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Gambling and Physical Activity among Ontario Adolescents

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Abstract

Given that physical activity is essential for optimal health, it is important to identify behaviours that may contribute to low levels of physical activity. The purpose of this study was to examine the association between gambling and physical activity among adolescents in Ontario using data from the 2017 Ontario Student Drug Use and Health Survey (OSDUHS). Multivariable generalized ordinal logistic regression models were used to examine the association between past-year gambling (status and modality) and past-week physical activity among a representative sample of Grade 7-12 students, while adjusting for covariates. We also tested for multiplicative effect measure modification by sex. Neither gambling status nor modality was associated with physical activity and no evidence of effect measure modification of either association by sex was found. While these behaviours may not be associated, gambling and inadequate physical activity nonetheless represent important public health concerns for adolescents.

Keywords

Physical activity, Moderate-to-Vigorous physical activity, gambling, land-based gambling, online gambling, sedentary behaviour, displacement hypothesis, adolescents, generalized ordinal logistic regression, Ontario Student Drug Use and Health Survey

Summary for Lay Audience

Physical activity is an important part of healthy living. In Canada, physicians and scientists recommend that children and youth should participate in physical activity that causes them to sweat and breathe harder than usual for at least 60 minutes each day (total time accumulated throughout the day). Physical activity of this intensity is known as "moderate-to-vigorous physical activity" (MVPA).

Some research suggests that young people are replacing physical activity with activities that mostly involve sitting (sedentary behaviours). This phenomenon often referred to as "displacement." Because physical activity protects against many chronic diseases, the possible displacement of physical activity by sedentary behaviours is a public health concern.

The present study examined the association between gambling behaviours and physical activity among Ontario youth in grades 7-12 using data from the Ontario Student Drug Use and Health Survey (OSDUHS). All data used in this study were collected in school classrooms between November 2016 and June 2017 and each student who provided data was surveyed only once. For the purposes of this study, gambling was assumed to be largely sedentary. Data analysis was performed using the computer program Stata.

We did not find evidence that student gamblers are any more or less active than student non-gamblers in Ontario (no displacement). However, about 1 in 3 (~35%) students gambled and only about 1 in 5 (~21%) got the recommended 60 minutes of MVPA every day; both gambling participation and low physical activity represent important public health concerns for adolescents. In order to create effective public health campaigns aimed at increasing the level of activity among young people, we recommend that researchers continue working to identify reasons that young people choose to be (or choose to not be) physically active. As well, our study should be repeated using improved survey questions. Since adult patterns of physical activity are often established during adolescence, increasing physical activity of young people is expected to have widespread public health benefits.

Dedication

Mom and Dad — Thank you for paving the way for me to be here today.

BL — Thank you for being my best friend and first roommate. Moving in together was a gamble (ha!) but look at us now – after two years and two apartments, we're still pals. Here's to navigating many more life crises together.

SM ♡ — Thank you for cheering me on through the imposter syndrome, and for enduring countless trips on the Greyhound to come visit me. I could always count on you to say something logical and reassuring when my brain felt like it had ten million tabs open.

CW and CW — Thank you for being my ride-or-die partners in crime these past two years. You are the best kind of people and you have both helped me tremendously. When I look back on this "it was the best of times, it was the worst of times…" period of our lives (to put it in the most dramatic way possible, as is our custom), I will think of only the best: strawberry rhubarb fritters, Spoke bagels, Inferno Hot Pilates, and Kawhi Leonard. Our London, Ontario shenanigans were some for the books.

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Chapter 1

1 Introduction

Physical activity is an essential determinant of human health (World Health Organization, 2018b). Regular and adequate physical activity improves muscular and cardiorespiratory fitness, facilitates weight control, and stabilizes energy levels (World Health Organization, 2018b). Physical activity may also enhance cognitive function, as well as positively impact the mental health of an individual by alleviating symptoms of anxiety and depression (Anderson & Shivakumar, 2013; Dinas, Koutedakis, & Flouris, 2011; Gomez-Pinilla & Hillman, 2013). Given that the majority of Canadian adolescents do not currently meet the age-specific, Canadian 24-hour movement guidelines for optimal health, which suggest 60 minutes of moderate-to-vigorous physical activity (MVPA) every day (Tremblay et al., 2016), it is important to identify factors that may be contributing to low levels of physical activity among this population, including sedentary behaviours.

