participation (yes/no), guideline adherence (yes/no), and sport participation (yes/no) were used as the RMLCA indicators. Number of possible response patterns is an important consideration for RMLCA, as too many possibilities can result in difficulty with convergence and problematic model fit [209]. Each binary indicator was measured at four time points (T1-T4, corresponding to grades 9, 10, 11, and 12), yielding a contingency table of $2^4 \times 2^4 \times 2^4 = 4{,}096$ possible response patterns. PE participation was originally collected in the COMPASS Study as a trichotomous variable (yes, this semester; yes, but not this semester; and no, not this year), however, it was collapsed into a binary indicator reflecting PE participation within a given school year to minimize the number of possible response patterns ($3^4 \times 2^4 \times 2^4 = 20{,}736$). Similarly, varsity, community, and sport participation were collapsed into one composite measure of sport participation to reduce the number of possible response patterns ($2^4 \times 2^4 \times 2^4 \times 2^4 \times 2^4 = 1{,}048{,}576$).

Model selection of RMLCA leverages measures of model fit to determine the number of latent classes. Akaike Information Criterion (AIC) [210] and Bayesian Information Criterion (BIC) [211] were used to assess relative model fit, with smaller fit criteria values indicating better model fit. The

Lo–Mendell–Rubin Adjusted Likelihood Ratio Test (LMRT) was used to compare model fit between a model with *k* classes compared to a model with *k-1* classes [212]. Alongside model fit indicators, parsimony and interpretability of the model were also considered when selecting the number of latent classes. Latent class membership and item-response probabilities were generated for each latent class; because the three indicator variables were dichotomous, item response probability values >0.50 were considered to indicate high probability of that behaviour, and conversely <0.50 were considered to indicate a low probability of that behaviour. RMLCA models handle missing data using a full-information maximum likelihood approach; this approach produces unbiased estimates under missing at random pattern missing data in the latent class indicators [213]. While RMLCA models can handle missing data, at least one indicator variable for each student was required to be present in the data for the student to be retained in the model. Relatedly, RMLCA models are unable to handle missing data on grouping variables (i.e., sex), and students who did not report their sex at T1 (n=9) were removed prior to analyses. RMLCA models were run using MPlus (Version 8) [214].

Sex-stratified multinomial logistic regression models were used to examine student characteristics associated with class membership. Student characteristics available in the COMPASS database that were known or suspected to influence at least one of the physical activity indicators (as established by previous literature) in the latent class models were examined. Logistic regression analyses were run using SAS version 9.4. A full description of the analytic approach for study 1 can be found in **Chapter 4**.

3.2.2 Study 2

Study 2 used linear mixed models (LMM) to estimate the average effect of PE participation on average daily MVPA levels in T2-T4 (grades 10 through 12). Models were stratified by sex to examine the differential impact of PE participation between female and male students. Student data from T1 (grade 9) was not included in this analysis as all students in Ontario are required to participate in grade 9 PE.

To account for the disproportionate influence of student characteristics on the probability of opting into PE, models were adjusted using doubly robust propensity score methodology which accounts for observed covariates known, or suspected, to influence PE participation. A propensity score representing the probability of a student opting-in to PE was calculated for each student given all their individual covariates. The propensity scores were recalculated during each school year to account for changes in

time varying confounders (e.g., age, current substance use) included in the propensity scores [184]. Student characteristics available in the COMPASS database that were known or suspected to influence PE participation or physical activity were included in the propensity scores [215, 216]. A complete list of covariates included in the propensity score model is presented in **Chapter 5**. Missing data indicator variables were generated for each covariate included in the propensity score to adjust for nonresponse [186]. The estimated propensity scores were therefore balanced both on the observed values of covariates as well as the pattern of missing value indicators. Propensity scores were applied as sampling weights to the LMMs through inverse probability of treatment weighting (IPTW)[184].

Estimated propensity scores represented the conditional probability of a student opting into voluntary PE, given their individual characteristics [185]. Students were assigned a propensity score between 0 (low probability of participation) and 1 (high probability of participation) which were used to generate sample weights. Students who opted-in to PE (i.e., exposed) have a weight of the inverse of their propensity score, whereas students who opted-out of PE (i.e., unexposed) have a weight of the inverse of 1 minus their propensity score. As such, students with a high probability of participating in PE will have a smaller weight and students with a low probability of participating in PE will have a larger weight. With this weighting, the distribution of student covariates that were used to estimate the propensity scores become independent of exposure status (i.e., participation in PE).

Sample weights generated from propensity scores at the extreme ends of the spectrum (i.e., 0 or 1) can lead to biased and unstable effect estimates [215, 217]. Subjects with extreme sample weights overcontribute to the pseudo-population and can dominate the weighted analysis, resulting in biased estimates [215, 217]. As a means of reducing the exertion of any influential weights, weights were stabilized and truncated at the 1^{st} and 99^{th} percentiles. Weight stabilization incorporated the overall probability of treatment (i.e., the proportion of students in our sample who participated in PE) into the formula to generate more stable weights that were less influenced by outliers. Weight truncation capped all weights exceeding the thresholds of the 1^{st} and 99^{th} percentiles, to reduce the possible effects of extreme weights and to ensure stable weighting [215, 217]. Sample weight stabilization and truncation increased the robustness of the analysis and generated more reliable estimates with a reduced risk of bias due to extreme values [217].

Standardized mean differences (SMD) were used to ensure that the propensity scores sufficiently removed any between group differences. SMDs represent the difference in means divided by the pooled

standard deviation, of each covariate both pre- and post-weighting. Any imbalances that remained between covariates following weighting were included as covariates in the LMMs [218]. LMMs can handle monotone missingness type (i.e. attrition) in the outcome, under the assumption that data is missing at random. LMMs are not able to handle missing data on predictor variables or covariates, and as such any student missing data on PE participation at any timepoint (N=57) were removed from the sample. Propensity score generation, and LMMs were conducted using SAS (Version 9.4).

3.2.3 Study 3

Study 3 used LMMs to estimate the average effect of PE participation on symptoms of anxiety, depression, and psychological wellbeing in T3-T4 (grades 11 through 12). Similar to study 2, models were stratified by sex to examine the differential impact of PE participation on female and male students. As previously described, the COMPASS mental health module was fully implemented in student questionnaires in the 2017-18 data collection year, therefore, two full waves of mental health data were available for inclusion in this analysis. As such, this study utilized longitudinal data from the 2017-18 and 2018-19 data collection years of the COMPASS study.

Study 3 implemented a similar analytical approach as outlined in study 2. Propensity scores were generated using all covariates known (or suspected) to influence PE participation and/or symptoms of anxiety, depression, and psychological wellbeing available in the COMPASS Study. Propensity scores were generated for each year of data included in the analysis and were applied as sampling weights using IPTW. Sample weights were stabilized and truncated at the 1^{st} and 99^{th} percentiles. Three unique LMMs were run to estimate the average effect PE participation on (a) symptoms of anxiety, (b) symptoms of depression, and (c) psychological wellbeing, independently. Propensity score generation, and LMMs were conducted using SAS (Version 9.4).

Chapter 4:

Study 1

Identifying latent classes of physical activity profiles over time among adolescents in Ontario, Canada

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4.1 Overview

Background: Physical activity behaviours are known to be highly correlated. Adolescents who participate in one type of physical activity (e.g., physical education) have a greater likelihood of participating in other physical activities (e.g., organized sports); however, little research has examined participation rates in various physical activity behaviours concurrently. This study identified longitudinal physical activity profiles among secondary school aged youth in Ontario, Canada.

Methods: We used data from the COMPASS Study, a school-based prospective cohort study of adolescents in Canada. Using a repeated measures latent class analysis, Ontario students who participated in grade 9 PE in 2015-16 were analysed through to 2018-19 (n = 1,917). Latent classes were defined by: PE participation, guideline adherence (≥60 minutes/day of moderate to vigorous activity over the last 7 days), and sport participation (varsity, community, and/or intramural). Multinomial logistic regression models were used to examine associations between latent class membership and student characteristics.

Results: Three distinct latent classes were identified for females, and four were identified for males. These classes were: 1) Guidelines (high probability of guideline adherence; females: 44%; males: 16%), 2) PE & Sports (high probability of PE and sport participation; females: 33%; males: 43%), 3) Guidelines & Sports (high probability of guideline adherence and sport participation; females: 23%; males: 23%;), and 4) Inactive (low probability of all physical activity indicators; males: 18%). Strength training, sleep, and English grade were associated with class membership among females. Ethno-racial identity, weekly spending money, strength training, and English and math grades were associated with class membership among males.

Conclusions: Findings suggest that latent physical activity profiles differ by sex. Guideline adherence was the most common class among females, indicating high levels of independent physical activity, whereas PE & Sport participation was the most common class among males, indicating greater tendency towards organized activities. Additionally, a substantial number of male students were not engaging in any physical activity. Participation in both PE and sports did not necessarily lead to meeting physical activity guidelines, highlighting that these activities alone may not be providing sufficient levels of physical activity that align with current recommendations for Canadian youth.

Keywords: physical activity, physical education, sport participation, adolescent, repeated measures latent class analysis

4.2 Introduction

Adolescence is a critical developmental period during which many behavioural patterns are established [1]. Health behaviours, including physical activity patterns, are set during adolescence and track into adulthood [4]. The World Health Organization (WHO) and the Canadian Society for Exercise Physiology (CSEP) recommends that adolescents accumulate ≥60min of moderate-to-vigorous physical activity (MVPA) daily and incorporate vigorous physical activities as well as muscle and bone-strengthening activities ≥3 days per week [9, 10]. However, evidence suggests that youth are not engaging in suggested levels of regular physical activity and have grown increasingly sedentary in the last decade [11]. Schools have been identified as an ideal setting for addressing physical inactivity among adolescents, given that they spend majority of their waking hours at school [141]. Opportunities for physical activity that are embedded within the school curriculum, such as physical education (PE) courses, can provide equal opportunity for youth of all ages and backgrounds to structure activity into their weekly routine [1, 112, 133].

Many PE programs are developed with the intention of fostering physically literate adolescents who are active both inside and outside of school settings [1, 219, 220]. Despite this, most secondary schools in Ontario, Canada do not mandate annual PE courses after grade 9, precipitating a substantial drop in PE participation rates with increasing age [133]. A similar age-related decline is seen globally and is more pronounced among female students; among the estimated 20-65% of secondary school students globally who are not enrolled in regular PE classes past grade 9 [112, 126–128, 133], girls comprise a larger proportion compared to boys [126, 131, 132]. In Canada, PE is developed and implemented at the provincial level; provincial and territorial Ministries of Education are responsible for overseeing the policies, curriculum, and operation of public education across each province and territory [116]. As such, the PE policy in Ontario is unique from those of other provinces, territories, regions, and countries.

Physical activity behaviours are known to be highly correlated; existing studies have demonstrated that previous physical activity participation [77] and community sports participation [78–80] are positively associated with current physical activity patterns in adolescence. Additionally, adolescents who participate in one type of physical activity (e.g., PE) have a greater likelihood of participating in other physical activities (e.g., organized sports) [84]. Further, diverse participation in physical activity during adolescence is associated with higher levels of physical activity in adulthood [85–87]. Despite

the need for a comprehensive approach to examine concurrent participation in various physical activity behaviours over time, PE participation research to date has primarily examined PE participation in isolation, without consideration of other co-occurring physical activity behaviours, and has been descriptive in nature [84, 126, 147, 177].

Data-driven statistical methods, such as latent class analysis and cluster analysis, are becoming increasingly common approaches to identifying connections between health behaviours [178–181]. Latent class analysis is a person-centred statistical approach that identifies clusters of participants that share common characteristics [180]. Repeated measures latent class analysis (RMLCA) is an extension of the traditional latent class analysis, permitting the examination of class indicators over multiple time points [182]. In the context of PE and physical activity research, RMLCA allows for the identification of common patterns of behaviour change (i.e., physical activity profiles), and the probability of engaging in those behaviours over time.

To better understand age-related decline in physical activity during adolescence, this research investigated longitudinal physical activity profiles (non-mandatory PE participation, adherence to physical activity guidelines, and sport participation) among a large sample of secondary students in Ontario, Canada. This study had the following objectives: 1) to identify the latent classes of physical activity profiles among secondary school aged adolescents over time; 2) to determine whether the identified latent classes differ between female and male adolescents; and 3) to determine which behavioural characteristics differentiate the latent classes.

4.3 Methods

4.3.1 Design

This study used data from the Cohort study of obesity, marijuana use, physical activity, alcohol use, smoking and sedentary behaviour (COMPASS Study), a school-based prospective cohort study (2012-2021) of adolescents in Canada. The COMPASS study collects student- and school-level data from schools in Alberta, British Columbia, Ontario, and Quebec, Canada using a purposive sampling approach and an active-information passive-consent parental permission protocol. All students attending participating schools were eligible to participate and could withdraw at any time. The COMPASS study received ethics clearance from the University of Waterloo Office of Research Ethics

(ORE: #30118) as well as participating school boards. A detailed description of COMPASS study methods is available online (www.compass.uwaterloo.ca) or in print [189].

4.3.2 Participants

This study used linked-longitudinal data from students in Ontario who participated in four consecutive years of the COMPASS Study (Time 1 (T1): 2015–16, n=37,106; Time 2 (T2): 2016-17, n=34,078; Time 3 (T3): 2017-18, n=31,654; Time 4 (T4): 2018-19, n=30,675). Student data were linked across timepoints using a unique, self-generated code as described in COMPASS data collection protocols [191]. A total of 2,036 students from 48 secondary schools across Ontario were successfully linked from T1 to T4. Students who were not enrolled in grade 9 at T1 (n=110) and those who did not report their sex at T1 (n=9) were excluded.

4.3.3 Measures

A detailed description of the development and selection of the measures used in the COMPASS questionnaire COMPASS has been previously published and is available online (www.compass.uwaterloo.ca) [194].

4.3.3.1 Physical activity

Physical activity measures included self-reported PE participation, guideline adherence, and sports participation. The COMPASS questionnaire does not measure the quantity of physical activity performed during various physical activity contexts (intramural, community, or varsity sports, and PE), rather it captures participation in each activity within a given academic school year.

PE participation was assessed by asking students to select one of the following response options: “Yes, I am taking one this term,” “Yes, I will be taking one or have one this school year, but not this term,” or “No, I am not taking a physical education class at school this year.” Responses were collapsed to a binary variable indicating PE participation or not during a given school year.

Physical activity guideline adherence was assessed using a modified version of the physical activity measure in the School Health Action Planning and Evaluation System (SHAPES) [194]; the COMPASS MVPA measure has been found to have acceptable test-retest reliability and criterion validity [196]. Students were asked to report the number of hours (0-4) and minutes (0-45) of both moderate (e.g., walking, biking to school, and recreational swimming) and hard (e.g., jogging, team

sports, and jump-rope) physical activity on each of the last 7 days. Responses were totaled, averaged, and dichotomized into two groups "<60 minutes on each of the last 7 days" and ≥60 minutes on each of the last 7 days" to align with one component of the WHO and CSEP guidelines [9, 10].

Sport participation was assessed through three distinct questions. Students were asked to report their participation in each intramural, community, and varsity sports as "Yes," "No," or "None offered at my school." A composite binary variable for overall sport participation was created; those reporting participation in at least one of the three sport programs were classified as sport participators.

4.3.3.2 Other Physical Activity Measures

Students were asked to report the number of days they engaged in strength training exercises. Responses were categorized into 0 days, 1-3 days, or 4-7 days. Sedentary behaviour was assessed by asking students to report the number of hours (0-9) and 15-min increments (0-45min) they spend engaging in various sedentary following activities (e.g., watching/streaming TV shows or movies, playing video/computer games, doing homework, talking on the phone, surfing the internet, and texting, messaging, or emailing,). Estimates across each activity, except "doing homework" were totaled, and averaged to provide a measure of hours of daily sedentary behaviour. Active transportation was assessed by asking students to report their method of travel both to and from school. Those who reported using active transportation (e.g., walk or bicycling) at least one way were classified as using active transportation.

4.3.3.3 Sleep

Sleep was assessed by asking students to report the number of hours and minutes they typically sleep each night. Responses were totalled, averaged, and reported as a binary indicator of the Canadian Society for Exercise Physiology (CSEP) guideline adherence (≥8 hours per night) [10].

4.3.3.4 Academic Indicators

Students were asked to report their approximate overall mark in their current or most recent English and Math courses. Responses for each course were categorized into <60%, 60-80%, 80-90%, and >90%. Desired educational attainment was assessed by asking students "What is the highest level of education you would like to get?" Response options included: "Some high school or less", "High school diploma or graduation equivalency", "College/trade/vocational certificate", "University Bachelor's degree", "Graduate school", or "I don't know".

4.3.3.5 Sociodemographic measures

Students were asked to self-report their sex (female, male) and age (13-18 years). Students were asked to self-report their ethno-racial identity. Responses were recategorized as a dichotomous indicator of racialized [Black, Asian, Latin American or Hispanic, Mixed, Other] or non-racialized [White]. As a proxy for student socioeconomic status, students were asked to report their weekly spending money ($0, $1–$20, $21–$100, $100+, Don't know). This measure has been previously demonstrated to be a more accessible value for youth to report on than household income [192].

4.3.4 Analysis

Descriptive statistics at T1 were examined for the entire sample and stratified by sex. Differences in baseline characteristics between males and females were compared using chi-square and t-tests, where appropriate. An RMLCA was used to identify latent classes characterized by different longitudinal patterns of physical activity indicators across four consecutive years of secondary school. A RMLCA was selected for this analysis rather than a latent transition analysis (LTA) as patterns of responses across all time points could be characterized in the latent classes (rather than examining probabilities of transitioning from a particular latent class at time 1 to another latent class at time 2) and it permitted a larger number of repeats (i.e., all 4 years of secondary school) [180]. Categorical indicators of PE participation, guideline adherence, and sport participation were used as the latent class indicators. Each binary indicator was measured at four time points (T1-T4, corresponding to grades 9, 10, 11, and 12). Sex was used as a grouping variable to explore the differences in the latent class structure between females and males. Models accounted for the nesting of students within schools by taking into account the non-independence of observations due to cluster sampling [221]. The number of latent classes were selected using various measures of model fit (relative: Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC); between-model: Lo–Mendell–Rubin Adjusted Likelihood Ratio Test). Alongside model fit indicators, parsimony and interpretability of the model were considered when selecting the number of latent classes.

Sex-stratified multinomial logistic regression models were used to examine student characteristics associated with class membership. A considerable amount of literature has established that numerous student characteristics and health behaviours influence physical activity, PE enrolment, and/or sports participation among adolescents [78, 126, 132, 136]. Student characteristics and health behaviour variables available in the COMPASS database that are known or suspected to influence at least one of

the physical activity indicators included in the latent class models were included in this analysis. Student characteristics included age [2, 77], ethno-racial identity [78, 79], weekly spending money [78], use of active transportation [222], sedentary behaviour [3, 78], sleep [223], strength training [224], desired educational attainment [82], English grade [83], and math grade [83]. RMLCA models were conducted using MPlus version 8 and logistic regression analyses using SAS version 9.4.

4.4 Results

4.4.1 Study participants

Overall, 1917 students were included in this study. Approximately half of the sample was female (53%), and the majority (77%) were 14 years of age at T1 (**Table** 4-1). Weekly spending money, minutes of MVPA, guideline adherence, and varsity and community sport participation differed between males and females at T1. Male students in this sample engaged in more minutes of MVPA (115.7 vs 96.4 mins/day) compared to female students. A greater proportion of males met the physical activity guidelines (55% vs 42%) and participated in varsity (47% vs 41%), or community sports (62% vs 50%) compared to females.

Table 4-1: Sample descriptives by sex at T1 (2015/16)

	Total sample (n=1,917) n (%)	Females (n=1,011) n (%)	Males (n=906) n (%)	Chi-square /t	P value
Age					
13	90 (5)	45 (4)	45 (5)	0.317	0.957
14	1473 (77)	778 (77)	695 (77)		
15	348 (18)	185 (18)	163 (18)		
16	6 (0)	3 (0)	3 (0)		
Ethno-racial identity					
Non-racialized	1407 (73)	742 (73)	665 (73)	0.0167	0.897
Racialized	500 (26)	262 (26)	238 (26)		
Missing	10 (0)	7 (1)	3 (0)		
Weekly spending money					
Zero	476 (25)	254 (25)	222 (24)	11.200	**0.024**
$1-$20	786 (41)	425 (42)	361 (40)		
$21-$100	319 (17)	157 (15)	162 (18)		
$100+	63 (3)	22 (2)	41 (4)		
Don't know	260 (13)	145 (14)	115 (13)		
Missing	13 (1)	8 (1)	5 (0)		

PE participation					
Yes	952 (50)	500 (49)	452 (50)	0.266	0.876
Yes, but not this semester	755 (39)	396 (40)	359 (40)		
No	191 (10)	104 (10)	87 (10)		
Missing	19 (1)	11 (1)	8 (1)		
MVPA (daily)					
Minutes (median, IQR)	107.1 (64.3 - 154.3)	96.4 (62.1 - 147.9)	115.7 (72.9 - 160.7)	4.106	**<0.0001**
Missing	90 (5)	40 (4)	50 (5)		
Guideline adherence (past week)					
Yes	926 (48)	428 (42)	498 (55)	30.634	**<0.0001**
No	953 (50)	562 (55)	391 (43)		
Missing	38 (2)	21 (2)	17 (2)		
Strength training					
0 days	361 (19)	189 (1)	172 (9)	2.680	0.444
1-3 days	826 (43)	452 (45)	374 (41)		
4-7 days	706 (37)	357 (35)	349 (38)		
Missing	24 (1)	13 (1)	11 (1)		
Sedentary behaviour (daily)					
Hours (median, IQR)	6.0 (4.0 – 8.5)	6.0 (3.75 – 8.5)	6.0 (4.0 – 8.5)	0.388	0.698
Missing	80 (4)	46 (4)	34 (4)		
Varsity sports					
Yes	841 (44)	416 (41)	425 (47)	6.807	**0.009**
No	1058 (55)	587 (58)	471 (52)		
Missing	18 (1)	8 (1)	10 (1)		
Community sports					
Yes	1073 (56)	506 (50)	567 (62)	30.969	**<0.0001**
No	830 (43)	498 (49)	332 (37)		
Missing	14 (1)	7 (1)	7 (1)		
Intramural sports					
Yes	803 (42)	417 (41)	386 (43)	0.338	0.561
No	1098 (57)	585 (58)	513 (57)		
Missing	16 (1)	9 (1)	7 (1)		
Sport participation					
Yes	1370 (71)	683 (67)	687 (76)	16.05	**0.0003**
No	539 (28)	323 (32)	216 (24)		
Missing	8 (0)	5 (0)	3 (0)		

Note: IQR = interquartile range. MVPA = moderate-to-vigorous physical activity. PE = physical education. Bolded values indicate significance.

4.4.2 Model selection

Model fit statistics for RMLCAs with one to five classes were considered (**Table** 4-2). A three-class model was selected as the best fitting model among females, whereas a four-class model was selected as the best fitting model among males. Models with the lowest model selection criteria, a statistically significant Lo-Mendell-Rubin test, and the most appropriate interpretability were selected for this study.

Table 4-2: Model fit indices for 1-5 latent class models among students who participated in COMPASS

Number of Classes	Log-Likelihood	FP	AIC	BIC	LMRT *p*-Value	Entropy
Female (n = 1011)						
1	-7450.1	12	14924.1	14983.1	-	1.00
2	-6701.1	25	13452.1	13575.1	0.00	0.87
3	**-6550.7**	**38**	**13177.3**	**13364.2**	**0.03**	**0.79**
4	-6467.7	51	13037.4	13288.3	0.34	0.74
Male (n = 906)						
1	-6678.595	12	13381.2	13438.9	-	1.00
2	-5931.161	25	11912.3	12032.5	0.00	0.86
3	-5764.971	38	11605.9	11788.7	0.04	0.80
4	**-5676.066**	**51**	**11454.1**	**11699.4**	**0.02**	**0.79**
5	-5607.787	64	11343.6	11651.4	0.24	0.77

Note: AIC = Akaike Information Criterion. BIC = Bayesian Information Criterion. FP = free parameters. LMRT = Lo–Mendell–Rubin Test. Bolded models were selected.

4.4.3 Class description

The three classes identified among female adolescents in this study, characterized by their clustered physical activity profiles, were labeled: Guidelines, Guidelines & Sports, and PE & Sports. All three classes identified among females were also identified among male students. One additional class, labeled Inactive, was identified among males. Item response probabilities for each physical activity indicator in each class among female and male adolescents are presented graphically in **Figure 4-1**.

The first latent class, “Guidelines”, represented 44% of female adolescents and 16% of male adolescents. This class was characterized by consistent adherence to the physical activity guidelines and no participation in sports or PE across timepoints. The “PE & Sports” class, which represented 33% and 43% of females and males, respectively, was characterized by consistent participation in sports across timepoints, participation in PE in grades 10 and 11, but no adherence to the physical activity

guidelines at any timepoint. The “Guidelines & Sports” class is characterized by consistent adherence to the physical activity guidelines and sport participation across all timepoints, but no participation in PE in grades 10-12. This class represented 23% of both female and male adolescents. Finally, the “Inactive” class, which represented 18% of male adolescents, was characterized by no adherence to the physical activity guidelines or participation in sports across all timepoints, and no participation in PE in grades 10-12.

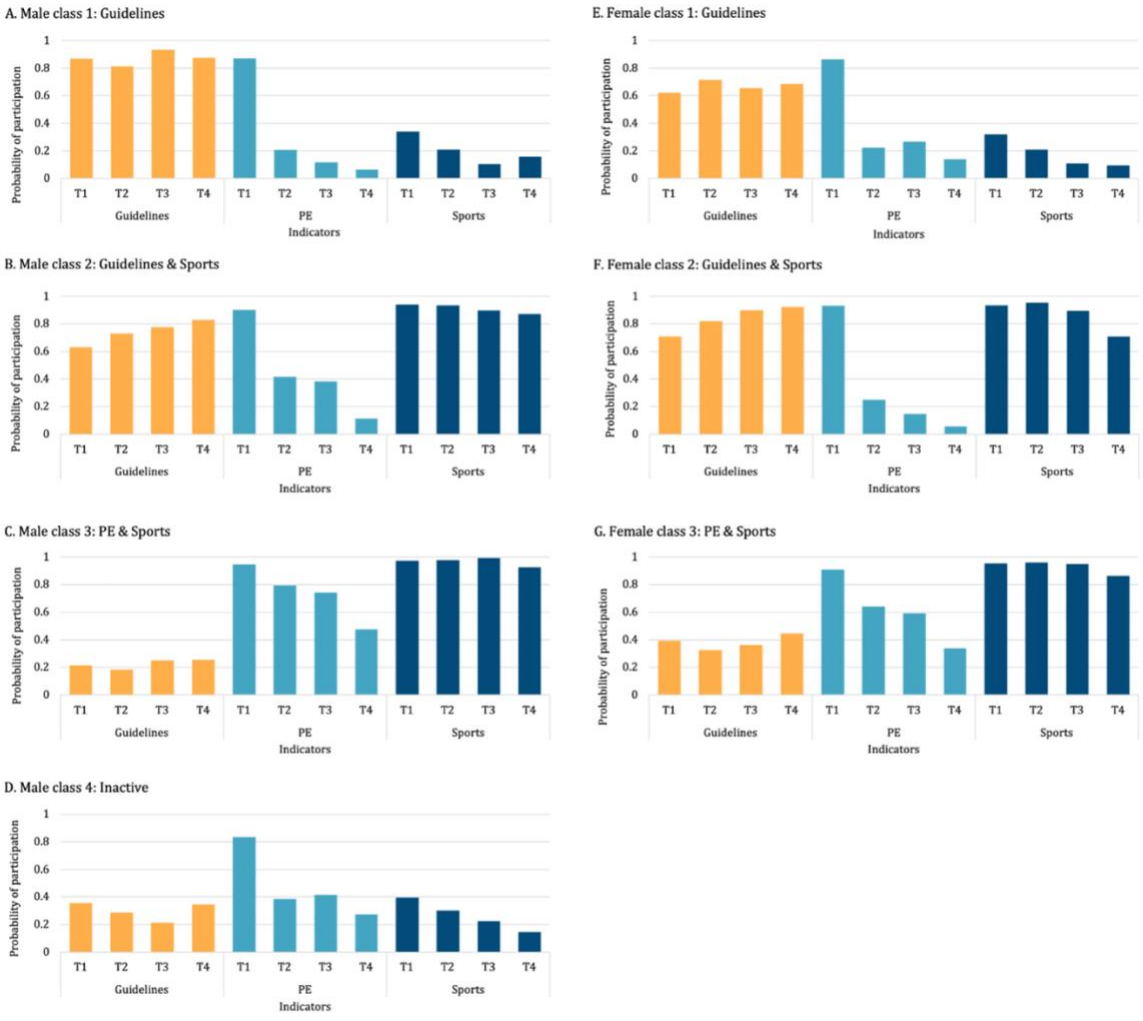

Figure 4-1 Physical activity profile item probabilities for each latent class among students who participated in COMPASS

4.4.4 Regression analyses

Results of the logistic regression models for female and male adolescents are presented in **Table** 4-3 and **Table** 4-4, respectively.

Among females, strength training of any frequency was positively associated with being in the Guidelines & Sports class, compared to the Guidelines class. Conversely, daily duration of sedentary behaviour was negatively associated with being in the Guidelines & Sports class. Strength training of any frequency, engaging in active travel, having weekly spending money between $21–100, and meeting the sleep guidelines were positively associated with being in the PE & Sports class, compared to the Guidelines class. Conversely, being racialized and having an English grade >90% were negatively associated with being in the PE & Sports class.

Among males, strength training 4-7 days a week and having weekly spending money between $21–100 were positively associated with being in the Guidelines & Sports class, compared to the Guidelines class. Conversely, being racialized and daily duration of sedentary behaviour were negatively associated with being in the Guidelines & Sports class. Similarly, strength training of any frequency, having weekly spending money between $21–100, and meeting the sleep guidelines were positively associated with being in the PE & Sports class, compared to the Guidelines class. Being racialized, daily duration of sedentary behaviour, having a desired educational attainment of secondary school or less, and having an English grade >60%, however, were negatively associated with being in the PE & Sports class. Finally, strength training of any frequency, having weekly spending money between $21–100, and having an English grade between 60-80% were positively associated with being in the Inactive class, and being racialized and having a desired educational attainment of graduate school were negatively associated with being in the Inactive class.

Table 4-3: Student characteristics associated with latent class membership among female students who participated in COMPASS

	Model 1: Class 2 (Guidelines & Sports) vs. Class 1 (Guidelines)	Model 2: Class 3 (PE & Sports) vs. Class 1 (Guidelines)
	OR (95% CI)	OR (95% CI)
Age		
	0.78 (0.53 - 1.15)	0.95 (0.67 - 1.34)
Ethno-racial identity		
Racialized	0.89 (0.59 - 1.35)	**0.59 (0.40 - 0.87)**
Non-racialized (ref)	-	-

Weekly Spending Money		
$0	0.93 (0.59 - 1.46)	0.94 (0.62 - 1.43)
$1–20 (ref)	-	-
$21–100	1.13 (0.65 - 1.95)	**1.73 (1.08 - 2.78)**
$100+	1.99 (0.61 - 6.47)	1.34 (0.41 - 4.35)
Don’t know/missing	0.99 (0.57 - 1.71)	1.18 (0.72 - 1.92)
Strength Training		
0 (ref)	-	-
1-3 days	**3.02 (1.73 - 5.26)**	**2.28 (1.35 - 3.83)**
4-7 days	**3.01 (1.78 - 5.09)**	**4.06 (2.53 - 6.52)**
Active Travel		
Yes	0.85 (0.54 - 1.35)	**0.49 (0.31 - 0.77)**
No (ref)	-	-
Sedentary Behaviour (hours, per day)		
	0.89 (0.85 - 0.95)	0.96 (0.92 - 1.01)
Sleep Guidelines		
Yes	1.15 (0.80 - 1.65)	**1.53 (1.10 - 2.13)**
No (ref)	-	-
Desired Educational Attainment		
Secondary School or less	0.26 (0.03 - 2.26)	0.76 (0.22 - 2.60)
College or Trade	0.82 (0.32 - 2.07)	0.87 (0.40 - 1.88)
Bachelors (ref)	-	-
Graduate School	1.61 (0.91 - 2.85)	1.56 (0.93 - 2.61)
I don't know	0.80 (0.42 - 1.51)	0.71 (0.40 - 1.26)
English Grade		
<60%	0.65 (0.06 - 6.52)	1.28 (0.27 - 6.12)
60-80%	0.70 (0.43 - 1.13)	1.04 (0.69 - 1.56)
80-90% (ref)	-	-
>90%	0.66 (0.42 - 1.04)	**0.61 (0.39 - 0.94)**
Math Grade		
<60%	0.33 (0.11 - 1.01)	0.49 (0.22 - 1.12)
60-80%	0.83 (0.52 - 1.34)	1.07 (0.71 - 1.62)
80-90% (ref)	-	-
>90%	1.46 (0.94 - 2.26)	1.31 (0.86 - 2.00)

Note: CAD = Canadian dollars. CI = confidence interval. OR = odds ratio. PE = physical education. Ref= reference category. Bolded values indicate significance.

Table 4-4: Student characteristics associated with latent class membership among male students who participated in COMPASS

	Model 3: Class 2 (Guidelines & Sports) vs. Class 1 (Guidelines)	Model 4: Class 3 (PE & Sports) vs. Class 1 (Guidelines)	Model 5: Class 4 (Inactive) vs. Class 1 (Guidelines)

	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age			
	0.95 (0.58 - 1.56)	0.90 (0.55 - 1.45)	1.22 (0.70 - 2.11)
Ethno-racial identity			
Racialized	**0.50 (0.30 - 0.85)**	**0.25 (0.15 - 0.42)**	0.72 (0.41 - 1.27)
Non-racialized (ref)	-	-	-
Weekly Spending Money			
$0	1.03 (0.58 - 1.82)	0.72 (0.41 - 1.26)	1.06 (0.56 - 2.01)
$1–20 (ref)	-	-	-
$21–100	**2.27 (1.05 - 4.91)**	**2.32 (1.11 - 4.84)**	**2.46 (1.08 - 5.58)**
$100+	2.49 (0.70 - 8.80)	1.38 (0.40 - 4.77)	1.31 (0.31 - 5.51)
Don’t know/missing	**2.82 (1.09 - 7.28)**	**2.86 (1.15 - 7.11)**	**2.87 (1.05 - 7.82)**
Strength Training			
0 (ref)	-	-	-
1-3 days	1.02 (0.54 - 1.93)	**2.98 (1.52 - 5.86)**	**2.10 (1.03 - 4.28)**
4-7 days	**1.80 (1.00 - 3.21)**	**11.03 (5.91 - 20.57)**	**3.22 (1.65 - 6.28)**
Active Travel			
Yes	1.28 (0.70 - 2.35)	1.06 (0.58 - 1.92)	1.32 (0.68 - 2.56)
No (ref)	-	-	-
Sedentary Behaviour (hours, per day)			
	0.93 (0.86 - 1.00)	**0.93 (0.87 - 0.99)**	0.98 (0.91 - 1.06)
Sleep Guidelines			
Yes	1.44 (0.88 - 2.35)	**1.64 (1.02 - 2.62)**	1.32 (0.77 - 2.27)
No (ref)	-	-	-
Desired Educational Attainment			
Secondary School or less	0.24 (0.05 - 1.10)	**0.27 (0.07 - 0.98)**	0.75 (0.22 - 2.55)
College or Trade	0.7 (0.25 - 1.93)	0.91 (0.36 - 2.30)	1.07 (0.40 - 2.84)
Bachelors (ref)	-	-	-
Graduate School	0.77 (0.36 - 1.66)	0.55 (0.26 - 1.17)	**0.33 (0.14 - 0.78)**
I don't know	0.85 (0.38 - 1.92)	0.76 (0.35 - 1.65)	0.66 (0.28 - 1.56)
English Grade			
<60%	0.84 (0.19 - 3.70)	0.81 (0.22 - 3.01)	1.26 (0.30 - 5.37)
60-80%	1.35 (0.75 - 2.45)	1.17 (0.67 - 2.04)	**2.28 (1.20 - 4.34)**
80-90% (ref)	-	-	-
>90%	0.67 (0.34 - 1.31)	**0.34 (0.17 - 0.68)**	0.57 (0.23 - 1.39)
Math Grade			
<60%	0.44 (0.13 - 1.48)	0.69 (0.24 - 1.96)	0.65 (0.20 - 2.10)
60-80%	0.57 (0.30 - 1.07)	0.84 (0.47 - 1.51)	0.92 (0.48 - 1.76)
80-90% (ref)	-	-	-
>90%	1.42 (0.75 - 2.67)	1.09 (0.58 - 2.06)	1.13 (0.52 - 2.42)

Note: CAD = Canadian dollars. CI = confidence interval. OR = odds ratio. PE = physical education. Ref= reference category. Bolded values indicate significance.

4.5 Discussion

This study examined latent physical activity profiles over time among a large sample of Ontario secondary school aged adolescents. Using a RMLCA, three and four unique physical activity profiles were identified among female and male adolescents, respectively. Three common patterns emerged among both female and male adolescents: Guidelines, PE & Sports, and Guidelines & Sports. A fourth latent class was identified only among male adolescents: Inactive. To the best of our knowledge, this is the first study to examine longitudinal patterns of PE participation within the context of other co-occurring physical activity indicators.

4.5.1 Latent classes

Our findings suggest that longitudinal physical activity profiles differ by sex. The most prevalent class among females was Guidelines, representing nearly half of female adolescents in this study. Physical activity participation in the Guidelines class was characterized by consistent guideline adherence without PE or sports participation, indicating high levels of independent physical activity. By contrast, the most prevalent class among male adolescents was PE & Sports, indicating a greater tendency towards organized activities. This observed difference suggests a sex-based preference for certain physical activity types. These findings align with previous sex- and gender-based physical activity literature demonstrating that a larger proportion of female adolescents tend to participate in individual physical activities (e.g., running, walking, fitness classes), whereas a larger proportion of male adolescents tend to participate in team-based sports [148, 149]. Additionally, previous literature has consistently identified higher PE participation rates among male adolescents compared to their female counterparts [126, 131]. Our findings extend previous research by suggesting that sex-based differences in physical activity participation exist across a variety of physical activity indicators examined concurrently.

Interestingly, a large proportion of adolescents in this study (33% of females, 43% of males) demonstrated consistent participation in both PE and sports but were not meeting physical activity guidelines, suggesting that these activities alone do not constitute sufficient levels of physical activity to align with current recommendations for adolescents (i.e., ≥ 60min of MVPA/day [9]). Either the

frequency of participation (days/week) or the duration of MVPA (min/day) while participating in these activities was not sufficient to meet recommendations. These findings are consistent with a recent systematic review demonstrating that youth only spend about 40% of a typical PE lesson engaging in MVPA [141]. Similarly, a recent study reported that while sport participants were more likely to meet physical activity guidelines compared to their non-participating counterparts, a large proportion were not meeting the guidelines [225]. Notably, adolescents in the Guidelines & Sports class consistently met physical activity guidelines while participating in organized sports, indicating it is possible for adolescents to meet recommendations by participating in sports, either alone or in combination with independent physical activity, if the frequency or duration is sufficient. These findings may reflect variation in the types of sport participation. Adolescents participating in community or varsity sports, with compulsory games, practices, and workouts throughout the week, may be more likely to meet guidelines than those enrolled in irregular or intramural sport programs.