Sedentary behaviour is highly prevalent among adolescents (Leatherdale & Wong, 2008). There is some evidence of an inverse correlation between sedentary behaviour and physical activity among young people, with higher participation in sedentary behaviours, such as watching television, coinciding with lower levels of physical activity (Graham, Bauer, Friend, Barr-Anderson, & Nuemark-Sztainer, 2014; Melkevik, Torsheim, Iannotti, & Wold, 2010). From a public health standpoint, it is important to further understand how engagement in different types of sedentary activities may influence the physical activity of young people.

The sedentary nature of many gambling activities and their possible contribution to low levels of physical activity has been theorized as a gambling-related harm, but research in this area remains limited and focused on populations of older adults (Anzalone, 2013; Burge, Pietrzak, Molina, & Petry, 2004; Humphreys, Ruseski, & Yang, 2017; Langham et al., 2016; O'Brien Cousins & Witcher, 2007; Pietrzak, Morasco, Blanco, Grant, & Petry, 2007; Subramaniam et al., 2015). Despite restrictions on gambling, Canadian data suggest that a large proportion (42%) of adolescents engage in gambling, with as many as 9% of all adolescents engaging in online gambling, a screen-based sedentary behaviour (Elton-Marshall, Leatherdale, & Turner, 2016; Wijesingha, Leatherdale, Turner, & Elton-Marshall, 2017).

As a sedentary behaviour, gambling may provide adolescents with yet another sedentary alternative to engaging in physical activity, exacerbating an already serious public health problem. However, few studies to date (and, to the best of our knowledge, none in Canada) have examined how gambling might relate to physical activity among adolescents (Chaumeton, Ramowski, & Nystrom, 2011; Gavriel-Fried, Bronstein, & Sherpsky, 2015). The present study will address this gap by examining the association between gambling and physical activity among Ontario adolescents. Specifically, this study will examine the association between past-year gambling and past-week physical activity among a representative sample of Ontario adolescents in grades 7 to 12. Given inherent differences between land-based gambling (gambling activities that are performed in traditional, physical settings) and online gambling (gambling activities that take place over the Internet), the association between gambling modality will also be examined. Findings will be interpreted in the context of an existing hypothesis regarding the relationship between sedentary behaviour and physical activity: the displacement hypothesis (i.e., time spent being sedentary displaces time otherwise spent being physically active).

1.1 Study Objectives and Hypotheses

This study aims to measure the association between gambling and physical activity among Ontario students. Using data from the 2017 Ontario Student Drug Use and Health Survey (OSDUHS), our objectives are as follows:

1.1.1 Objective 1: Gambling Status and Physical Activity

- To measure the association between past-year gambling status (presence/absence of past-year gambling behaviour) and past-week physical activity level (inactive/active below guidelines/active at or above guidelines). In line with the hypothesis that sedentary behaviour displaces physical activity, we hypothesize that gamblers will be less physically active than non-gamblers.

1.1.2 Objective 2: Gambling Modality and Physical Activity

- To measure the association between past-year gambling modality (presence/absence of land-based and online gambling) and past-week physical activity level. Because online gambling is a screen-based sedentary behaviour, we hypothesize that online gamblers will be less physically active than both land-based only gamblers and non-gamblers.

1.1.3 Objective 3: Modification of the Association between Gambling and Physical Activity by Sex

- To determine whether multiplicative interaction is present between (a) past-year gambling status and sex and (b) past-year gambling modality and sex in models predicting past-week physical activity. We hypothesize that the association between gambling and physical activity will vary by sex (rationale described in Section 2.3).

1.2 Study Overview

This study is divided into five chapters. The present chapter serves as a brief introduction to the research, the study objectives, and the accompanying hypotheses. The next chapter describes relevant existing literature on what is presently known about the association between sedentary gambling behaviours and physical activity. Study significance will also be described. The third chapter outlines the methods used to collect the cross-sectional data used in this study, as well as the analytic strategy employed to meet the study objectives. Results are presented in the fourth chapter. Finally, the fifth chapter concludes with a discussion of the findings.

Chapter 2

2 Literature Review

This chapter begins with an overview of physical activity and its importance for adolescent health. Following this overview, literature conceptualizing gambling as a sedentary behaviour is presented. Two hypotheses regarding the nature of the association between gambling (as a sedentary behaviour) and physical activity are described, followed by a review of literature describing other factors associated with physical activity (to be included as covariates in the present study). Finally, a theoretical model of the adjusted association between gambling and physical activity to be tested is suggested. The chapter concludes with the anticipated significance of the present study.

2.1 Physical Activity

Physical activity is defined by the World Health Organization as "any bodily movement produced by skeletal muscles that requires energy expenditure" (World Health Organization, 2018b). Physical activity encompasses structured exercise aimed at improving or maintaining physical fitness, such as weight-lifting and distance running, as well as any activity of daily living that requires individuals to move (World Health Organization, 2018b). Examples of the latter include occupational tasks, recreational activities, routine household cleaning, and active commuting between home, work, school, and other locations (e.g., walking or bicycling).