Unique to male adolescents, an Inactive class was identified. Roughly one in five male adolescents in this study were not engaging in any type of physical activity. This contradicts research on sex-based patterns of physical activity behaviours suggesting lower levels of physical activity among female adolescents across all behaviours compared to males [2, 76, 77]. Male adolescents in this class should be considered the highest risk group with respect to physical inactivity, as they did not participate in any type of physical activity behaviour beyond their compulsory grade 9 PE class. Future research should explore reasons for non-participation and strategies to overcome barriers to participation among this group of male adolescents.

4.5.2 Characteristics of classes

Another objective of this study was to determine which student-level characteristics were predictive of class membership. We observed a strong relationship between strength training and class membership among both female and male adolescents. Adolescents who engaged in strength training were more likely to be in the PE & Sports and the Guidelines & Sports classes. The strongest association was observed between participating in 4-7 days per week of strength training and being in the PE & Sports class. These findings are consistent with previous research indicating that strength training activities are particularly common among adolescents involved in sport participation [226, 227], as strength training activities are often key components of weekly training programs for many competitive sports teams. Interestingly, strength training of any frequency among males was associated with being

in the Inactive class. While somewhat unexpected, these findings are consistent with previous research indicating that strength training has become increasingly popular among adolescents not involved in sports, possibly as a means to increase muscularity [226]. Further research into the intentions behind strength training and how participation impacts other physical activity indicators is warranted. We also observed an association between hours of sedentary behaviour and class membership among both female and male adolescents. Students who engage in more sedentary behaviours were less likely to belong to the Guidelines & Sports (among both females and males) or PE & Sports (males only) classes. These results align with previous research demonstrating that greater physical activity participation is associated with less sedentary behaviour [3].

Racialized youth were less likely to belong to the PE & Sports and Guidelines & Sports classes, consistent with previous literature demonstrating that PE and sports participation often differs by race or ethnicity [228, 229]. These findings must be considered within the context of intersectionality. Race, gender, socio-economic status, ability, and other socio-demographic factors play an important role in shaping an individual's access, experience, and attitudes towards physical education, physical activity, and sport [75]. Equitable opportunity for all youth requires that physical activity programming be receptive to diverse social identities and attentive to ways in which youth are differentially impacted by policies and practices [75].

4.5.3 Strengths and limitations

We applied sex-stratified RMLCA models to a large cohort of adolescents in Ontario, Canada who participated in four consecutive years of the COMPASS study. RMLCA analyses permitted the examination of class indicators over multiple time points, allowing for identification of common patterns of behaviour change.

This study has a few limitations that should be noted. Firstly, student-level COMPASS data are not nationally representative, and as such, our findings may not be generalizable to all adolescents in Ontario. COMPASS was not designed to collect nationally representative data, instead relying on purposive sampling procedure to ensure robust sample sizes. Active-information passive-consent data collection procedures yield high participation rates and reduced selection bias [190]. We advise readers to consider the influence of differing populations, curricula, and implementation strategies between school boards, regions, and countries when generalizing the findings from this study. Secondly, data for this study were collected using self-report questionnaires. Self-report data may be influenced by

recall bias or social desirability bias and could result in an overestimation of true physical activity levels [230]. It is possible that this overestimation could have influenced latent class identification and class membership estimates. The questionnaires used in the COMPASS study, however, have been previously validated as reliable measures of physical activity in youth [196]. Thirdly, the self-report ethno-racial identity question used in this study was selected for inclusion in the COMPASS student questionnaire in 2012 and captures the constructs of both race and ethnicity [193]. For this study, this variable has been operationalized as "ethno-racial identity" to align with the recently published guidance on the reporting of race and ethnicity by the Canadian Medical Association Journal [193]. To create more inclusive and specific options for participants, the question was updated for the 2020-2021 COMPASS data collection cycle. Fourth, the PE and sport participation questions used in this study do not take into consideration the frequency of participation and the quantity of physical activity performed during these physical activity contexts. This could result in a heterogeneity among students reporting participation in PE and sports and could have influenced the findings of this study. Finally, COMPASS does not collect data on physical literacy, attitudes towards physical activity types, or intention for participation in physical activity. Previous research suggests that physical activity enjoyment and intentions are strong indicators of physical activity engagement [231–233] necessitating future research to explore their impact on class membership.

4.5.4 Implications

The findings from this study have important implications for adolescent health research and public health policy. Alarmingly, a large proportion of male adolescents in this study were not consistently engaging in any type of physical activity beyond their mandatory grade 9 PE requirements. PE provides a unique opportunity to reach a large population of children and adolescents, particularly those who may not be able to participate outside of school [114]. The pre-existing infrastructure of PE positions it to be one of the most cost-effective population-level health-promotion strategies targeting adolescents [20]. The implementation of compulsory PE programming throughout secondary school may be a key first-step in promoting physical and health literacy and ultimately physical activity among youth; however, findings from this study suggest that adolescents who consistently participate in PE do not necessarily meet physical activity recommendations. The impact of physical activity participation extends beyond meeting the current recommendations; physical activity participation, when delivered in appropriate frequency, intensity, and context, can positively influence mental health outcomes [39, 40, 234]. It remains unknown, however, whether the quantity of physical activity accrued during PE is

associated with favourable mental health outcomes. Future research should aim to evaluate the impact of PE participation on physical and health literacy as well as physical activity levels, mental health, and overall wellbeing.

Our findings also indicated that physical activity profiles over time varied by sex; male adolescents had a greater tendency to engage in organized sport and female adolescents had a greater tendency to engage in independent physical activities. While many PE curricula in Canada are beginning to deviate from sport- and game-focused learning, the time lag between curriculum design and development to implementation and culture change [117] could partially explain the low PE participation rates, particularly among female adolescents. Our findings may provide some justification for expanding the variety of activities offered in PE programs. However, a better understanding of how the variety of activities provided during PE lessons influences participation rates is required.

4.6 Conclusion

This study investigated longitudinal physical activity profiles in a large sample of adolescents in Canada. Our findings reaffirm that physical activity profiles among adolescents are clustered and appear to vary by sex. In light of declining rates of physical activity among youth today, these findings can help inform public health programming, particularly within the school context. The bodies that govern curriculum decision-making in Canada, such as the Ministries of Education, should consider implementation of mandatory PE programming for all students throughout secondary school, with special care taken to ensure types of activities offered suitable and accessible for all youth. Future research quantifying the impact of PE and sports participation on overall physical activity levels and wellbeing is warranted.

Chapter 5:
Study 2

Examining the longitudinal impact of participation in school-based physical education lessons on physical activity levels among a large sample of adolescents in Ontario, Canada

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5.1 Overview

Objectives: This study examined the impact of physical education (PE) participation on moderate-to-vigorous physical activity (MVPA) among adolescents in Canada, controlling for observed differences in individual characteristics using propensity scores.

Methods: This study utilized linked longitudinal data from Ontario students who participated in three years (2015/16-2018/19) of the COMPASS study. Sex-stratified linear mixed models were used to examine associations between PE participation and minutes of MVPA from grades 10 through 12. Models were adjusted using doubly robust propensity score methodology, through inverse probability of treatment weighting, accounting for observed covariates that may influence PE participation.

Results: Overall, 988 female and 872 male students were included in analyses. Female and male students who participated in PE during the semester of data collection reported on average 29 (22-35) and 36 (29-43) additional minutes of MVPA per day, respectively, compared to those who did not participate in PE that year. Female and male students who participated in PE during the opposite semester of data collection reported on average 11(4-18) and 14 (7-22) additional minutes of MVPA per day, respectively, compared to students who did not participate in PE that year.

Conclusions: Findings suggest that secondary school PE participation has a significant impact on MVPA levels over time. Effects appear to be most pronounced among male students and during the semester of PE participation. These findings highlight the potential benefits of daily PE on physical activity patterns and provides evidence in support of approaches aimed at increasing PE enrollment throughout secondary schools in Ontario.

Keywords: physical activity, physical education, adolescent, propensity scores, longitudinal, school

5.2 Background

Physical activity plays an important role in promoting individual health and wellbeing throughout the lifespan [5], with adolescence being a particularly critical window for establishing healthy behavior patterns [4]. As such, current youth physical activity guidelines recommend an average of 60min/day of moderate-to-vigorous physical activity (MVPA), with a focus on vigorous physical activities and muscle and bone strengthening activities ≥3 days per week [9]. Recognizing the significance of consistent engagement throughout adolescence, programs and strategies that increase physical activity participation among youth can have profound, lifelong impacts [11]. Despite the multitude of health benefits, evidence suggests that youth adherence to the physical activity guidelines is relatively low [235].

Schools are considered an ideal environment for the promotion of physical activity among youth, offering various avenues for participation including physical education (PE) classes, intramural and varsity sport programs, and active transportation to and from school [1, 107]. In comparison to many other sources of physical activity, PE provides a structured learning environment and exposure to physical activity for nearly all youth [108], including those who may not be able to participate in physical activity outside of school (e.g., community sport participation) [114]. The aim of PE is to allow youth to develop and refine their physical and health literacy (e.g., movement competency, and the appreciation and enjoyment of physical activity) to foster lifetime engagement in physical activity [1]. Physical Education has the potential to influence youth physical activity levels by (a) allocating time to daily physical activity through PE lessons (direct effects) [140]; and (b) encouraging youth to continue engaging in physical activity during their leisure-time (indirect effects) [140].

Most countries globally have implemented policies or best practices to provide some level of PE administration throughout compulsory schooling [115]; however, the frequency, quantity, and duration of these programs differ across countries, regions, or even between schools [115]. In Canada, PE is compulsory for all students in Canada throughout elementary and middle school (grades 1-8 [ages 5 – 13]); however, in secondary school (grades 9-12 [ages 13 – 18]), PE becomes non-mandatory for many students. PE programming in Canada is developed and implemented at the provincial level, with each province and territory regulating their own PE policies. The province of Ontario currently has the most lenient PE policy in Canada, with students only required to complete one secondary school-level PE course [111].

Despite the potential for PE programming to influence youth physical activity levels, there has been a decline in PE participation rates globally since 1998. Anywhere from 20-65% of secondary school students are not enrolled in regular PE classes [126–128, 133]. Among those not enrolled in PE, a greater proportion are represented by female students [126, 132, 183], and those in higher grades [126]. International research has demonstrated that PE is positively associated with time spent engaging in physical activity [128, 132, 137, 139, 143, 183]. Recent studies have reported that participation in non-mandatory PE was associated with more days of being physically active for ≥60min [137], meeting the current physical activity recommendations [126], and a higher likelihood of achieving an average of 60min of daily physical activity [84] among adolescents. However, there is a paucity of research evaluating PE programming in Canada [84, 123, 145]. To date, only one study has examined the impact of participation in Ontario's secondary school PE program on physical activity levels finding a 30min/day benefit of participation [134]. These findings are limited in that data was pooled from schools in Ontario and Alberta, limiting the interpretability of the results for provincial policy makers, and while data was linked between grades 9 and 12, student behaviours in grades 10 and 11 were not taken into consideration.

Previous research has established that participation in non-mandatory PE is not random and numerous student- and school-level variables influence enrollment among adolescents [126, 132, 136]. Similar to those reported for other physical activity behaviours, correlates of PE participation include sex, age, geographical region, physical activity patterns, parental education and employment status, school size, and school grade [126, 132]. The effectiveness of PE participation at increasing physical activity engagement is particularly important to explore within a real-world context, taking into consideration the numerous variables that may influence this association [128]. Many studies in this area utilize regression analyses to examine the impact of PE participation on MVPA [84, 128, 183]; however, this can limit the ability to control for numerous covariates within a single model [184]. As such, much of the current PE literature is unable to examine the relationship between non-mandatory PE and MVPA, independent from the individual characteristics which may influence enrollment choices.

In addition to the need for Canada- and Ontario-specific research, there is also a need to adjust for inherent self-selection bias. Since there are many factors that influence a student's choice to enroll in non-mandatory PE, and these factors can confound the relationship between PE and other behaviours, evaluating the effectiveness of PE can be challenging [84, 128, 183]. The purpose of this study was to

address both research gaps by examining the impact of PE participation on MVPA levels from grades 10 through 12, among secondary school students in Ontario, Canada, while controlling for potential self-selection bias differences in observed individual characteristics using propensity scores.

5.3 Methods

5.3.1 Study design

We used data from the COMPASS (Cannabis use, Obesity, Mental health, Physical activity, Alcohol use, Smoking, Sedentary behaviour) study. The COMPASS Study is a school-based prospective cohort study (2012-2027) of adolescents in Canada. The COMPASS Study uses a purposive sampling approach with an active-information, passive-consent parental permission protocol to collect student- and school-level data from participating secondary schools in the following Canadian provinces: Alberta, British Columbia, Ontario, Quebec, and Prince Edward Island. All students attending participating schools were eligible to participate and were free to withdraw at any time. The COMPASS Study received ethics clearance from the University of Waterloo Office of Research Ethics (ORE: #30118) as well as from the participating school boards. The COMPASS Study has been previously described in detail online (www.compass.uwaterloo.ca) and in print [189].

5.3.2 Participants

This study used longitudinal data from students in Ontario who participated in four consecutive years of the COMPASS Study (Time 1 (T1): 2015–16; Time 2 (T2): 2016–17; Time 3 (T3): 2017-18; Time 4 (T4): 2018-19). Data from these years of the COMPASS study were used to avoid the impact of the COVID-19 pandemic. Overall, 2,036 students from 48 secondary schools in Ontario were linked from T1 to T4. Students who were not enrolled in grades 10 at T1, 11 at T2, and 12 at T3 [n=79] and those who were missing data on predictors (PE participation, grade, or sex) [n=92] were excluded. Students who reported more than one sex over the study period [n=5] were excluded as there were insufficient numbers to create a meaningful third category for analysis. Student data were linked across timepoints using a unique, self-generated code as described in COMPASS protocols [191].

5.3.3 Measures

5.3.3.1 PE participation

Students were asked to report their **PE participation** as: "Yes, I am taking one this term," "Yes, I will be taking one or have one this school year, but not this term," or "No, I am not taking a PE class at school this year." Students were categorized into three mutually exclusive groups depending on their participation during the school year (yes, this term=1; yes, but not this term=2; no =0).

5.3.3.2 Daily MVPA

Students were asked to report the number of hours (0-4) and minutes (0, 15, 30, 45) of both **moderate** (e.g., walking, biking to school, and recreational swimming) and **vigorous** (e.g., jogging, team sports, and jump-rope) **physical activity** on each of the previous 7 days. Student estimates were totaled and averaged to provide a measure of minutes of daily MVPA. This measure has been previously validated for use among adolescents [195], and has been found to have acceptable test-retest reliability and criterion validity [196].

5.3.3.3 Covariates

The following covariates were included in this study.

Demographic variables included student report of **sex** (female, male), **age** (13-18 years), **ethno-racial identity** (racialized [Black, Asian, Latin American or Hispanic, Mixed, Other], non-racialized [White]), body mass index (**BMI)** (weight/height^2), **weight perception** (underweight, about right, overweight), and their **weight-control intentions** (nothing, maintain, lose, gain). As a proxy for student socioeconomic status, students reported their **weekly spending money** ($0, $1–$20, $21–$100, $101+, Don't know); This measure was used as adolescents may not be able to accurately report household income [192].

Movement behaviours included weekly **strength training** (0-7 days), **sedentary behaviours** (0-9.75 hours; activities included watching/streaming TV shows or movies, playing video/computer games, talking on the phone, surfing the internet, texting, messaging, and/or emailing), participation in **intramural sports** (yes, no), **community sports** (yes, no), or **varsity sports** (yes, no), **active transportation** (i.e., walk or bicycling) to and/or from school (yes, no), and **sleep** (0-9.75 hours per night). Lastly, students reported their number of **physically active friends** (≥1, 0).

Academic indicators included most recent **English** and **Math grades** (<60%, 60-80%, and >80%), **highest desired level of education** (high school diploma or less, college or trade certificate, university bachelor's degree, graduate school, or I don't know), the number of classes they **missed due to health issues** (0, 1-5, ≥6) or **skipped** (0, 1-5, ≥6), and **school connectedness** (score 6-24; a 6-item modified version of the National Longitudinal Study of Adolescent Health School Connectedness scale [236]. Lastly, students reported their experience with **bullying perpetration** (yes, no), and/or **bullying victimization** (yes, no).

Substance use behaviours included any report of **binge-drinking** in the past month (yes, no), **e-cigarette/vaping** use in the past month (yes, no), and **cannabis** use in the past year (yes, no).

5.3.4 Analysis

Descriptive statistics at T1 were examined for the entire sample and stratified by sex. Differences in baseline characteristics between females and males were compared using chi-square and t-tests, where appropriate.

Linear mixed models (LMMs) were used to estimate the average effect of PE participation on average daily MVPA levels in grades 10 through 12, stratified by sex. To account for the disproportionate influence of student characteristics on the probability of opting into PE, models were adjusted using doubly robust propensity score (PS) methodology.

Propensity scoring is a statistical technique employed to reduce the impact of confounding or self-selection biases in observational studies [185]. Propensity scoring generates conditional probability assignments to a particular exposure (e.g., treatment, intervention) given a set of observed covariates [186]. Propensity scores act as balancing measures to aggregate a set of observed covariates believed to influence the treatment assignment into a single score. When propensity scores are similar across treatment or exposure groups, participants are assumed to have similar characteristics, regardless of treatment assignment or exposure status [186].

A PS representing the probability of a student opting-in to PE was calculated for each student given all their individual covariates (listed in Section 2.3.3). All covariates known, or suspected, to influence PE participation or physical activity available in the COMPASS system were included in the PS [215, 216]. Propensity Scores were used as weights through inverse probability of treatment weighting (IPTW) to account for confounding in the LMMs. To account for longitudinal changes in time varying

confounders (e.g., age, current substance use), PSs were recalculated at the start of each school year [184]. Using IPTW, the distribution of student covariates used to estimate the PSs become independent of exposure status (e.g., PE participation). Stabilized weights truncated at the 1st and 99th percentiles were used to reduce the exertion of any influential weights. Weight stabilization incorporates the sex-specific annual probability of PE participation, which preserves the original sample size in the weighted sample and produces more appropriate estimation of the variance of the main effect [237, 238].

Standardized mean differences (SMD) (representing the difference in means divided by the pooled standard deviation) of each covariate were used to assess covariate balance pre- and post-weighting. A SMD cut-off of 0.1 was used to indicate appropriate covariate balance after weighting. Unlike p-values, SMD are a bivariate test to ensure that the propensity scores have sufficiently removed any between group differences that are not sensitive to sample size [239]. Remaining covariate imbalances were accounted for by including any variables that remained unbalanced after weighting as covariates in the final model [218]. In the final model for female students, binary indicators of bullying perpetration, ≥6 classes missed due to health issues, the intention to gain weight, weekly spending money of $101+, and sleep were included. For male students, the final model included a dummy variable adjustment for missing data on screentime, and binary indicators of English grade of <60%, Math grade of 60-80%, 1-5 classes missed due to health issues, and sleep. PS generation and LMMs were conducted using SAS version 9.4.

5.4 Results

5.4.1 Student Characteristics

Overall, 1,860 students were included in this study. Roughly half of the sample was female (53%), the mean age in grade 10 was 15 years, and the majority of students were of non-racialized backgrounds (**Table** 5-1). Rates of PE participation in grade 10 were higher among male students (52%) compared with female students (36%). Among those participating in PE in grade 10, approximately half did so during the semester of data collection (female: 48%; male: 55%). PE participation rates decreased among both female and male students with increasing grade; in grade 11, 34% of female and 50% of male students were enrolled, and by grade 12, 18% of female and 28% of male students were enrolled in PE.

Weekly spending money, desired educational attainment, weight perceptions, weight-control intentions, school connectedness, minutes of MVPA, number of active friends, strength training, binge drinking, and varsity, intramural, and community sport participation differed between students enrolled in PE and students not enrolled in PE for both females and males in grade 10. A smaller proportion of students from racialized backgrounds reported enrollment in PE, and this was consistent across female and male students. Students enrolled in PE in Grade 10 engaged in on average 50 additional minutes of MVPA per day and one additional day of strength training compared to those not enrolled in PE. A greater proportion of students enrolled in PE also participated in intramural, varsity, or community sports. Male students were found to obtain, on average, one additional hour of sleep per night compared with female students, which was consistent across PE categories.

Table 5-1: Sample descriptives by sex at T1 (2015/16)

Variable	Female students (n=988)				Male students (n=872)			
	PE (n=355)	No PE (n=633)	Unweighted SMD	Weighted SMD	PE (n=456)	No PE (n=416)	Unweighted SMD	Weighted SMD
Age, mean (SD)								
Years	15 (0.45)	15 (0.47)	-	-	15 (0.50)	15 (0.48)	-	-
Ethno-racial identity, % (n)								
Racialized	11% (40)	20% (129)	0.252	0.024	18% (80)	22% (91)	0.109	-0.009
Weekly spending money, % (n)								
Zero	15% (52)	19% (122)	0.123	-0.045	20% (91)	24% (99)	0.093	-0.002
$1-$20	29% (102)	35% (220)	0.130	0.037	33% (151)	31% (130)	-0.040	0.055
$21-$100	31% (110)	23% (147)	-0.175	-0.027	23% (106)	22% (92)	-0.027	-0.035
$101+	12% (42)	9% (59)	-0.082	0.006	13% (61)	13% (52)	-0.026	-0.093
Don't know	14% (48)	13% (80)	-0.026	0.025	10% (47)	10% (42)	-0.007	0.069
Missing	0% (1)	1% (5)	-	-	0% (0)	0% (1)	-	-
Sports Participation, yes, % (n)								
Intramural	53% (187)	34% (216)	-0.381	-0.001	50% (230)	37% (153)	-0.278	-0.012

Community	57% (203)	34% (216)	-0.476	-0.026	69% (316)	41% (171)	-0.591	0.050
Varsity	63% (222)	30% (188)	-0.698	-0.019	64% (291)	38% (159)	-0.530	-0.021
Daily MVPA, median (IQR)								
Minutes	120 (77 - 169)	69 (36 - 120)	-	-	139 (94 - 197)	90 (45 - 137)	-	-
Daily screen time, median (IQR)								
Hours	7 (4 - 9)	7 (4 - 9)	0.040	-0.031	7 (5 - 9)	7 (4 - 9)	-0.020	-0.051
Strength training, median (IQR)								
Days	3 (2 - 4)	2 (0 - 3)	0.452	0.009	3 (2 - 5)	2 (0 - 4)	0.441	-0.045
Sleep, median (IQR)								
Hours	7 (7 - 8)	7 (7 - 8)	0.123	-0.009	8 (7 - 8)	8 (7 - 8)	0.162	-0.001

IQR: interquartile range; MVPA: moderate-to-vigorous physical activity; PE: physical education; SMD: standardized mean difference; SD: standard deviation

5.4.2 Mixed models

Adjusted and unadjusted LMM results are presented in **Table 5-2**. IPTW adjusted models demonstrated that participation in PE had a significant positive effect on daily MVPA levels. Female students currently participating in PE reported on average 29 more minutes of MVPA per day than students who did not participate in PE that year. Female students enrolled (but not currently participating) in PE reported on average 11 more minutes of MVPA per day than students who did not participate in PE that year. Similarly, male students currently participating in PE reported on average 36 more minutes of MVPA per day than students who did not participate in PE that year. Male students enrolled (but not currently participating) PE reported on average 14 more minutes of MVPA per day than students who did not participate in PE that year.

Daily MVPA levels were found to decrease with increasing age. Female students in grade 12 report on average, 10 fewer minutes of MVPA per day than grade 10s. Male students in grade 12 report on average 9 fewer minutes of MVPA per day than grade 10s.

Table 5-2 Unadjusted and IPTW-adjusted longitudinal association between PE participation and minutes of daily MVPA

Effect	Female students (n=988)		Male students (n=872)	
	Unadjusted estimate (95% CI)	IPTW-adjusted estimate (95% CI)	Unadjusted estimate (95% CI)	IPTW-adjusted estimate (95% CI)
PE: No	–	–	–	–
PE: Yes, this semester	+34 min (28 – 40)	+29 min (22 – 35)	+41 min (34 – 48)	+36 min (29 – 43)
PE: Yes, but not this semester	+16 min (9 – 23)	+11 min (4 – 18)	+20 min (13 – 28)	+14 min (7 – 22)
Grade 10	–	–	–	–
Grade 11	-7 min (-11 – -2)	-6 min (-10 – -1)	-3 min (-8 – 3)	-2 min (-8 – 3)
Grade 12	-9 min (-14 – -5)	-10 min (-15 – -6)	-9 min (-14 – -3)	-9 min (-15 – -4)

Note: All estimates were statistically significant at the $p<0.05$ level. CI: confidence interval; IPTW: inverse probability of treatment weighting; MVPA: moderate-to-vigorous physical activity; PE: physical education.

5.5 Discussion

This study examined the impact of participation in secondary school PE on daily MVPA using a robust statistical technique that adjusted for a large number of confounding factors. Our findings demonstrate that after adjusting for factors that influence the propensity for PE enrollment, participation in PE has a significant positive impact on MVPA levels over time and that MVPA levels were found to decrease with increasing age. Since effects were most pronounced among male students and during the semester of PE participation, findings suggest that improving female student engagement in PE should be a key priority. Overall, this study demonstrates that secondary school PE holds the potential to positively contribute to the health and wellbeing of adolescents in Canada.

5.5.1 Sex based differences

Findings from this study highlight key sex-based differences in the association between PE participation and MVPA. Participation rates in non-mandatory PE were found to differ by sex, with fewer female students electing to participate and a more pronounced grade-related decline in participation among female students relative to male students. In addition to the differences in enrollment, PE participation had a differential impact on student physical activity patterns, with male students who participated in PE obtaining roughly 30% more MVPA per day compared to females who

participated in PE. These findings align with previous research demonstrating that participation rates are generally higher among male adolescents (and male athletes in particular) [148, 149] compared to female adolescents [126, 131, 132, 137] and that the association between PE and physical activity is stronger among male adolescents [84]. Together, these results suggest that PE may be more successful at engaging male adolescents in physical activity. A possible explanation for these findings is related to the administration of PE classes; PE lessons often include sport-based activities [117] with research suggesting that this may favor participation by males over females, as they may be more inclined towards competitive and team-oriented physical activities [117]. Existing literature suggests that female adolescents are reported to have a greater tendency for individual or fitness-related activities over team-based sports [148, 149], possibly due to factors including body dissatisfaction, the desire to promote an image of femininity, fear of stigmatization or teasing in sports settings, and disinterest in competition [148, 240–243]. Diversifying the range of activities offered in PE classes can support various interests and preferences (e.g., yoga, running/jogging groups), creating a more inclusive environment and engaging a broader range of students irrespective of age, sex, or background.

5.5.2 Direct vs indirect effects

Our findings demonstrate that the impact of PE participation on daily MVPA was more pronounced during the semester of participation. These results are to be expected given that PE acts as a source of physical activity, contributing to students' daily accumulation of MVPA [140]. Students concurrently participating in PE reported an additional 30min of MVPA per day compared with students who did not participate in PE that year, accounting for roughly 50% of their recommended daily MVPA [9]. This observed 30min/day benefit aligns with findings from two prior studies conducted within the Canadian context [123, 134] and is generally consistent with findings from a recent systematic review which identified that youth spend roughly 40% of a secondary school PE lesson (which is typically about 75 minutes in length) engaging in MVPA [141]. Assuming a structure consistent with most secondary schools in Canada (two semesters per school year, with students enrolled in four courses per semester, taken daily) the additional MVPA from PE participation identified in this study could amount to 150 additional minutes per week or 2,400 minutes per semester. These findings underscore the potential benefits of daily PE on physical activity patterns and provides evidence in support of mandating year-long PE participation or other approaches aimed at increasing PE enrollment among adolescents in Canada.

Our findings extend previous research by demonstrating that PE has the potential to positively influence MVPA levels beyond the minutes gained directly though PE lessons, as greater MVPA was observed during the semester where PE enrollment was not concurrent with data collection. To the best of our knowledge, no previous studies have examined the indirect impact of PE participation on student MVPA levels. Although the mechanism for these indirect effects is unknown, it is possible that participation in PE programs may foster positive attitudes towards physical activity among students [144]. This could translate into a greater willingness to engage in physical activities outside of the school setting. PE programs have also been shown to contribute to improved physical and health literacy and movement competency [1, 124], which in turn could boost student's confidence in participating in physical activities independently. It is also possible; however, that these findings were influenced by variables unmeasured in the COMPASS data set; thus, not accounted for in the propensity score models. For example, perceptions (e.g., motivation and enjoyment) of PE and its influence on physical activity is an area of future research that should be explored.

5.5.3 Age-related decline

We observed a meaningful age-related decline in daily MVPA levels; students in grade 12 reported roughly 10 fewer minutes of MVPA per day compared to their grade 10 counterparts. This age-related decline is a well-documented phenomenon in physical activity research among children and adolescents [64, 65, 72, 244]. Declines may reflect some of the challenges associated with this life stage, including lifestyle changes, increased responsibilities, and shifting priorities [72]. This represents a key area for intervention, as youth who engage in physical activity during adolescence maintain higher activity levels into adulthood [85–87], possibly as a result of establishing healthy behaviour patterns [4]. Motivation and enjoyment of physical activity have also been shown to predict adulthood physical activity [231–233] and can attenuate the slope of this age-related decline [245]. PE not only provides opportunities to teach students about the benefits of physical activity but can also foster autonomy and enjoyment of physical activity among adolescents, building the foundation for the formation of life-long positive health behaviours.

5.5.4 Strengths and limitations

To our knowledge, this study is the first to quantify the impact of secondary school PE participation on physical activity levels among youth in Canada, using a robust statistical technique to control for confounding due to self-selection bias. Other strengths of this study include the large sample of

adolescents in Ontario and use of an active information–passive consent protocol. Active-information passive-consent data collection procedures yield high participation rates, reduce selection bias, and more truthful self-reporting of health behaviours [190]. Perhaps the greatest strength of this study is the use of PS weighting to adjust for measured confounding in this real-world context.

Several limitations should be noted. First, while IPTW is a robust statistical technique aimed at minimizing the impact of confounding, it is sensitive to misspecification [184]. Relatedly, IPTW can only balance students on known, observed covariates and samples should not be assumed to be identical. Second, student-level COMPASS data are not nationally representative, limiting the external validity of the study findings. It should be noted; however, that COMPASS was not designed to collect nationally representative data and instead relies on a purposive sampling procedure to ensure robust sample sizes. Third, data used in this study were self-reported and are at risk for recall or social desirability bias. Data collection procedures adopted by COMPASS, including anonymity may help mitigate this. Finally, COMPASS does not collect data on the frequency of sport participation, engagement in light physical activity, or motivation for- and enjoyment of PE and PE participation, which could significantly influence the association between PE participation and MVPA.

5.6 Conclusion

Findings of this study suggest that PE participation throughout secondary school has a significant impact on MVPA levels over time. These results are promising, given the current state of physical activity levels among Canadian adolescents, however, the low enrollment rates act as a barrier to the potential population level health benefits of PE. Given the lenient PE policy, Ontario schools should consider revising existing PE programming to increase enrollment in PE courses. This could include mandating annual PE across all grades, in addition to moving PE curriculum away from sports-specific skill development and toward independent movement skills that focus on the development of physical and health literacy. These changes may improve physical activity levels for all youth.

Chapter 6:

Study 3

The longitudinal impacts of physical education participation on adolescent mental health: a sex-stratified propensity score analysis

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6.1 Overview

Purpose: The objective of this study was to examine the impact of participation in secondary school physical education (PE) on symptoms of anxiety and depression, and psychological wellbeing among adolescents in Canada, controlling for observed differences in individual characteristics using propensity scores.

Methods: This study utilized longitudinal data from 1,860 Ontario secondary school students who participated in four waves of the COMPASS Study (2015/16 to 2018/19) as they transitioned from grades 9 to 12. Three sex-stratified linear mixed models were used to estimate the average effect of PE participation on symptoms of anxiety and depression, and psychological wellbeing in grades 11 and 12. Doubly robust propensity score methodology was used to adjust for confounding impacts of student characteristics on the probability of voluntary enrolment in PE.

Results: Overall, 988 female and 872 male students were included in analyses. No significant associations were found between PE participation and anxiety or depression among female or male students, or psychological wellbeing among female students. Male students enrolled (but not currently participating) in PE were found to have a higher average psychological wellbeing (ß= 1.699, 95% CI [0.438, 2.96]) compared to male students who did not participate in PE that year.

Conclusions: The results of this study provide valuable insights into the impact of PE on student mental health, demonstrating that while PE participation was not protective against anxiety and depression symptomatology, it also did not appear to exacerbate symptoms of anxiety or depression and instead may enhance psychological wellbeing among male adolescents.

Keywords: anxiety, depression, psychological wellbeing, physical education, adolescent, propensity scores**,** longitudinal, school

6.2 Background

Adolescence is a key period in the development and onset of mental disorders. Nearly half (44%) of secondary school-aged youth in Ontario report a moderate-to-severe level of psychological distress (i.e., symptoms of anxiety and depression) [31], and an estimated 8% and 13% of youth in Canada have a diagnosis for an anxiety or mood disorder, respectively [32]. Without appropriate support and treatment, poor mental health can lead to a variety of adverse outcomes including poor academic outcomes, substance use, self-harm, and suicidal behaviour [33–35]. Moreover, mental disorders experienced during adolescence have a high risk of chronicity, which may lead to the emergence of more severe mental disorders later in life [36, 37]. From a public health perspective, identifying modifiable factors that promote positive mental health and reduce the risk of mental disorder during adolescence can have long-term positive impacts on population health and wellbeing [11, 187].

There is substantial evidence suggesting that physical activity is positively associated with mental health among youth, including lower symptoms of depression [38, 39], higher physical self-concept [39], and small-to-moderate positive effects on anxiety [40]. Engagement in physical activity provides youth the opportunity to develop both personal and social skills, reinforcing their self-esteem [41], self-efficacy [42], and self-control [43] – all of which are indicators of positive mental health. Positive mental health reflects a state of positive wellbeing extending beyond the absence of mental disorders and can be reflected through strong self-efficacy and self-esteem, satisfying personal relationships, and resilience [44]. Male adolescents that meet the recommended 60 minutes of daily activity are more likely to experience better psychosocial wellbeing compared to those not meeting the recommendations [58]. Literature in this space has led to general consensus that consistent engagement in physical activity has a protective and positive effect on mental health and wellbeing among adolescents.

Physical education (PE) is a core component of the school curriculum aimed at promoting physical activity and overall wellbeing among youth [1, 111]. Engaging in regular physical activity through PE classes is believed to have a positive impact on mental wellbeing as a result of the dose of physical activity it provides [150]. Additionally, PE provides a structured environment for students to develop social connections and build a sense of community, which has demonstrated protective effects for the prevention of isolation and loneliness [153, 154]. Moreover, the physical challenges and accomplishments experienced in PE can boost self-confidence and resilience, contributing to a sense of personal achievement and wellbeing [111, 155].

Existing research has speculated that enrollment in voluntary PE may be biased, whereby athletes and students with a higher social standing may be more likely to enrol [162]. This may lead to a competitive environment both in terms of athletic ability and social confidence, ultimately creating a non-inclusive environment. Such environments may heighten anxiety and depression due to performance pressure and complex social dynamics, particularly among students who are less physically or socially confident [151]; negative experiences in PE, including feelings of embarrassment, peer comparisons, body image concerns, and bullying are identified barriers to PE (and ultimately physical activity) participation [162–166]. This highlights the importance of evaluating whether PE participation is associated with mental health indicators in adolescents.

Many PE curricula are designed with the intention of fostering positive mental health through the promotion of resilience, positive relationships, and self-concept [111, 119]; however, there is limited evidence rigorously evaluating whether this intention holds true. The dearth of research on this topic limits our understanding of whether PE participation can positively impact mental health. Much of the published literature relating to PE and mental health has evaluated the impact of specific interventions (e.g., teacher workshops or high intensity interval training programmes) on mental health outcomes, rather than the impact of PE participation more broadly [150]. Few observational studies have evaluated this association, and even fewer have quantified this association longitudinally or examined if there may be differential impacts on boys compared to girls [150]. Therefore, the purpose of this study was to examine the impact of participation in secondary school PE on symptoms of anxiety, depression, and psychological wellbeing among students in Ontario, Canada, controlling for observed differences in individual characteristics.

6.3 Methods

6.3.1 Study design

This study used data from COMPASS, a school-based prospective cohort study (2012-2027) in Canada. The COMPASS Study collects student- and school-level data from secondary schools in five provinces across Canada (Alberta, British Columbia, Ontario, Quebec, and Prince Edward Island). All students attending participating schools were eligible to participate; the COMPASS Study uses a purposive sampling approach with an active-information, passive-consent parental permission protocol. Participation in the COMPASS Study is entirely voluntary, and students were free to withdraw at any time. The COMPASS Study received ethics approval from all participating school boards and the

University of Waterloo Office of Research Ethics (ORE: #30118). Additional information on the COMPASS Study, including sampling procedures and data collection tools, is described in detail online (www.compass.uwaterloo.ca) and in print [189].

6.3.2 Participants

This study used longitudinal data of students from 48 secondary schools in Ontario who participated in four consecutive years of the COMPASS Study as they transitioned from grades 9 to 12 (Time 1 (T1): 2015–16; Time 2 (T2): 2016–17; Time 3 (T3): 2017-18; Time 4 (T4): 2018-19). Data across all four timepoints were linked using unique, self-generated anonymous codes [191]. Students from schools outside of Ontario were excluded from this study due to variances in provincial physical education curricula and policies. A total of 2,036 students were linked across four timepoints. Students who were not enrolled in grades 10 at T1, 11 at T2, and 12 at T3 [n=79], those who were missing data on predictors (PE participation, grade, or sex) [n=92], and those who reported more than one sex over the study period [n=5] were excluded. Sample characteristics at T1 have been previously published online [246].

6.3.3 Measures

6.3.3.1 PE participation

COMPASS asks students to self-report their participation in PE during the current school year. Response options include: “Yes, I am taking one this term,” “Yes, I will be taking one or have one this school year, but not this term,” or “No, I am not taking a PE class at school this year.” Students were categorized into three mutually exclusive cohorts based on their participation during the school year (yes, this term=1; yes, but not this term=2; no=0).

6.3.3.2 Symptoms of anxiety

COMPASS uses the Generalized Anxiety Disorder 7-item scale (GAD-7) [203] to assess risk of generalized anxiety. Students are asked to self-report on how often they experienced various symptoms of anxiety (e.g., worrying, nervousness, irritability) over the past 2 weeks. Response options are provided on a 4-point Likert scale (0 = “Not at all,” 1 = “Several days,” 2 = “Over half the days,” 3 = “Nearly every day”) with individual sum scores ranging from 0 to 21 (higher scores indicating greater symptoms). The GAD-7 has been previously validated for use among adolescents [204–206].

6.3.3.3 Symptoms of depression

COMPASS uses a shortened version of the Center for Epidemiologic Studies Depression Revised (CESD-R-10) scale [199, 200] to assess risk of major depression. Students are asked to self-report on how often they experienced various depressive symptoms (e.g., sadness, loneliness, trouble concentrating or sleeping) in the past week. Response options are provided on a 4-point Likert scale (0 = "none or less than 1 day," 1 = "1-2 days," 2 = "3-4 days," 3 = "5-7 days") with individual sum scores ranging from 0 to 30 (higher scores indicating greater symptoms). The CESD-R-10 has been previously validated for use among adolescents [201, 202].