2.1.1 Physical Activity and Health

Physical activity is essential for optimal health (World Health Organization, 2018b). Regular and adequate physical activity improves muscular and cardiorespiratory fitness, facilitates weight control, and stabilizes energy levels (Landry & Driscoll, 2012; Loprinzi, Cardinal, Loprinzi, & Lee, 2012). Physical activity may also enhance cognitive function, as well as positively impact the mental health of an individual by alleviating symptoms of anxiety and depression (Anderson & Shivakumar, 2013; Dinas et al., 2011; Gomez-Pinilla & Hillman, 2013).

Physical activity has been identified as a protective factor against many non-communicable diseases, including obesity, coronary heart disease, stroke, Type 2 diabetes, hypertension, breast cancer, and colon cancer (Hills, Andersen, & Byrne, 2011; Kyu et al., 2016; Lee et al., 2012; World Health Organization, 2018b). Data from 142 countries, representing 93% of the world's population, suggest that the direct and indirect costs of coronary heart disease, stroke, Type 2 diabetes, breast cancer, and colon cancer totaled $53.8 billion (international currency) in 2013 alone (Ding et al., 2016).[1] By protecting against these chronic diseases, physical activity reduces the financial burden on health care systems.

Recognizing the substantial global health and economic benefits of physical activity, the World Health Organization recently launched *More Active People for a Healthier World*, a 12-year global action plan promoting active lifestyles worldwide (World Health Organization, 2018a).

2.1.1.1 Physical Activity and Adolescent Health

Regular engagement in physical activity is a health-related behaviour that may be established during adolescence (Sawyer et al., 2012). Adolescence, the unique developmental stage marking the transition between childhood and adulthood, is generally defined as the period between the ages of 10 and 19 (Canadian Paediatric Society, 2003). Longitudinal studies have found that physical activity in adolescence may predict physical activity in adulthood (Huotari, Nupponen, Mikkelsson, Laakso, & Kujala, 2011; Telama, Yang, Laakso, & Viikari, 1997).

Engaging in regular and adequate physical activity is important for individuals of all ages, but it is especially important for the healthy development of youth. In Canada, it is estimated that 33% of children and adolescents aged 5-17 are overweight or obese (Roberts, Shields, de Groh, Aziz, & Gilbert, 2012), with almost 1 in 7 young people

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[1] Bills for hospital care, medical procedures, and medication are considered 'direct costs', while loss of income and workplace productivity due to illness, disability, or premature death are described as 'indirect costs' (Janssen, 2012).

living with obesity (Rao, Kropac, Do, Roberts, & Jayaraman, 2016). Physical activity may reduce an adolescent's risk of obesity (Goran, Reynolds, & Lindquist, 1999), and promotion of physical activity is an essential public health strategy in combatting the contemporary youth obesity epidemic (Hills et al., 2011; Rao et al., 2016). However, the benefits of physical activity for adolescents extend beyond weight control.

Strong and colleagues (2005) conducted a systematic review and found adequate-to-strong evidence of a beneficial effect of physical activity on the musculoskeletal and cardiovascular health, adiposity, blood pressure, self-concept, mental health, and academic performance of adolescents. Congruent with these findings, a more recent systematic review identified physical activity as being positively associated with physical, psychological, social and cognitive adolescent health (Poitras et al., 2016).

2.1.2 Physical Activity Guidelines for Adolescents

The Canadian 24-hour movement guidelines recommend that adolescents accumulate 60 minutes of moderate-to-vigorous physical activity (MVPA) every day (Tremblay et al., 2016). This translates to roughly 12,000 steps per day, 20% more than the common target of 10,000 steps per day (Colley, Janssen, & Tremblay, 2012). Moderate-to-vigorous activities require *at least* 4.6 metabolic equivalents (METs), which may be conceptualized as 4.6 times the energy that is required to sit quietly (Treuth et al., 2004). In comparison, among healthy adolescents, moderate physical activities demand 4-5.9 METs, while vigorous physical activities are characterized by an energy expenditure of 6.0 METs or more (Trost, Loprinzi, Moore, & Pfeiffer, 2011).