6.3.3.4 Psychological wellbeing

COMPASS uses the Flourishing scale [207] to measure self-perceived psychological wellbeing. Students are asked to report their self-perceived success in various areas of wellbeing (e.g., relationships, self-esteem, life purpose, optimism). Response options are provided on a 5-point Likert scale (1 = "Strongly disagree," 2 = "Disagree," 3 = "Neither agree nor disagree," 4 = "Agree," 5 = "Strongly agree") with individual sum scores ranging from 8 to 40 (higher scores indicating greater wellbeing). The Flourishing scale has been previously validated for use among Canadian adolescents using COMPASS data [208].

6.3.3.5 Covariates

The following covariates were included in the propensity score calculation based on their potential to influence voluntary enrolment in PE. Propensity scores were calculated in both grade 11 and grade 12.

COMPASS asks students to self-report their age (13-18 years), sex (female, male), ethno-racial identity (racialized [Black, Asian, Latin American or Hispanic, Mixed, Other], non-racialized [White]), height (feet), weight (lbs), weight perception (underweight, about right, overweight), and weight-control intentions (nothing, maintain, lose, gain). Student height and weight were used to calculate body mass index. Students were asked to report their weekly spending money ($0, $1–$20, $21–$100, $101+, Don't know) as a proxy for familial socioeconomic status, as adolescents may not be able to accurately report household income [192].

COMPASS asks students to estimate the number of hours (0-4) and minutes (0-45) they spent engaging in both moderate (e.g., walking, biking to school, and recreational swimming) and vigorous

(e.g., jogging, team sports, and jump-rope) physical activity on each of the previous 7 days. Responses were totaled and averaged to provide an estimate of daily moderate-to-vigorous physical activity (MVPA) [195]. Students were asked to describe their participation in weekly strength training (0-7 days), time engaging in leisure-time screen-based sedentary behaviours (0-9.75 hours), participation in intramural sports (yes, no), community sports (yes, no), or varsity sports (yes, no), use of active transportation (i.e., walking or bicycling) to and/or from school (yes, no), and average sleep duration (0-9.75 hours per night). Lastly, students were asked to report their number of physically active friends (≥1, 0).

Students were asked to report on numerous academic indicators, including their most recent English and Math grades (<60%, 60-80%, and >80%), educational aspirations (high school diploma or less, college or trade certificate, university bachelor's degree, graduate school, or I don't know), and the number of classes skipped in the past month (0, 1-5, ≥6). COMPASS asks students to complete a 6-item modified version of the National Longitudinal Study of Adolescent Health School Connectedness scale [236, 247] to assess school connectedness (score 6-24). Lastly, students were asked to report on their experience with bullying perpetration (yes, no), bullying victimization (yes, no), past-month binge-drinking (yes, no) and e-cigarette/vaping use (yes, no), and past-year cannabis use (yes, no).

6.3.4 Analysis

Descriptive statistics were generated for sample characteristics at T3 (grade 11), the baseline timepoint for this analysis as it was the first year that mental health outcomes were available in the COMPASS Study. Descriptive statistics were calculated for the entire sample, as well as stratified by sex. Differences in sample characteristics between female and male students were compared using chi-square and t-tests, where appropriate.

Linear mixed models (LMMs) were used to estimate the average effect of PE participation on symptoms of anxiety and depression, and psychological wellbeing in grade 11 and 12, stratified by sex. Doubly robust propensity score methodology was used to adjust for the impact confounding of student characteristics on the probability of voluntary enrollment in PE. Propensity scores were applied as weights using inverse probability of treatment weighting (IPTW) to adjust for observed confounders in the LMMs.

A propensity score representing the probability of a student opting-in to PE was calculated for each student given all their individual observed covariates known, or suspected, to influence PE participation

or symptoms of anxiety and depression, and psychological wellbeing available in the COMPASS system (listed in section 5.3.3) [215, 216]. Propensity scores were recalculated in each academic year to account for longitudinal variations in time-varying covariates (e.g., age and current MVPA levels) [184]. By implementing IPTW, the distribution of student covariates used to estimate the propensity scores become independent of the exposure status (i.e., participation in PE). Stabilized weights, truncated at the 1st and 99th percentiles, were utilized to minimize the influence of any extreme weights.

Standardized mean differences (SMD) were used to assess covariate balance pre- and post-propensity score weighting. SMD represent the difference in means divided by the pooled standard deviation of covariates and are used to evaluate whether the propensity scores have sufficiently removed any between group differences that are not sensitive to sample size [239]. A threshold SMD of 0.1 was used to indicate appropriate covariate balance after weighting [239]. All variables that exceeded this threshold were included as covariates in the final model to account for any residual confounding [218]. Propensity score generation and LMMs were conducted using SAS version 9.4.

6.4 Results

6.4.1 Student Characteristics

Overall, 1,860 students were included in this study. Just over half of the sample was female (53%), with a mean age of 16 years in grade 11, and the majority (82%) of students were of non-racialized backgrounds (**Table** 6-1). Rates of PE participation in grade 11 were lower among female students (34%) compared with male students (50%). Among students who participated in grade 11 PE, just over half did so during the semester of data collection (female: 61%; male: 52%). The median anxiety and depression scores among female students increased from 8.00 to 9.00 and 9.00 to 10.00, respectively, as they progressed from grade 11 to grade 12. The median anxiety and depression scores among male students remained unchanged at 4.00 and 6.00, respectively, from grade 11 to grade 12. The median psychological wellbeing score remained consistent at 32.00 for both female and male students over time.

Female students enrolled in PE in Grade 11 reported higher average anxiety (7.5 vs 7.0 points) and the same average depression (9.0 points) scores compared to those not enrolled in PE. Male students enrolled in PE in Grade 11 reported lower average anxiety (3.0 vs 4.0 points) and depression (6.0 vs

7.0 points) scores compared to those not enrolled in PE. Students enrolled in PE reported higher average psychological wellbeing scores compared to students not enrolled in PE, and this was consistent across both female (32.0 vs 31.0 points) and male students (33.0 vs 32.0 points).

Table 6-1 Student characteristics among male and female participants at T3 (2017/18)

Variable	Female students (n=988)				Male students (n=872)			
	PE (n=336)	No PE (n=652)	Unweighted SMD	Weighted SMD	PE (n=435)	No PE (n=437)	Unweighted SMD	Weighted SMD
Age, mean (SD)								
Years	16 (0.45)	16 (0.45)	-	-	16 (0.46)	16 (0.48)	-	-
Ethno-racial identity, % (n)								
Racialized	16% (54)	18% (115)	0.042	-0.036	17% (72)	23% (102)	0.171	-0.037
Weekly spending money, % (n)								
Zero	10% (34)	16% (105)	0.178	-0.036	14% (63)	19% (82)	0.115	-0.049
$1-$20	16% (53)	18% (118)	0.062	-0.086	19% (84)	22% (96)	0.066	0.083
$21-$100	34% (113)	26% (172)	-0.159	-0.016	25% (108)	21% (92)	-0.090	0.021
$101+	32% (108)	27% (173)	-0.123	**0.106**	32% (138)	27% (120)	-0.094	-0.052
Don't know	8% (28)	13% (84)	0.148	0.010	10% (42)	11% (47)	0.036	0.000
Sports Participation, yes, % (n)								
Intramural	41% (137)	30% (197)	-0.222	0.094	48% (209)	29% (128)	-0.392	0.052
Community	48 % (162)	29% (188)	-0.406	0.069	63% (274)	36% (159)	-0.552	0.065
Varsity	52% (174)	31% (205)	-0.422	0.086	64% (277)	36% (157)	-0.578	0.030
Daily MVPA, median (IQR)								
Minutes	111.4 (68.6 - 156.4)	64.3 (34.3 - 117.9)	-	-	128.6 (85.7 - 195.0)	83.6 (42.9 - 137.1)	-	-

Daily screen time, median (IQR)								
Hours	6.8 (4.5 - 9.1)	6.0 (3.8 - 8.0)	0.181	-0.093	6.8 (4.5 - 9.3)	6.5 (4.5 - 9.0)	0.038	0.053
Strength training, median (IQR)								
Days	3.0 (1.5 - 5.0)	1.0 (0.0 - 3.0)	0.653	0.009	3.0 (2.0 - 5.0)	2.0 (0.0 - 4.0)	0.570	-0.011
Sleep, median (IQR)								
Hours	7.0 (6.0 - 8.0)	7.0 (6.0 - 8.0)	0.127	**0.124**	7.2 (6.5 - 8.0)	7.0 (6.0 - 8.0)	0.217	-0.002
Symptoms of anxiety, median (IQR)								
Score	7.5 (3.0 - 13.0)	7.0 (4.0 - 13.0)	-	-	3.0 (1.0 - 7.0)	4.0 (2.0 - 8.0)	-	-
Symptoms of depression, median (IQR)								
Score	9.0 (5.0 - 13.0)	9.0 (5.0 - 15.0)	-	-	6.0 (4.0 - 9.0)	7.0 (5.0 - 12.0)	-	-
Psychological wellbeing, median (IQR)								
Score	32.0 (30.0 - 37.0)	31.0 (27.0 - 35.0)	-	-	33.0 (31.0 - 37.0)	32.0 (28.0 - 35.0)	-	-

IQR: interquartile range; MVPA: moderate-to-vigorous physical activity; PE: physical education; SMD: standardized mean difference; SD: standard deviation. Bolded values represent variables that remained imbalanced after IPTW adjustment.

6.4.2 Mixed models

Adjusted and unadjusted LMMs examining the association between PE participation and anxiety scores, depression scores, and psychological wellbeing are presented in **Table** 6-2, **Table** 6-3, and **Table** 6-4, respectively.

Participation in PE showed no significant association with anxiety scores among either female or male students. Anxiety scores were found to increase with increasing age only among female students, regardless of weighting. Female students in grade 12 reported higher anxiety scores compared to female students in grade 11 (ß=0.480, 95% CI [0.181 – 0.779]). No significant associations were found between MVPA and anxiety scores among either female or male students.

Table 6-2: Unadjusted and IPTW-adjusted longitudinal association between PE participation and anxiety scores

Effect	Female students (n=988)		Male students (n=872)	
	Unadjusted estimate (95% CI)	IPTW-adjusted estimate (95% CI)	Unadjusted estimate (95% CI)	IPTW-adjusted estimate (95% CI)
PE: No	–	–	–	–
PE: Yes, this semester	-0.045 (-0.561, 0.471)	0.000 (-0.519, 0.518)	-0.21 (-0.663, 0.243)	0.035 (-0.416, 0.486)
PE: Yes, but not this semester	-0.209 (-0.822, 0.405)	-0.113 (-0.729, 0.503)	0.002 (-0.489, 0.493)	0.223 (-0.262, 0.707)
Grade 11	–	–	–	–
Grade 12	**0.511 (0.202, 0.819)**	**0.480 (0.181, 0.779)**	0.208 (-0.110, 0.526)	0.198 (-0.107, 0.503)
MVPA	0 (-0.003, 0.003)	0 (-0.003, 0.003)	0.002 (-0.001, 0.004)	0.002 (0.000, 0.004)

Note: Bolded estimates indicate statistical significance at the p<0.05 level. CI: confidence interval; IPTW: inverse probability of treatment weighting; MVPA: moderate-to-vigorous physical activity; PE: physical education.

Participation in PE showed no significant association with depression scores among either female or male students. A small but statistically significant negative association between MVPA and depression scores was found among male students (ß=-0.005, 95% CI [-0.007, -0.002]), indicating that greater minutes of MVPA were associated with lower depression scores among male students. MVPA was measured in minutes which accounts for the small effect sizes.

Table 6-3: Unadjusted and IPTW-adjusted longitudinal association between PE participation and depression scores

Effect	Female students (n=988)		Male students (n=872)	
	Unadjusted estimate (95% CI)	IPTW-adjusted estimate (95% CI)	Unadjusted estimate (95% CI)	IPTW-adjusted estimate (95% CI)
PE: No	–	–	–	–
PE: Yes, this semester	-0.103 (-0.643, 0.436)	-0.175 (-0.719, 0.370)	-0.235 (-0.712, 0.242)	-0.369 (-0.834, 0.096)
PE: Yes, but not this semester	0.257 (-0.385, 0.899)	0.294 (-0.356, 0.945)	-0.014 (-0.530, 0.501)	-0.148 (-0.648, 0.352)
Grade 11	–	–	–	–
Grade 12	-0.321 (-0.646, 0.004)	-0.289 (-0.611, 0.034)	-0.239 (-0.566, 0.089)	-0.208 (-0.521, 0.105)
MVPA	0 (-0.003, 0.003)	0 (-0.003, 0.003)	**-0.004 (-0.007, -0.002)**	**-0.005 (-0.007, -0.002)**

Note: Bolded estimates indicate statistical significance at the p<0.05 level. CI: confidence interval; IPTW: inverse probability of treatment weighting; MVPA: moderate-to-vigorous physical activity; PE: physical education.

Participation in PE showed no significant association with psychological wellbeing among female students. No significant associations were found between (current semester) PE participation and

psychological wellbeing scores among male students. Male students enrolled (but not currently participating) in PE reported higher psychological wellbeing scores than male students who did not participate in PE that year (ß= 1.708, 95% CI [0.443 – 2.972]). A significant positive association between grade and psychological wellbeing scores was identified among both female (ß= 0.866, 95% CI [0.207 – 1.525]) and male (ß= 1.086, 95% CI [0.275 –1.898]) students, indicating that higher grade was associated with higher psychological wellbeing.

Table 6-4: Unadjusted and IPTW-adjusted longitudinal association between PE participation and psychological wellbeing

Effect	Female students (n=988)		Male students (n=872)	
	Unadjusted estimate (95% CI)	IPTW-adjusted estimate (95% CI)	Unadjusted estimate (95% CI)	IPTW-adjusted estimate (95% CI)
PE: No	–	–	–	–
PE: Yes, this semester	0.635 (-0.398, 1.669)	0.318 (-0.714, 1.351)	0.216 (-0.946, 1.378)	-0.169 (-1.340, 1.001)
PE: Yes, but not this semester	1.222 (-0.029, 2.473)	1.211 (-0.038, 2.461)	**1.819 (0.560, 3.077)**	**1.708 (0.443, 2.972)**
Grade 11	–	–	–	–
Grade 12	**0.886 (0.199, 1.573)**	**0.866 (0.207, 1.525)**	**1.067 (0.247, 1.886)**	**1.086 (0.275, 1.898)**
MVPA	0.003 (-0.002, 0.009)	0.002 (-0.003, 0.008)	-0.001 (-0.007, 0.005)	-0.003 (-0.008, 0.003)

Note: Bolded estimates indicate statistical significance at the $p<0.05$ level. CI: confidence interval; IPTW: inverse probability of treatment weighting; MVPA: moderate-to-vigorous physical activity; PE: physical education.

6.5 Discussion

This study aimed to examine the longitudinal associations between PE participation, anxiety and depression symptoms, and psychological wellbeing, among grade 11 and 12 students, using robust statistical approaches to account for potential confounding. After controlling for confounding factors, no significant associations were found between PE participation and symptoms of anxiety or depression among either female or male students. Findings revealed a significant relationship between PE participation and psychological wellbeing that varied by sex and timing of PE involvement. The findings of this study demonstrate that participation in secondary school PE was neither protective nor deleterious against depression or anxiety symptomatology, rather may promote psychological wellbeing, specifically among male students.

6.5.1 Association between PE and symptoms of anxiety and depression

Our findings demonstrate that participation in PE was not associated with symptoms of anxiety or depression among adolescents in Ontario. These findings, while disappointing, are not surprising, given that certain features of the PE environment have been found to negatively impact student mental health [151]. In particular, PE environments that promote competition and peer comparisons, and reward athletic ability have been associated with higher levels of anxiety among secondary school students [156, 159]. It has also been hypothesized that the physical demands (e.g., physical ability, fitness testing) and social dynamics (e.g., peer pressure, bullying) of PE lessons could negatively impact students' mood and self-esteem [151, 162, 163]. As previously described, students who enrol in PE may differ systematically from those who opt-out [126, 132, 136, 162], which could confound a negative PE climate. Our study demonstrated that when controlling for these types of self-selection biases (e.g., participation in extracurricular sports or bullying victimization), participation in PE was not associated with heightened symptoms of anxiety or depression. However, it should be noted that while PE participation did not increase depression and anxiety symptoms among adolescents, it was not protective against symptomatology either. It is possible that there is a combination of factors at play in this study; these aforementioned negative aspects of PE may indeed be present and may attenuate the positive impacts that structured physical activity provides for adolescent mental health. Future research exploring the mediating role that negative social dynamics in PE and the related environment may play in this relationship is warranted, as it may elucidate any protective impacts of PE on mental health.

Another possible explanation for the null findings identified in this study could be that the quantity of physical activity accrued during PE lessons is not sufficient for students to see an impact on their mental health. PE participation is believed to contribute to positive mental health and wellbeing through the regular dose of physical activity students receive during their PE lessons [152]; however, previous research has demonstrated that students spend only about 40% of their allotted PE lesson engaging in MVPA [141], which may amount to as little as 30 minutes one-to-two times per week, depending on provincial or national PE policies. Previous research has also reported that participation in PE on ≥2 days per week is associated with lower adolescent stress levels than participation on only 1 day per week, suggesting a possible dose-response relationship between PE participation and mental health [150]. Increasing PE frequency or extending lesson duration may be a key first step in the promotion of positive mental health and reduction of mental disorder during adolescence.

A significant association was identified between higher levels of MVPA and lower depression symptoms among male adolescents only. These findings are consistent with previous research demonstrating that the relationship between physical activity levels and symptoms of depression among adolescents differs by sex [54]; small, but statistically significant, negative associations are reported between physical activity levels and depression among male, but not female, adolescents [6, 54, 248]. These results highlight the importance of exploring sex-based differences in research examining the impact of PE and/or physical activity participation and mental health.

6.5.2 Relationship between PE and psychological wellbeing

Our most notable findings pertain to the association between PE participation and psychological wellbeing. Male students enrolled (but not currently participating) in PE were found to have higher psychological wellbeing compared to those not enrolled in PE; however, this association was not found to be significant among female students, suggesting there may be sex-based differences in the psychological benefits of PE participation. The intentions behind physical activity and sport participation are often found to differ by sex, with males perceiving greater benefits from physical activity participation than females with respect to social connectivity, enjoyment, and confidence [54, 234, 248]. It is possible that these perceived benefits of physical activity translate to improvements in psychological wellbeing, as previous PE research has demonstrated the positive impact of participation on resilience and loneliness [111, 153–155]. It is also important to consider the potential role that body image may have on the link between physical activity and mental health. Previous research has indicated that improving one's physical appearance and weight management are reported reasons for participation in physical activities among adolescents [163, 164, 166], and among female adolescents in particular [249]. The null findings among female students in this study could reflect the complex relationship between physical activity participation and mental health experienced by many female adolescents [54]. Future research should investigate whether PE participation exacerbates existing negative relationships with exercise and body-related anxieties and the role that student sex and gender may have in this relationship [163, 164, 166].

Findings from this study suggest that the benefits of PE on psychological wellbeing may extend beyond the immediate period of participation, but it remains unclear why there were no significant associations found during the semester of participation. Future research should explore whether there is unmeasured confounding between current PE participation and psychological wellbeing. These

findings extend the limited evidence base surrounding the impact of PE participation on psychological wellbeing [150] and underscore the need for further exploration into the differential impact of participation on female and male adolescents.

6.5.3 Strengths and limitations

To our knowledge, this is the first study to quantify the impact of PE participation on symptoms of depression, and only the second to quantify the impact on symptoms of anxiety among secondary school students in Canada [150]. Additionally, we implemented robust propensity score methodology to adjust for potential confounding due to self-selection bias. Other notable strengths of this study include the large sample size and breadth of variables collected as part of the COMPASS study and available for inclusion in the propensity score model.

Findings from this study should be interpreted within the context of several limitations. While the method employed in this study is a robust technique aimed at minimizing the impact of confounding due to self-selection biases, the model is sensitive to misspecification [184] and can only account for observed confounding. Residual confounding may persist due to variables that were not collected in COMPASS and therefore not accounted for in the models (e.g., enjoyment of physical activity or athletic ability), and the cohorts should not be assumed to be identical post-IPTW adjustment. Secondly, it is possible that some covariates included in the propensity score model lie on the causal pathway between PE enrollment and mental health outcomes. As such, it is possible that their inclusion has masked the association between PE participation and mental health indicators examined. Future research should explore mechanisms through which PE participation may impact mental health outcomes. A third limitation pertains to the use of self-reported data collection procedures. While self-reported data is at risk for recall bias and social desirability bias, COMPASS is anonymous (no student names are ever used) and utilizes active-information passive-consent data collection procedures which are proven to yield high participation rates, reduce selection bias, and more truthful self-reporting of health behaviours [190]. Finally, COMPASS does not collect data on attitudes or experiences in PE, which may play a pivotal role in the relationship between PE participation and mental health.

6.6 Conclusion

The results of this study provide valuable insights into the impact of secondary school PE participation on student mental health. This study demonstrated that PE participation was not

significantly associated with symptoms of anxiety or depression among adolescents in Ontario, Canada. Notably, PE participation was positively associated with psychological wellbeing among male adolescents only. Findings from this study suggest that while structured PE classes might not be sufficient to positively impact symptoms of mental disorder on its own, overall physical activity remains important for positive mental health, particularly for promoting psychological wellbeing among all adolescents and reducing depressive symptoms among males. Future research should explore the specific elements of PE programs that contribute to mental health benefits, such as the type and intensity of activities, student engagement, and the social environment.

Chapter 7:
General Discussion

7.1 Overview

While the foundations of many PE programs are grounded in evidence, there has historically been a lack of rigorous research evaluating and quantifying the impact of PE participation on adolescent health and wellbeing, particularly in Canada [84, 123]. Understanding if and how PE participation influences adolescent health outcomes has important implications for shaping PE policies and programs; an evidence-informed understanding of program effectiveness is essential for making meaningful recommendations or improvements. This dissertation sought to fill this notable gap by comprehensively examining participation in non-mandatory secondary school PE among a large sample of adolescents in Ontario, Canada. Study 1 characterized longitudinal physical activity profiles of non-mandatory PE participation, adherence to physical activity guidelines, and sport participation throughout secondary school. The results from Study 1 illustrated distinct clustered physical activity profiles among adolescents which varied by sex. Findings from Study 1 suggested that enrollment in non-mandatory PE, as well as engaging in the other physical activity behaviours (i.e., sport participation and guideline adherence), was not random; as such, there was a need for robust statistical techniques which controlled for confounding due to self-selection bias. Studies 2 and 3 leveraged such approaches while quantifying the impact of participation in PE on student MVPA levels and mental health outcomes over time. Study 2 demonstrated that participation in secondary school PE had a significant positive impact on MVPA levels over time, and effects were most pronounced among males and for those concurrently participating in PE in the same semester. However, the benefits to MPVA also remained present for non-concurrent PE participation, suggesting that the benefits of PE extended beyond the MVPA accumulated during class-time. Study 3 demonstrated that PE participation was neither protective nor detrimental to anxiety and depression symptomatology among adolescents and may enhance psychological wellbeing among male adolescents in particular. Taken together, the findings of this dissertation suggest that PE participation has the potential to positively impact physical activity levels and wellbeing among Ontario secondary school students, even after adjusting for individual differences that contribute to likelihood of PE enrollment. However, findings also suggest that many students are opting-out of Ontario PE programs in upper years and PE programming may be falling short of some key aims, including fostering positive student mental health, particularly among female adolescents.

7.2 Summary of Key Findings

Study 1 examined longitudinal physical activity profiles of non-mandatory PE participation, adherence to physical activity guidelines, and sport participation, among a large sample of secondary school students in Ontario. Three common profiles were identified among all students (Guidelines, PE & Sports, and Guidelines & Sports). The proportion of students that belonged to each profile, however, varied between male and female students, suggesting that there were sex-based preferences for certain physical activity types. The most common profile among female students was Guidelines – implying high rates of independent physical activity, whereas the most common profile among male students was PE & Sports – implying a preference for team-based activities. Notably, a fourth profile, Inactive, was identified among male adolescents only – representing nearly 20% of males in this study. This Inactive profile reflects a high-risk cohort of male adolescents who were not engaging in any physical activity beyond their grade 9 PE requirements. Counterintuitively, strength training of any frequency was associated with belonging to the Inactive profile. Identification of these profiles and understanding the key characteristics of students belonging to each profile fills a knowledge gap with respect to physical activity engagement of Ontario adolescents and could inform the development of programs, curricula, and policies tailored to these subgroups. For example, generating opportunities for activities that interest the 'inactive' cohort of male students (e.g., strength training) or the 'Guidelines' cohort of female students (e.g., independent activities) into PE programming may promote greater enrolment from these populations. Findings from this study extend previous physical activity behaviour research by suggesting that sex-based differences in physical activity participation exist across a variety of physical activity indicators when examined concurrently.

Findings from Study 1 demonstrated that there are distinct clusters of physical activity behaviours, and a substantial proportion of adolescents participate in PE and organized sports but are not meeting the physical activity guidelines. What remained unknown, was the contribution of PE participation towards overall physical activity levels. Study 2 aimed to address this gap by quantifying the impact of PE participation on MVPA levels, leveraging propensity score weighting to adjust for self-selection biases in PE enrollment. Study 2 identified a substantial grade-related decline in PE participation throughout secondary school; as expected, the largest declines were seen among grade 10 students (when PE participation becomes non-mandatory) and among female adolescents. After propensity score weighting, participation in PE was found to have a significant positive impact on MVPA levels over time. Effects were most pronounced among male students and during the semester of PE

participation. These findings were not surprising given that PE acts as a source of physical activity, contributing to students' daily accumulation of MVPA [140], and the association between PE and physical activity is reported to be stronger among male adolescents [84]. The effects of PE, however, remained present when students were enrolled, but not currently participating, in PE, suggesting that the benefits of participation can extend beyond the MVPA accumulated during class-time. Findings from this study are promising, given the declining physical activity levels among Canadian adolescents; Canadian schools should consider efforts to increase enrollment in PE throughout secondary school as a strategy for increasing physical activity levels, particularly among female adolescents.

Studies 1 and 2 highlighted that only a small proportion of students opted-in to non-mandatory PE throughout secondary school, and that propensity to opt-in to PE was clustered with other physical activity behaviours (i.e., sports participation). Further, students who elected to participate in PE reported greater overall MVPA than those who did not participate in PE. In addition to physical health, physical activity is known to have a positive impact on mental health, however, there was limited evidence rigorously evaluating whether PE participation was associated with student mental health. As such, Study 3 aimed to examine the impact of PE participation on student mental health, specifically symptoms of anxiety, depression, as well as overall psychological wellbeing. After controlling for confounding factors, PE participation was not found to be significantly associated with either symptoms of anxiety or depression. Male students enrolled (but not currently participating) in PE were found to have higher psychological wellbeing compared to those not enrolled in PE; however, this association was not found to be significant among female students. These findings indicate that there may be sex-based differences in the relationship between PE participation and positive mental health. Future research should explore the specific elements of PE programs that contribute to mental health benefits, such as the type and intensity of activities, student engagement, and the social environment, with a specific focus on female students.

The findings from this dissertation are novel as they provide preliminary evidence that PE programming in Ontario was effective at fostering active adolescents both inside and outside of the school setting. The Ontario PE curriculum was developed on the foundation that by fostering physical and health literacy among adolescents, they will have a greater willingness to engage in physical activities during their leisure-time [1, 124]. The findings from Studies 1 and 2 highlight the potential benefits of daily PE on adolescent physical activity patterns and suggest that PE is in part achieving this objective. These findings provide evidence in support of annual, year-long, PE participation or

other approaches aimed at increasing PE enrollment among adolescents in Ontario. The current secondary school PE policy in Ontario requires students complete only one PE course to meet their graduation requirements [111]; in considering this policy in the context of these findings and the substantial grade-related decline in PE participation outlined in this dissertation, there is a clear opportunity for intervention. Increasing PE participation offers a promising strategy for increasing overall physical activity levels among adolescents. While PE was found to have a positive effect on adolescent physical activity levels, participation, even when concurrent with organized sport participation, did not necessarily lead to sufficient physical activity to meet the physical activity guidelines established by the WHO and CSEP [9, 10]. These findings imply that participation in these activities, were either too infrequent (i.e., days per week) or too short (i.e., minutes per day) for adolescents to achieve the recommended 60 minutes of MVPA each day of the week [9]. The 30 additional minutes of MPVA students gained from PE participation seen in Study 2 is generally consistent with findings from a recent systematic review which identified that youth spend roughly 40% of a secondary school PE lesson (which is typically about 75 minutes in length) engaging in MVPA [141]. Assuming a structure consistent with most secondary schools in Canada (two semesters per school year, with students enrolled in four courses per semester, taken daily) PE participation could amount to 150 additional minutes of MVPA per week or 2,400 minutes per semester – contributing substantially to the overall physical activity levels of adolescents in Canada. Together, these findings highlight that in addition to efforts targeted at increasing enrollment in PE, it remains essential to promote day-to-day leisure-time physical activity to ensure physical activity guidelines can be consistently met. To gain additional insight into the mechanisms through which PE participation influences leisure-time physical activity, future research should explore the mediating role of physical and health literacy in the association between PE participation and physical activity behaviours.

Study 3 of this dissertation is the first study to longitudinally examine the impact of PE participation on adolescent mental health in Canada. While PE participation was not found to be associated with anxiety and depression symptomatology among students, it appeared to have a positive effect on psychological wellbeing, specifically among male students. Concerningly, this association was not found to be significant among female students, indicating that there may be sex-based differences in the relationship between PE participation and positive mental health. While we had hypothesized that participation in PE may reduce symptoms of anxiety and depression based on the protective effects of physical activity [6], our findings were also not surprising given that certain features of the PE

environment have been found to negatively impact student mental health [151]. PE environments that promote competition and peer comparisons, and reward athletic ability have been found to increase anxiety [156, 159]; similarly, the physical demands (e.g., physical ability, fitness testing) and social dynamics (e.g., peer pressure, bullying) of PE lessons are hypothesized to negatively impact students' mood and self-esteem [151, 162, 163]. The lack of association in this study suggests that these potential negative impacts on depression or anxiety were not present in this Ontario sample. Given the high rates of poor mental health reported among adolescents, these findings have important implications for public health and PE programming; there does not appear to be a downside to increasing PE participation, in fact, male students who participate in elective PE may see improvements in their psychological wellbeing. These findings contribute to the limited evidence base surrounding the impact of PE on psychological wellbeing [150]; however, additional research is needed to elucidate the mechanism through which PE may impact mental health outcomes, and how these relationships differ by sex. Identifying strategies for how PE can improve psychological wellbeing among female students should be a priority. It is important to note that while PE was not found to be detrimental to student mental health in this study, it does not mean that all students have positive experiences in PE; a substantial grade-related decline in participation was identified in Study 2, demonstrating that many students are choosing to drop out of PE when it becomes optional. Many students who opt-out of voluntary PE cite negative experiences in PE and a lack of enjoyment in PE as key barriers to participation [125, 136]. Additional research is warranted to identify strategies to improve the PE experience for a wider variety of students irrespective of age, sex, or background.

Findings from all three studies in this dissertation illustrated important sex-based differences in the association between PE participation, physical activity, and mental health. Participation in various physical activity behaviours was found to differ between female and male students. Female students were found to engage in higher rates of independent physical activities; fewer female students elected to participate in non-mandatory PE; and the grade-related decline in PE participation was more pronounced among female students relative to their male counterparts. In addition to the differences in enrollment, PE participation had a differential impact on student physical activity patterns and mental health outcomes. Male students who participated in PE saw greater benefits in their minutes of MVPA engagement and their psychological wellbeing relative to female students. These findings suggest that PE may be more successful at engaging male adolescents in physical activity as males obtained roughly 30% more MVPA per day compared to females through participation in PE (both during and outside

of class-time). These findings align with previous research demonstrating that participation rates are generally higher among male adolescents compared to their female counterparts [126, 131, 132, 137] and that the association between PE and physical activity is stronger among male adolescents [84]. While consistent with previous research, these findings raise concerns about the current state of PE programming in Ontario and highlight the importance of increasing PE enrollment and engagement among adolescents, with a special focus on female adolescents. Cumulatively, the differences observed in this dissertation strongly suggest a sex-based preference for certain physical activity types, with female students having a disinclination towards PE and other team-based activities. Previous sex- and gender-based physical activity literature has demonstrated that a greater proportion of female adolescents tend to participate in individual physical activities (e.g., running, walking, fitness classes), whereas a larger proportion of male adolescents tend to participate in team-based sports [148, 149]. Female adolescents may have a greater tendency for individual or fitness-related activities over team-based sports due to factors such as body dissatisfaction, the desire to promote an image of femininity, fear of stigmatization or teasing in sports settings, and disinterest in competition [148, 240–243]. It is possible that the PE environment, either through the activities offered or the social environment more broadly, discourages participation from female students. Policy-related elements of the PE environment, including uniforms, showering, and communal change rooms may further discourage enrollment and engagement among female students [241, 242]. PE classes with a focus on lifetime physical activities, that involve students in course development and design, and that establish positive and respectful learning environments have been associated with high retention of female adolescents [135, 250]. Moreover, findings from a school-based intervention study in British Columbia demonstrated that incorporating autonomy, building competence, and fostering relatedness in PE was an effective strategy for increasing participation in PE among female adolescents [136]. When we consider the success of these strategies in the context of other research in this domain, it suggests that female adolescents value PE courses that feel more personalized and informative rather than a "one-size-fits all" PE approach [136, 251]. Given the volitional nature of PE programming in Canada, students who do not perceive value in PE, will likely opt-out of future participation; it is therefore plausible that incorporating these elements into the Ontario PE design and implementation could increase enrollment rates and ultimately the health-related benefits among female adolescents.

7.3 Implications

This dissertation has illustrated that secondary school PE, while non-mandatory, can play a pivotal role in promoting physical activity participation and may support psychological wellbeing among adolescents, with benefits extending beyond structured class time. Findings from this dissertation provide preliminary evidence in support of integrating PE into adolescent health-promotion strategies for both physical and mental health benefits, while also highlighting the potential areas for future research.

7.3.1 Dose-response relationship (some is better than none)

This dissertation illustrates the wide range of physical activity levels among adolescents in Ontario. Some adolescents are highly active, meeting the recommended 60 minutes per day of physical activity (as highlighted by the *Guidelines* class in Study 1); others are moderately active, but fall short of meeting these recommendations (as noted by the *PE & Sports* class); and finally, some adolescents are minimally active and are not consistently participating in organized activities or meeting the physical activity recommendations (as outlined by *Inactive* class). Existing research has identified a clear dose-response relationship between the amount of physical activity and overall health and wellbeing, where greater physical activity participation is associated with greater health benefits [13–17]. The nature of the dose-response relationship is such that the largest benefits are often seen among those on the lowest end of the activity spectrum [13–16]. As such, increasing physical activity levels among adolescents who are inactive (or minimally active) should lead to the greatest improvements in health and wellbeing. For example, increasing activity from 10 to 30 minutes per day would result in greater health related improvements compared with increasing activity from 60 to 80 minutes per day (even though both are gaining 20 additional minutes per day). This is particularly important when we consider that PE participation resulted in an additional 29-36 minutes of MVPA per day; this is an opportunity to provide students who are not currently participating in any type of physical activity with roughly 50% of their recommended daily activity before finishing the school day. While the physical activity gained from participation in PE alone may not be sufficient for students to meet the physical activity guidelines, the dose-response relationship between physical activity volume and health suggests that this quantity of physical activity would be particularly beneficial for those who are less active.

7.3.2 Recommendations for policy and practice

Physical education is well positioned to increase physical activity levels and wellbeing among adolescents [1]; the pre-existing infrastructure of PE positions it to be one of the most cost-effective population-level health-promotion strategies targeting youth [20]. Most schools across Canada have the facilities (e.g., gymnasiums, tracks, and/or fields) required to deliver effective physical activity programming [252, 253], PE teachers at the secondary school level are required to complete post-secondary training in PE, and dedicated lesson time is scheduled into the academic timetable [253]. This dissertation demonstrates that when delivered over an extended period (i.e., across the four years of secondary school), PE has the potential to lead to a positive impact on physical activity levels and modest benefits to psychological wellbeing, providing preliminary evidence in support of increasing PE participation at the population-level. While the goals of this dissertation were not to examine potential practice changes for PE, findings from this dissertation do suggest such changes are needed. Based on available evidence, a number of considerations could be made in an attempt to increase the rates of participation and the effectiveness of PE programming in Ontario, particularly for female adolescents and those not engaging in any form of physical activity.

7.3.2.1 A joint effort (schools, family, and friends)

The promotion of physically active lifestyles should be a joint effort, with families, friends, and communities playing crucial roles alongside schools. Schools have been identified as an ideal setting for the promotion of physical activity, however, youth also must engage in physical activity during their leisure time to develop lifelong positive habits surrounding physical activity [1]. PE, when implemented effectively, should encourage youth to lead active lives beyond the classroom by fostering physical literacy and positive attitudes toward physical activity. Physical Health and Education (PHE) Canada, a national charitable association supporting professionals working in the field of physical and health education, has developed a number of resources to support educators in establishing positive learning environments in PE for physical literacy development; these resources have been made available on their website [254]. Importantly, relying solely on schools to provide youth with all their recommended daily physical activity is not a sustainable solution for addressing lifelong population-level inactivity. Parents and families of youth share responsibility for encouraging participation in physical activity, particularly outside of the school setting. Parents and families can set a positive example for youth by integrating physical activities into their daily lives; for example, parents can encourage youth to use

active modes of transportation to and from school or participate in extracurricular sports (formal or informal) and can create safe and engaging environments for youth to be active.

7.3.2.2 Facilitating participation in PE

As evidenced in this dissertation, increasing participation in non-mandatory PE could be an effective strategy to address the physical inactivity crisis among adolescents in Canada, as it is likely to lead to a higher number of active or moderately active adolescents. To increase participation, it is important to consider how to eliminate (or at minimum, reduce) barriers to PE or physical activity participation experienced by students who opt-out of PE [136, 162]. Many students have complicated relationships with PE participation, and physical activity more broadly, with past experiences in PE strongly influencing future participation [162–166]. Race, sex, gender, socio-economic status, physical ability, and other socio-demographic factors play an important role in shaping an individual's access, experience, and attitudes towards physical education, physical activity, and sport [55]; by creating safe and inclusive environments for all students, schools may see increases in enrollment [255]. Barriers and facilitators to PE and physical activity participation are found to differ quite significantly between active and inactive and between female and male adolescents; barriers cited by inactive adolescents (e.g., competitive activities and/or environments) are often reported as facilitators among active adolescents [164]. Equitable opportunity for all youth requires that physical activity and PE programming be receptive to diverse social identities and attentive to how youth are differentially impacted by policies and practices [55]. One strategy that may help achieve this objective is to engage students in the curriculum design and implementation process. Evidence suggests that empowering students to contribute to the design of PE programming not only increases their autonomy [256], but increases the likelihood that the curriculum more closely aligns with their interests and intentions behind participation [125]. Future research should consider ways to have youth inform (or even spearhead) initiatives such as curriculum reform. Such an approach would require evaluation to examine how student engagement can be better integrated into curriculum development activities.

An alternative strategy to increasing voluntary PE participation across Ontario is mandating participation across all four years of secondary school. Contrary to what might be expected, the published evidence to date suggests that Manitoba's 2008 compulsory policy PE did not appear to have a significant impact on the physical activity levels of secondary school students [123, 145]; however, authors highlight that evaluation design, key differences in the exposed and control groups, as well as

reasonably active and healthy samples may have contributed to the null findings [257]. Further research is needed to evaluate the long-term impact of this policy to help inform PE policy across other Canadian provinces and territories. There are, however, several challenges with mandating PE throughout secondary school that should be noted; these include limited resources, course load requirements, and policymaker buy-in [1]. It should also be considered that by mandating participation (rather than encouraging participation), students may lose the enjoyment associated with physical activity participation and compensate by decreasing their leisure-time activity. Overall, we may see the greatest improvements in adolescent physical activity levels if schools prioritize the creation of positive PE environments, whether that be voluntary or compulsory, where youth feel safe and motivated to engage in physical activity.