When performing MVPA, adolescents will find themselves sweating, and their breathing may be laboured (Statistics Canada, 2017). Some examples of moderate-to-vigorous activities include brisk walking, aerobics, hiking uphill, jogging, fast cycling, and weightlifting (U.S. Department of Health and Human Services, 2018). Each week, a balanced combination of aerobic, muscle-strengthening, and bone-strengthening exercises should be included as part of the daily 60 minutes of MVPA. It is recommended that each of these subcategories of MVPA be performed on at least three days of the week (Janssen & LeBlanc, 2010; Piercy et al., 2018). Although exceeding current physical activity guidelines results in greater health benefits, engaging in *any* level of physical activity (including levels below the guidelines) is preferable to doing no physical activity at all (Janssen & LeBlanc, 2010; World Health Organization, 2011).

2.1.3 Prevalence of Physical Activity among Adolescents

2.1.3.1 Global Prevalence

Around the world, physical activity among adolescents does not generally meet recommended levels (Amornsriwatanakul, Lester, Bull, & Rosenberg, 2017; Babey, Wolstein, & Diamant, 2018; Cheah, Lim, Kee, & Ghazali, 2016). Repeated cross-sectional data from the Health Behaviour in School-aged Children Study (collected in 32 countries) revealed a marginal increase in the global proportion of adolescents accumulating at least 60 minutes of MVPA daily between 2002 and 2010 (Kalman et al., 2015). While encouraging, this increase is not enough. In 2010, global estimates suggested that 81% of adolescents in high-, middle-, and low-income countries surveyed still did not achieve the recommended levels of physical activity (World Health Organization, 2018b). In 2014, *The Lancet* Physical Activity Observatory identified increasing the proportion of adolescents worldwide who achieve at least 60 minutes of MVPA daily as a primary surveillance goal (Hallal, Martins, & Ramírez, 2014).

2.1.3.2 Canadian Prevalence

Congruent with global trends, the majority of adolescents in Canada fall short of the recommended 60-minute daily minimum of MVPA (J. D.[2] Barnes et al., 2016; Colley et al., 2011). Between 2007 and 2015, fewer than 7% of Canadian children and adolescents aged 5 to 17 years met this target (Colley et al., 2017). In part, low levels of physical activity may be attributable to a widespread lack of awareness of current physical activity guidelines among the general Canadian public (LeBlanc et al., 2015).

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[2] Throughout this document, first initials are used to differentiate between authors with the same surname, as per the 6th edition of the Publication Manual of the American Psychological Association (2009-2010).

Given that many adolescents are insufficiently physically active, it is important to understand factors (including behaviours) associated with physical activity during adolescence. This information is important for informing the development of initiatives to increase physical activity among adolescents, which is vital for improved long-term public health outcomes.

2.2 Sedentary Behaviour

Physical activity is often discussed alongside sedentary behaviour. Sedentary behaviour was formerly equated with "physical inactivity" but is now generally conceptualized as a distinct category of behaviour (Owen, Healy, Matthews, & Dunstan, 2010; Pate, O'Neill, & Lobelo, 2008). Common sedentary behaviours among adolescents include watching television and using a laptop, tablet, or smartphone while seated, as well as doing homework and sitting in a motor vehicle. Sedentary behaviour does not include sleep, a necessary restorative process (Saunders & Vallance, 2017).

The Canadian 24-hour movement guidelines recommend no more than two hours of recreational screen time per day (Tremblay et al., 2016). However, Canadian children and youth are highly sedentary, spending approximately 8.6 hours a day (~62% of their waking hours) sitting (Colley et al., 2011).

2.2.1 Gambling as a Sedentary Behaviour

Gambling includes (but is not limited to) betting money or something of value on the outcome of a game, dare, or event (e.g., card games, sporting events, video games), betting money at a casino, and purchasing lottery tickets (Elton-Marshall et al., 2016). "Land-based gambling" refers to gambling activities that are performed in traditional, physical settings, whereas "online gambling" takes place over the Internet (Elton-Marshall et al., 2016).

Although many gambling activities are sedentary behaviours, they have not garnered much attention in the literature as sedentary exposures, with the exception of a study examining Bingo as a sedentary form of recreation among older women (O'Brien Cousins & Witcher, 2007). It has been suggested that gambling may appeal to older adults whose physical activity is limited by health problems (Leppink, Fridberg, Redden, & Grant, 2016). Indeed, problem gambling has been associated with sedentariness and infrequent physical activity among adults (Algren, Ekholm, Davidsen, Larsen, & Juel, 2015).