7.3.2.3 The importance of variety in PE

There is a growing body of evidence in support of maximizing variety in youth physical activity programming [258]. Within the physical activity context, variety can refer to providing a range of activities, equipment, locations, or delivery styles [259], and research has demonstrated that variety is associated with enjoyment of, motivation for, and overall engagement in physical activity [258, 260–262]. The provision of variety within the context of PE is important for several reasons. Most notably, by providing youth with a wide variety of opportunities and activities in PE, it may cater to the diverse interests, abilities, and backgrounds of secondary school students – potentially leading to increased participation and engagement [259, 260]. For example, educators could offer students a variety of activity types (e.g., strength training vs. soccer), activity formats (e.g., individual vs. team-based activities), or assessment types (e.g., effort-based). Similarly, exposing students to diverse forms of physical activity in PE may help them discover an appreciation and/or interest in new types of activities [262]. This interest could lead to participation outside of the school setting, contributing to the development of lifelong healthy habits [1] – aligning with PE's overall objectives [1, 111]. As further evidence in support of this recommendation, sampling a wide variety of activities in adolescence has been linked to higher performing athletes, fewer sports-related injuries, increased MVPA levels in young adulthood, and exercise behaviour in adulthood [262, 263].

Variety has been identified as a desired quality in school sport and PE programs among adolescents, and among inactive adolescents in particular [264]. Relatedly, the lack of variety in PE has been reported as a major contributing factor in the declining physical activity participation rates [261]. Thus,

increasing variety within the PE context may be an effective strategy at increasing PE (and ultimately physical activity) participation rates as well as encouraging greater physical activity engagement during PE lessons themselves, particularly among adolescents at a higher risk of opting-out of PE (i.e., inactive and/or female adolescents). It is also plausible that the provision of variety in PE programming (in terms of activities, peer groups, and assessment practices) may also help improve the negative social climate and competitive environment often associated with PE [136, 259]; improving the PE climate could uncover mental-health related benefits associated with participation that were not found among our sample of adolescents. Additional research is needed to identify what types of physical activities increase participation in this cohort of students and to evaluate the effectiveness of increased variety in PE through a natural experiment.

7.3.3 Future directions

This dissertation provides preliminary evidence that participation in non-mandatory secondary school PE could lead to positive health outcomes among students in Ontario. However, additional research is needed to build upon the findings of this dissertation and understand the mechanisms through which this occurs. An important area of future study is to explore the role that physical and/or health literacy plays in the relationship between PE participation, physical activity levels, and adolescent health and wellbeing. As previously described, the primary goal of PE programming in schools is to build physical and health literacy among students and it is through this physical and health literacy that students will develop the skills and understanding needed to lead healthy, active lives [113, 124]. Future research should evaluate whether PE participation elicits a change in physical and/or health literacy over time and whether this increased literacy could lead to meaningful increases in physical activity levels and/or mental health outcomes.

Relatedly, previous research suggests that physical activity enjoyment and intentions are strong indicators of physical activity engagement [231–233] and enjoyment of, autonomy in, and motivation for PE, specifically, are predictive of student participation in leisure-time physical activity [265]. Future research should explore the role that perceptions of PE (or physical activity more broadly) may play in the associations between PE participation and physical activity levels and/or mental health outcomes. Discerning which students may be at a disadvantage for seeing benefits from PE participation could have meaningful impacts on PE programming. Further, understanding how adolescents who have positive experiences in PE see greater PE-related benefits (either short or long-term) both in their

activity levels and their mental health differ from those who report negative experiences could provide further evidence in support of the creation of inclusive, positive PE environments for all youth. As previously mentioned, provincial decision makers and school educators should consider exploring ways to engage youth in the curriculum development and course design process; process and outcome evaluations will be needed to explore the success and/or challenges associated with piloting such an approach.

Future research may also consider exploring how specific features of the PE program (e.g., frequency and/or duration, variety of activities, assessment and evaluation) and environment (e.g., teaching styles, social dynamics) impact voluntary enrollment in PE within the Ontario context. Moreover, understanding how these features of PE programs and environments may influence the impact of participation on physical activity or mental health outcomes is warranted. PE environments that elicit negative feelings and experiences in PE (for example competitive environments, negative relationships with teachers and/or other students, and lack of choice/autonomy) may decrease the effectiveness of PE programming on health and wellbeing. Identifying features of PE programming and environments that lead to negative student experiences and exploring strategies to improve or eliminate them could help maximize PE participation and PE-related benefits for a greater proportion of adolescents.

As previously described, PE is developed and implemented at the provincial level in Canada; therefore, the studies that make up this dissertation examined PE programming in Ontario, Canada only. The findings from this dissertation may not be directly applicable to the PE programs of other provinces and territories in Canada, particularly when we consider the rather substantial variations in PE policies. Future research should replicate the studies in this dissertation using data from other provinces and territories to explore the influence of differing populations, curricula, and implementation strategies across Canada.

7.4 Strengths and limitations

This dissertation comprised the first set of studies to comprehensively explore participation in, and examine the effectiveness of, secondary school PE in Ontario as it relates to physical activity engagement and mental health and wellbeing. This dissertation implemented novel methodological approaches to tackle important gaps in the PE literature in Canada. First, there was a distinct lack of research examining longitudinal patterns of PE participation within the context of other co-occurring physical activity behaviours. Study 1 addressed this gap by identifying longitudinal latent physical

activity profiles among a large cohort of adolescents in Ontario. This study applied a person-centered modelling technique (RMLCA), focusing not only on the relationships between variables, but also the relationships between individuals, to identify clusters of students that shared common physical activity behaviours [266]. Second, there was a paucity of research evaluating the effectiveness PE programming in Canada, particularly with respect to mental health and wellbeing. Studies 2 and 3 aimed to fill this gap by quantifying the impact of elective participation in PE in Ontario on adolescent physical activity and mental health outcomes. The most prominent strength of these studies was the implementation of robust propensity score methodology to adjust for potential confounding due to self-selection bias associated with PE enrollment; this approach allowed for a more accurate estimation of the benefits of participation in PE on health and wellbeing of adolescents separate from self-selection bias by proxying randomization. To the best of our knowledge these two studies represented the first to implement propensity score methodology within this area of research. Other notable strengths of these studies include the large sample size and breadth of variables collected as part of the COMPASS Study and available for inclusion in the propensity score model. While this dissertation made important contributions to the PE literature, it is not without its limitations.

7.4.1 Self-report data

There are some limitations specific to the data collected as part of the COMPASS Study. Data for the COMPASS Study, and therefore this dissertation, were collected using self-report questionnaires. Self-report measures of demographics and health behaviour variables are subjective in nature and can be influenced by recall and social desirability biases [267]. Self-reported physical activity data can be an overestimation of true objective physical activity levels [230] and may be influenced by perceived level of exertion and knowledge of physical activity (e.g., moderate compared to hard physical activity) [267]. It is possible that overestimation of physical activity levels could have influenced the findings from studies 1 and 2 in this dissertation. The questionnaires used in this study, however, have been previously validated and demonstrated reliability for measuring physical activity in youth [196]. The measures of mental health and wellbeing included in COMPASS are indicative of symptoms of anxiety and depression rather than clinical diagnostic measures. While they are not objective diagnostic tools, studies have supported the validity of the CESD-R-10, GAD-7, and Flourishing Scale for use in population-based samples for research and monitoring purposes [202, 204–206, 208]. Overall, data collection procedures adopted by COMPASS, including anonymity and active-information passive-

consent data collection procedures, are found to lead to more truthful self-reporting of health behaviours [190].

7.4.2 Generalizability

The COMPASS Study collects data used in this study are collected from a convenience sample of schools and are not provincially representative, limiting the external validity of our findings. The COMPASS Study, however, implements active-information passive-consent procedures which have been found to yield high participation rates and reduced selection bias [190]. Although the findings from this dissertation cannot be generalized to all adolescents in Ontario, this dissertation benefited from the robust sample size of students in the COMPASS Study. Additionally, the variety of participating schools (e.g., in terms of urbanicity, geographic location, school area median income) and full school samples in the COMPASS Study help to support generalizability. The influence of differing populations, curricula, and implementation strategies between school boards, regions, and countries should be considered when generalizing the findings from this dissertation.

7.4.3 Repeated measures latent class analysis methodology

Implementation of an RMLCA permitted the identification of common clusters of physical activity behaviours over time, using a person-centered approach [180]. While this approach permitted the examination of multiple time points allowing for identification of common patterns of physical activity behaviour, it is not without its limitations. Like any latent class model, RMLCA models the probability of class membership based on identified patterns in the indicator variables over time. Each student is provided with a probability of class membership and thus true class assignment is not guaranteed. Another important limitation of all latent class analyses is naming fallacy; as latent classes are named by the researchers, they are ultimately a subjective interpretation of class probabilities. It should also be noted that while RMLCA allowed the identification of physical activity behaviour patterns over time, the method does not have the ability to examine model changes or transitions between the identified classes across time points [268]. As such the model may overlook key transitions in individual physical activity behaviours over time. Future research should explore transitions in PE participation, sport participation, and MVPA levels over time using latent transition analysis.

7.4.4 Propensity score methodology

This study implemented a novel methodological approach to examine the impact of PE participation on health outcomes among a large cohort of adolescents in Ontario. Propensity score methodology has been extensively used in clinical research [269–271], but its application in observational behavioural study contexts remains relatively limited [272, 273]. This dissertation leveraged this novel methodological approach to address research questions that otherwise would have been at a high risk of confounding. Nonmandatory PE participation is highly influenced by self-selection bias as a wide range of student-level factors have been found to correlate with PE participation [126, 132, 136, 162]; relatedly, among students who voluntarily participate in PE, participation may differentially impact student physical activity and/or mental health outcomes based on their individual characteristics (e.g., athletic ability, body size) [163]. Utilizing propensity scores in this research permitted all student-level covariates known, or suspected, to influence PE participation, physical activity, or mental health available in the COMPASS Study to be accounted for in the models. Propensity scores aggregate covariates into a single score, permitting the inclusion of numerous variables without limiting model interpretability or leading to overfitting [184].

While the use of propensity score through inverse probability of treatment weighting (IPTW) is a robust statistical technique aimed at minimizing the impact of confounding, propensity scores are limited to observed and measurable confounding. IPTW is not able to adjust for unmeasured (or unmeasurable) confounding that may impact either the independent (PE participation) and/or dependent (physical activity levels or mental health outcomes) variables [184]. Therefore, it is possible that variables not collected in the COMPASS Study (e.g., perception of PE, motivation for physical activity) or not included in the propensity score models may have influenced the described associations. Samples should not be assumed to be identical as unmeasured covariates could remain imbalanced between groups [185, 239]. Relatedly, propensity scores can be sensitive to misspecification (e.g., key confounding variables are not included), where imbalances may remain among covariates between study groups [173, 184]. This misspecification could ultimately lead to biases in the treatment-outcome relationship. To mitigate the potential of misspecification or residual confounding, all variables included in the COMPASS Study that were known, or suspected, to be associated with either PE participation, or physical activity levels or mental health outcomes were included in the propensity score models.

7.5 Conclusions

This dissertation sought to fill a notable gap with respect to our understanding of non-mandatory PE participation and its association with physical activity levels and mental health among secondary school adolescents in Ontario, Canada. By characterizing longitudinal physical activity profiles, we found that the majority of students are electing not to enrol in secondary school PE in Ontario. A high-risk subgroup of male adolescents was found to not be engaging in any type of physical activity behaviour during secondary school. This dissertation has also demonstrated that participation in non-mandatory PE had positive impacts on time spent engaging in MVPA among all adolescents and positive impacts on psychological wellbeing among male adolescents only in this sample. Together these findings suggest that PE holds the potential to positively contribute to the health and wellbeing of adolescents in Ontario, however, the low enrollment rates act as a barrier to the potential population level health benefits of PE.

In light of declining rates of physical activity and mental health and wellbeing among youth today, the findings in this dissertation can help inform public health programming, particularly within the school context. The bodies that govern curriculum decision-making in Canada, such as the Ministries of Education, should consider exploring strategies to increase PE participation across secondary schools in Canada. Strategies that include the promotion of autonomy and variety in PE and include students in the decision-making process with respect to curriculum development could lead to greater student engagement and enhance the positive health benefits associated with participation throughout secondary school. Special attention should be given to ensure PE environments are inclusive for all students regardless of athletic ability, needs, or backgrounds, and to ensure the types of activities offered in PE are suitable and accessible for all students. These changes are a feasible first step in improving the physical activity levels and mental health and wellbeing of adolescents across Canada.

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APPENDICES

Appendix A:
COMPASS Study Funding

The COMPASS study has been supported by a bridge grant from the CIHR Institute of Nutrition, Metabolism and Diabetes (INMD) through the "Obesity – Interventions to Prevent or Treat" priority funding awards (OOP-110788; awarded to SL), an operating grant from the CIHR Institute of Population and Public Health (IPPH) (MOP-114875; awarded to SL), a CIHR project grant (PJT-148562; awarded to SL), a CIHR bridge grant (PJT-149092; awarded to KP/SL), a CIHR project grant (PJT-159693; awarded to KP), and by a research funding arrangement with Health Canada (#1617-HQ-000012; contract awarded to SL), a CIHR-Canadian Centre on Substance Use and Addiction (CCSA) team grant (OF7 B1-PCPEGT 410-10-9633; awarded to SL), a project grant from the CIHR Institute of Population and Public Health (IPPH) (PJT-180262; awarded to SL and KP).

A SickKids Foundation New Investigator Grant, in partnership with CIHR Institute of Human Development, Child and Youth Health (IHDCYH) (Grant No. NI21-1193; awarded to KP) funds a mixed methods study examining the impact of the COVID-19 pandemic on youth mental health, leveraging COMPASS study data. The COMPASS-Quebec project additionally benefits from funding from the Ministère de la Santé et des Services sociaux of the province of Québec, and the Direction régionale de santé publique du CIUSSS de la Capitale-Nationale.

Appendix B:
COMPASS Student Questionnaire

The following pages include the entire COMPASS student questionnaire for the 2018/19 data collection year.

Compass

- This is NOT a test. All of your answers will be kept confidential. No one, not even your parents or teachers, will ever know what you answered. So, please be honest when you answer the questions.

- Mark only one option per question unless the instructions tell you to do something else.

- Choose the option that is the closest to what you think/feel is true for you.

Please, use a pencil to complete this questionnaire

Please mark all your answers with full, dark marks like this:

START HERE

Please read each sentence below carefully. <u>Write</u> the correct letter, number, or word on the line and then <u>fill</u> in the corresponding circle.

Note: These five questions are <u>only used to link data</u> from one year to the next. They cannot be used to identify participants. Only University of Waterloo researchers have access to the responses, and they never have access to student names or other information. All responses are strictly confidential.

The first letter of your **middle** name (if you have more than one middle name use your first middle name; if you don't have a middle name use "Z"):____	The name of the month in which you were born: ________	The **last** letter of your full **last** name: ___	The **second** letter of your full **first** name: ___	The **first** initial of your **mother's** first name (think about the mother you see the most):___
A J S B K T C L U D M V E N W F O X G P Y H Q Z I R	1 January 2 February 3 March 4 April 5 May 6 June 7 July 8 August 9 September 10 October 11 November 12 December	A J S B K T C L U D M V E N W F O X G P Y H Q Z I R	A J S B K T C L U D M V E N W F O X G P Y H Q Z I R	A J S B K T C L U D M V E N W F O X G P Y H Q Z I R

[serial]

About You

1. What grade are you in?

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

Quebec students only

- ① Secondary I
- ② Secondary II
- ③ Secondary III
- ④ Secondary IV
- ⑤ Secondary V
- ⑥ Other

2. How old are you today?

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

3. Are you female or male?

- ① Female
- ② Male

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

- ① White
- ① Black
- ① Asian
- ① Aboriginal (First Nations, Métis, Inuit)
- ① Latin American/Hispanic
- ① Other

5. About how much money do you usually get <u>each week</u> to spend on yourself or to save?
(Remember to include all money from allowances and jobs like baby-sitting, delivering papers, etc.)

- ① Zero
- ② $1 to $5
- ③ $6 to $10
- ④ $11 to $20
- ⑤ $21 to $40
- ⑥ $41 to $100
- ⑦ More than $100
- ⑧ I do not know how much money I get each week

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

To school	From school
① By car (as a passenger)	① By car (as a passenger)
② By car (as a driver)	② By car (as a driver)
③ By school bus	③ By school bus
④ By public bus, subway, or streetcar	④ By public bus, subway, or streetcar
⑤ By walking	⑤ By walking
⑥ By bicycling	⑥ By bicycling
⑦ Other	⑦ Other

7. Did you attend this school last year?

① Yes, I attended the same school last year
② No, I was at another school last year

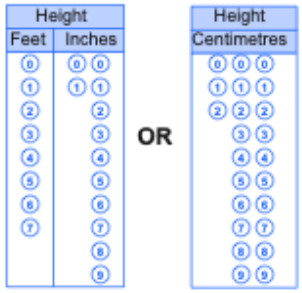
8. How tall are you without your shoes on? (Please write your height in feet and inches **OR** in centimetres, and then fill in the appropriate numbers for your height.)

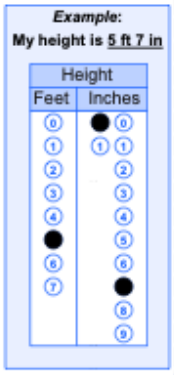
① **I do not know how tall I am**

"My height is ____feet, _____inches"

OR

"My height is _____ centimetres"





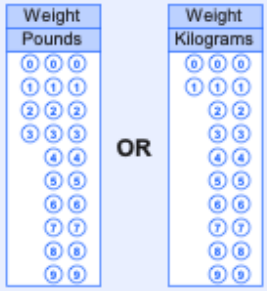
9. How much do you weigh without your shoes on? (Please write your weight in pounds **OR** in kilograms, and then fill in the appropriate numbers for your weight.)

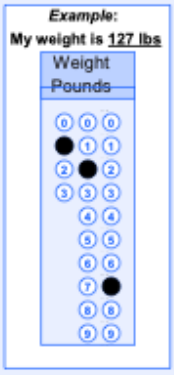
① **I do not know how much I weigh**

"My weight is _____ pounds"

OR

"My weight is _____ kilograms"





[serial]

10. How do you describe your weight?

① Very underweight
② Slightly underweight
③ About the right weight
④ Slightly overweight
⑤ Very overweight

11. Which of the following are you trying to do about your weight?

① **Lose** weight
② **Gain** weight
③ **Stay** the same weight
④ I am **not trying to do anything** about my weight

12. How much time per day do you *usually* spend doing the following activities?

For example: If you spend about 3 hours watching TV each day, you will need to fill in the 3 hour circle, and the 0 minute circle as shown below:

a) Watching/streaming TV shows or movies — Hours: 3 — Minutes: 0

	Hours	Minutes
a) Watching/streaming TV shows or movies		
b) Playing video/computer games		
c) Doing homework		
d) Talking on the phone		
e) Surfing the internet		
f) Texting, messaging, emailing **(note: 50 texts = 30 minutes)**		
g) Sleeping		

13. In the last 30 days, did you gamble online for money?

① Yes
② No

Physical Activity

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

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

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

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

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

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

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

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

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

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

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

① Yes
② No, I was *more* active in the last 7 days
③ No, I was *less* active in the last 7 days

[serial]

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

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

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

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

19. Do you participate in before-school, noon hour, or after-school physical activities organized by your school? *(e.g., intramurals, non-competitive clubs)*

1 Yes
2 No
3 None offered at my school

20. Do you participate in competitive school sports teams that compete against other schools? *(e.g., junior varsity or varsity sports)*

1 Yes
2 No
3 None offered at my school

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

1 Yes
2 No
3 There are none available where I live

22. On how many days in the last 7 days did you do exercises to strengthen or tone your muscles? *(e.g., push-ups, sit-ups, or weight-training)*

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

Healthy Eating

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

① I eat breakfast every day

① I don't have time for breakfast
① The bus comes too early
① I sleep in
① I'm not hungry in the morning
① I feel sick when I eat breakfast
① I'm trying to lose weight
① There is nothing to eat at home
① Other

24. In a *usual* school week *(Monday to Friday)*, on how many days do you do the following?	None	1 day	2 days	3 days	4 days	5 days
a) Eat breakfast	⓪	①	②	③	④	⑤
b) Eat breakfast provided to you **as part of a school program**	⓪	①	②	③	④	⑤
c) Eat lunch at school - lunch packed and brought from home	⓪	①	②	③	④	⑤
d) Eat lunch at school - lunch purchased in the cafeteria	⓪	①	②	③	④	⑤
e) Eat lunch purchased at a fast food place or restaurant	⓪	①	②	③	④	⑤
f) Eat snacks purchased from a vending machine **in your school**	⓪	①	②	③	④	⑤
g) Eat snacks purchased from a vending machine, corner store, snack bar, or canteen **off school property**	⓪	①	②	③	④	⑤
h) Drink sugar-sweetened beverages (soda pop, Kool-Aid, Gatorade, etc.) Do not include diet/sugar-free drinks	⓪	①	②	③	④	⑤
i) Drink high-energy drinks (Red Bull, Monster, Rock Star, etc.)	⓪	①	②	③	④	⑤
j) Drink coffee or tea **with sugar** (include cappuccino, frappuccino, iced-tea, iced-coffees, etc.)	⓪	①	②	③	④	⑤
k) Drink coffee or tea **without sugar**	⓪	①	②	③	④	⑤

25. On a *usual* weekend *(Saturday and Sunday)*, on how many days do you do the following?	None	1 day	2 days
a) Eat breakfast	⓪	①	②
b) Eat lunch	⓪	①	②
c) Eat foods purchased at a fast food place or restaurant	⓪	①	②
d) Eat snacks purchased from a vending machine, corner store, snack bar, or canteen	⓪	①	②
e) Drink sugar-sweetened beverages (soda pop, Kool-Aid, Gatorade, etc.) Do not include diet/sugar-free drinks	⓪	①	②
f) Drink high energy drinks (Red Bull, Monster, Rock Star, etc.)	⓪	①	②
g) Drink coffee or tea **with sugar** (include cappuccino, frappuccino, iced-tea, iced-coffees, etc.)	⓪	①	②
h) Drink coffee or tea **without sugar**	⓪	①	②

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

- ⓪ None
- ① 1 serving
- ② 2 servings
- ③ 3 servings
- ④ 4 servings
- ⑤ 5 or more servings

***Canada's Food Guide* Serving Sizes of Meats and Alternatives**

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

- ⓪ None
- ① 1 serving
- ② 2 servings
- ③ 3 servings
- ④ 4 servings
- ⑤ 5 servings
- ⑥ 6 servings
- ⑦ 7 servings
- ⑧ 8 servings
- ⑨ 9 or more servings

***Canada's Food Guide* Serving Sizes of Vegetables and Fruits**

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

- ⓪ None
- ① 1 serving
- ② 2 servings
- ③ 3 servings
- ④ 4 servings
- ⑤ 5 servings
- ⑥ 6 or more servings

***Canada's Food Guide* Serving Sizes of Milk and Alternatives**

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

- ⓪ None
- ① 1 serving
- ② 2 servings
- ③ 3 servings
- ④ 4 servings
- ⑤ 5 servings
- ⑥ 6 servings
- ⑦ 7 servings
- ⑧ 8 servings
- ⑨ 9 or more servings

***Canada's Food Guide* Serving Sizes of Grain Products**

Your Experience with Smoking

30. Have you ever tried cigarette smoking, even just a few puffs?

① Yes
② No

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

① Definitely yes
② Probably yes
③ Probably not
④ Definitely not

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

① Definitely yes
② Probably yes
③ Probably not
④ Definitely not

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

① Definitely yes
② Probably yes
③ Probably not
④ Definitely not

34. Have you ever smoked 100 or more whole cigarettes in your life?

① Yes
② No

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

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

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

⓪ None
① 1 friend
② 2 friends
③ 3 friends
④ 4 friends
⑤ 5 or more friends

37. Have you ever tried to quit smoking cigarettes?

① I have never smoked
② I have only smoked a few times
③ I have never tried to quit
④ I have tried to quit once
⑤ I have tried to quit 2 or 3 times
⑥ I have tried to quit 4 or 5 times
⑦ I have tried to quit 6 or more times

38. Have you ever tried an electronic cigarette, also known as an e-cigarette?

① Yes
② No

39. Have you used e-cigarettes for any of the following reasons? *(Mark all that apply)*

① I have not used e-cigarettes
① Curiosity / to try something new
① I can use e-cigarettes in places where smoking is not allowed
① To smoke fewer cigarettes
① To help me quit smoking cigarettes
① I have used e-cigarettes for some other reason

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

① Pipe tobacco
① Cigarillos or little cigars (*plain or flavoured*)
① Cigars (not including cigarillos or little cigars, *plain or flavoured*)
① Roll-your-own cigarettes (tobacco only)
① Loose tobacco mixed with marijuana
① E-cigarettes (electronic cigarettes that \produce vapour instead of smoke, not including Juul)
① Juul
① Smokeless tobacco (chewing tobacco, pinch, snuff, or snus)
① Nicotine patches, nicotine gum, nicotine lozenges, or nicotine inhalers
① Hookah (water-pipe) to smoke tobacco
① Hookah (water-pipe) to smoke herbal sheesha/shisha
① Blunt wraps (a sheet or tube made of tobacco used to roll cigarette tobacco)
① I have not used any of these things in the last 30 days

41a. On how many of the last 30 days did you use an e-cigarette (not including Juul)?

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

41b. On how many of the last 30 days did you use Juul?

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

[serial]

Alcohol and Drug Use

*Please remember that we will keep your answers **completely confidential**.*

A DRINK means: 1 regular sized bottle, can, or draft of beer; 1 glass of wine; 1 bottle of cooler; 1 shot of liquor (rum, whisky, etc); or 1 mixed drink (1 shot of liquor with pop, juice, energy drink).

42. In the last 12 months, how often did you have a drink of alcohol that was more than just a sip?

1. I have never drunk alcohol
2. I did not drink alcohol in the last 12 months
3. I have only had a sip of alcohol
4. Less than once a month
5. Once a month
6. 2 or 3 times a month
7. Once a week
8. 2 or 3 times a week
9. 4 to 6 times a week
10. Every day

43. How old were you when you first had a drink of alcohol that was more than just a sip?

1. I have never drunk alcohol
2. I have only had a sip of alcohol
3. I do not know

8. 8 years or younger
9. 9 years
10. 10 years
11. 11 years
12. 12 years
13. 13 years
14. 14 years
15. 15 years
16. 16 years
17. 17 years
18. 18 years or older

44. In the last 12 months, how often did you have 5 drinks of alcohol or more on one occasion?

1. I have never done this
2. I did not have 5 or more drinks on one occasion in the last 12 months
3. Less than once a month
4. Once a month
5. 2 to 3 times a month
6. Once a week
7. 2 to 5 times a week
8. Daily or almost daily

45. In the last 12 months, have you had alcohol mixed or pre-mixed with an energy drink (such as Red Bull, Rock Star, Monster, or another brand)?

1. I have never done this
2. I did not do this in the last 12 months
3. Yes
4. I do not know

46. In the last 12 months, how often did you use marijuana or cannabis? (a joint, pot, weed, hash)

① I have never used marijuana
② I have used marijuana but not in the last 12 months
③ Less than once a month
④ Once a month
⑤ 2 or 3 times a month
⑥ Once a week
⑦ 2 or 3 times a week
⑧ 4 to 6 times a week
⑨ Every day

47. If you have used marijuana or cannabis in the last 12 months, how did you use it? *(Mark all that apply)*

① I have used it by smoking it (e.g., in a joint, a pipe, a bong)
① I have used it by vaping it
① I have used it by eating or drinking it (e.g., in brownies, cookies, candies, tea)
① I have not used marijuana or cannabis in the last 12 months

48. How old were you when you first used marijuana or cannabis?

① I have never used marijuana
② I do not know

⑧ 8 years or younger
⑨ 9 years
⑩ 10 years
⑪ 11 years
⑫ 12 years
⑬ 13 years
⑭ 14 years
⑮ 15 years
⑯ 16 years
⑰ 17 years
⑱ 18 years or older

49. Do you think it would be difficult or easy for you to get marijuana if you wanted some?

① Difficult
② Easy
③ I do not know

50. Have you used or tried any of the following medications TO GET HIGH?

	No, I have never done this	**Yes**, I have done this in the last 12 months	**Yes**, I have done this, but NOT in the last 12 months
a) Oxycodone (oxy, OC, APO, OxyContin®, percs, roxies, OxyNEO®)	①	②	③
b) Fentanyl (china white, synthetic heroin, china girl)	①	②	③
c) Other prescription pain relievers (codeine, morphine, Tylenol 3)	①	②	③

51. Do you think it would be difficult or easy to get pain relievers (Oxycodone, Fentanyl, codeine, etc.) if you wanted some?

① Difficult
② Easy
③ I do not know

○○○○○○○○○○○○○○○○○○○○○○○○ [serial]

Mental Health

52. How much do you agree or disagree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
a) I have a happy home life	1	2	3	4	5
b) My parents/guardians expect too much of me	1	2	3	4	5
c) I can talk about my problems with my family	1	2	3	4	5
d) I can talk about my problems with my friends	1	2	3	4	5

53. How much do you agree or disagree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
a) I lead a purposeful and meaningful life	1	2	3	4	5
b) My social relationships are supportive and rewarding	1	2	3	4	5
c) I am engaged and interested in my daily activities	1	2	3	4	5
d) I actively contribute to the happiness and well-being of others	1	2	3	4	5
e) I am competent and capable in the activities that are important to me	1	2	3	4	5
f) I am a good person and live a good life	1	2	3	4	5
g) I am optimistic about my future	1	2	3	4	5
h) People respect me	1	2	3	4	5
i) I generally recover from setbacks quickly	1	2	3	4	5

54. Choose the answer that best describes how you feel.

	True	Mostly true	Sometimes true, sometimes false	Mostly false	False
a) In general, I like the way I am	1	2	3	4	5
b) Overall, I have a lot to be proud of	1	2	3	4	5
c) A lot of things about me are good	1	2	3	4	5
d) When I do something, I do it well	1	2	3	4	5
e) I like the way I look	1	2	3	4	5

55. If you had concerns regarding your mental health, are there any reasons why you would not talk to an adult at school (e.g., a school social worker, child and youth worker, counsellor, psychologist, nurse, teacher, or other staff person)? *(Mark all that apply)*

1 I would have no problem talking to an adult at school about my mental health

1 Worried about what others would think of me (e.g., I'd be too embarrassed)
1 Lack of trust in these people - word would get out
1 Prefer to handle problems myself
1 Do not think these people would be able to help
1 Would not know who to approach
1 There is no one I feel comfortable talking to

56. Over the last 2 weeks, how often have you been bothered by the following problems?

	Not at all	Several days	Over half the days	Nearly every day
a) Feeling nervous, anxious, or on edge	①	②	③	④
b) Not being able to stop or control worrying	①	②	③	④
c) Worrying too much about different things	①	②	③	④
d) Trouble relaxing	①	②	③	④
e) Being so restless that it is hard to sit still	①	②	③	④
f) Becoming easily annoyed or irritable	①	②	③	④
g) Feeling afraid as if something awful might happen	①	②	③	④

57. Please indicate how often the following statements apply to you:

	Almost never	Sometimes	About half the time	Most of the time	Almost always
a) I have difficulty making sense out of my feelings	①	②	③	④	⑤
b) I pay attention to how I feel	①	②	③	④	⑤
c) When I'm upset, I have difficulty concentrating	①	②	③	④	⑤
d) When I'm upset, I believe there is nothing I can do to make myself feel better	①	②	③	④	⑤
e) When I'm upset, I lose control over my behaviour	①	②	③	④	⑤
f) When I'm upset, I feel ashamed for feeling that way	①	②	③	④	⑤

58. On how many of the last 7 days did you feel the following ways?

	None or less than 1 day	1-2 days	3-4 days	5-7 days
a) I was bothered by things that usually don't bother me	①	②	③	④
b) I had trouble keeping my mind on what I was doing	①	②	③	④
c) I felt depressed	①	②	③	④
d) I felt that everything I did was an effort	①	②	③	④
e) I felt hopeful about the future	①	②	③	④
f) I felt fearful	①	②	③	④
g) My sleep was restless	①	②	③	④
h) I was happy	①	②	③	④
i) I felt lonely	①	②	③	④
j) I could not get "going"	①	②	③	④

59. In general, how would you rate your mental health?

① Excellent
② Very good
③ Good
④ Fair
⑤ Poor

If you are a young person in Canada who needs support, you can reach out to Kids Help Phone's professional counsellors by calling 1-800-668-6868 or visiting kidshelpphone.ca. Their service is free, anonymous, confidential, and available 24/7/365.

Kids Help Phone

1-800-668-6868

[serial]

Your School and You

60. 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	①	②	③	④
b) I feel I am part of my school	①	②	③	④
c) I am happy to be at my school	①	②	③	④
d) I feel the teachers at my school treat me fairly	①	②	③	④
e) I feel safe in my school	①	②	③	④
f) Getting good grades is important to me	①	②	③	④

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

① I have not been bullied in the last 30 days
① Physical attacks (e.g., getting beaten up, pushed, or kicked)
① Verbal attacks (e.g., getting teased, threatened, or having rumours spread about you)
① Cyber-attacks (e.g., being sent mean text messages or having rumours spread about you on the internet)
① Had someone steal from you or damage your things

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

① I have not been bullied by other students in the last 30 days
② Less than once a week
③ About once a week
④ 2 or 3 times a week
⑤ Daily or almost daily

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

① I did not bully other students in the last 30 days
① Physical attacks (e.g., beat up, pushed, or kicked them)
① Verbal attacks (e.g., teased, threatened, or spread rumours about them)
① Cyber-attacks (e.g., sent mean text messages or spread rumours about them on the internet)
① Stole from them or damaged their things

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

① I did not bully other students in the last 30 days
② Less than once a week
③ About once a week
④ 2 or 3 times a week
⑤ Daily or almost daily

65. How supportive is your school of the following?

	Very supportive	Supportive	Unsupportive	Very unsupportive
a) Making sure there are opportunities for students to be physically active	①	②	③	④
b) Making sure students have access to healthy foods and drinks	①	②	③	④
c) Making sure no one is bullied at school	①	②	③	④
d) Giving students the support they need to resist or quit tobacco	①	②	③	④
e) Giving students the support they need to resist or quit drugs and/or alcohol	①	②	③	④

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

① 90% - 100%
② 80% - 89%
③ 70% - 79%
④ 60% - 69%
⑤ 55% - 59%
⑥ 50% - 54%
⑦ Less than 50%

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

① 90% - 100%
② 80% - 89%
③ 70% - 79%
④ 60% - 69%
⑤ 55% - 59%
⑥ 50% - 54%
⑦ Less than 50%

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

① Some high school or less
② High school diploma or graduation equivalency
③ College/trade/vocational certificate
④ University Bachelor's degree
⑤ University Master's / PhD / law school / medical school / teachers' college degree
⑥ I don't know

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

① Some high school or less
② High school diploma or graduation equivalency
③ College/trade/vocational certificate
④ University Bachelor's degree
⑤ University Master's / PhD / law school / medical school / teachers' college degree
⑥ I don't know

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

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

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

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

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

① Never
② Seldom
③ Often
④ Usually

[serial]

Appendix C:

CSEP Physical Activity Guidelines

CANADIAN 24-HOUR MOVEMENT GUIDELINES FOR CHILDREN AND YOUTH:

An Integration of Physical Activity, Sedentary Behaviour, and Sleep

PREAMBLE

These guidelines are relevant to apparently healthy children and youth (aged 5–17 years) irrespective of gender, race, ethnicity, or the socio-economic status of the family. Children and youth are encouraged to live an active lifestyle with a daily balance of sleep, sedentary behaviours, and physical activities that supports their healthy development.

Children and youth should practice healthy sleep hygiene (habits and practices that are conducive to sleeping well), limit sedentary behaviours (especially screen time), and participate in a range of physical activities in a variety of environments (e.g., home/school/community; indoors/outdoors; land/water; summer/winter) and contexts (e.g., play, recreation, sport, active transportation, hobbies, and chores).

For those not currently meeting these 24-hour movement guidelines, a progressive adjustment toward them is recommended. Following these guidelines is associated with better body composition, cardiorespiratory and musculoskeletal fitness, academic achievement and cognition, emotional regulation, pro-social behaviours, cardiovascular and metabolic health, and overall quality of life. The benefits of following these guidelines far exceed potential risks.

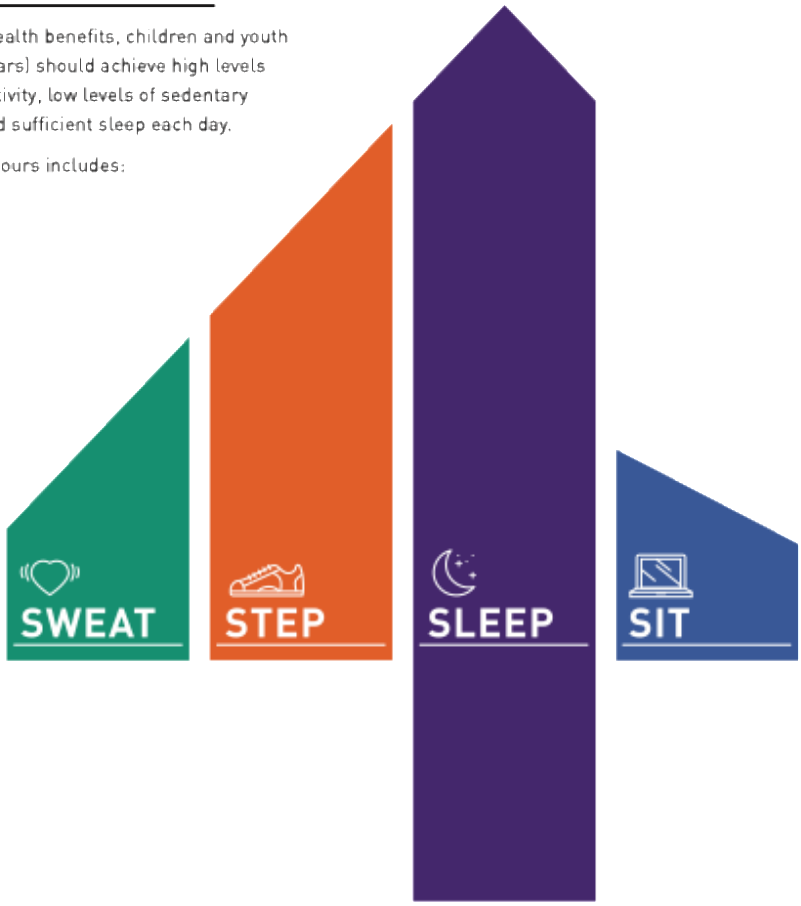
These guidelines may be appropriate for children and youth with a disability or medical condition; however, a health professional should be consulted for additional guidance.

The specific guidelines and more details on the background research informing them, their interpretation, guidance on how to achieve them, and recommendations for research and surveillance are available at www.csep.ca/guidelines.

GUIDELINES

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

A healthy 24 hours includes:



SWEAT

MODERATE TO VIGOROUS PHYSICAL ACTIVITY

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

STEP

LIGHT PHYSICAL ACTIVITY

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

SLEEP

SLEEP

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

SIT

SEDENTARY BEHAVIOUR

No more than 2 hours per day of recreational screen time;

Limited sitting for extended periods.

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