Quantitative research measuring the association between gambling and physical activity among adolescents is limited (Chaumeton et al., 2011; Gavriel-Fried et al., 2015). In recent qualitative research, gambling was identified as a sedentary behaviour that could impact physical activity (Ssewanyana, Abubakar, van Baar, Mwangala, & Newton, 2018). A focus group of adolescents (*n*=78) living in a Kenyan coastal village cited three gambling activities – card games, sports betting, and casino games – as popular sedentary pastimes that encroach on physical activity.[3] While the cultural differences between adolescents in Kenya and Canada should not be ignored, the results of these focus groups suggest that gambling is a sedentary behaviour that may take time away from physical activity and that examining gambling as a sedentary behaviour is conceptually valid.

2.2.1.1 Gambling Modality

Recent research has closely examined associations between common screen time sedentary behaviours, such as television viewing and computer use, and youth health behaviours (Hale & Guan, 2015; Katapally, Thorisdottir, Laxer, Qian, & Leatherdale, 2018; Mireku et al., 2019; Saunders & Vallance, 2017). However, online media is advancing quickly, with new platforms – including online gambling sites – becoming available all the time. While many online and land-based gambling activities may be engaged in while sitting down, online gambling and land-based gambling are inherently different in that the former is screen-based, while the latter is not. Among a sample of 810 adult gamblers in Québec, Papineau and colleagues (2018) found that participants who had gambled online were more likely to have reduced the time they devote to

[3] The purpose of the focus groups was to identify factors that contributed to sedentary lifestyles of adolescents in this coastal region of Kenya. Compared to other areas of Kenya, disproportionately lower prevalence of physical activity has been documented in this coastal region.

physical activity since they started gambling compared to land-based only gamblers. This finding suggests that it may be important to examine associations between specific gambling modalities and physical activity.

2.2.1.2 Gambling Among Adolescents

Most gambling research conducted among adolescent populations has framed gambling as a risky behaviour that may cause significant social and psychological harm (Derevensky & Gupta, 2004). As an example, in a recent population study of Finnish adolescents, Raisamo and colleagues (2013) found that adolescents who gambled once a week or more (termed "frequent gamblers") were more likely to experience gambling-related harms compared to adolescents who gambled less frequently. In this study, commonly cited harms included feelings of guilt and shame, relationship problems, and disrupted daily rhythms of life due to gambling.

Interestingly, the sedentariness of many gambling activities has not been a focus of prior research. One plausible explanation for why gambling has not been examined as a sedentary behaviour among adolescents is the misconception that adolescents are not gambling. Previous research suggests that adolescents engage in both land-based gambling and online gambling, despite age restrictions (Elton-Marshall et al., 2016; Rossen, Butler, & Denny, 2011). Recent data from roughly 10,000 Grade 9-12 students living in Ontario, Newfoundland and Labrador, and Saskatchewan found that approximately 33% had engaged exclusively in land-based gambling and 9% had engaged in online gambling in the three months prior to the study (Elton-Marshall et al., 2016). The latter statistic translates to approximately 58,000 adolescent online gamblers in the three provinces included in the study (Elton-Marshall et al., 2016). Therefore, while less prevalent than land-based gambling, there is evidence that online gambling appeals to, and is being accessed by, adolescents (Sirola, Kaakinen, Savolainen, & Oksanen, 2019).

There is also evidence to suggest that gambling begins at a young age (Stinchfield & Winters, 1998). Rahman and colleagues (2012) surveyed 1,624 Connecticut high school students between 13 and 18 years of age and found that about 70% of participants had begun gambling in some form before the age of 12. For many adolescents, gambling onset may occur prior to experimentation with sex, drugs, or alcohol (Volberg, Gupta, Griffiths, Olason, & Delfabbro, 2010).

2.2.2 The Association of Gambling with Physical Activity: Compensation and Displacement Hypotheses

The nature of the association between sedentary behaviours, such as some types of gambling, and physical activity among adolescents remains a point of discussion (Pate et al., 2008; Ricciardi, 2006; Stamatakis et al., 2018; van der Ploeg & Hillsdon, 2017). Two hypotheses have been posed for this association: (1) the ActivityStat hypothesis and (2) the displacement hypothesis.

2.2.2.1 ActivityStat Hypothesis

The ActivityStat hypothesis (also known as the ‘compensation’ hypothesis) suggests that sedentary behaviour compensates for physical activity, and vice versa (Baggett et al., 2010; Gomersall, Rowlands, English, Maher, & Olds, 2013), as represented in Figure 1. First suggested by Rowland (1998), the underlying premise of this hypothesis is that each individual has a “preferred” level of energy expenditure (a setpoint) that their body strives to maintain over time (Frémeaux, Mallam, Metcalf, Hosking, & Wilkin, 2011; Gomersall et al., 2013). Time spent being sedentary and time spent being physically active are therefore positively associated, increasing and decreasing together.

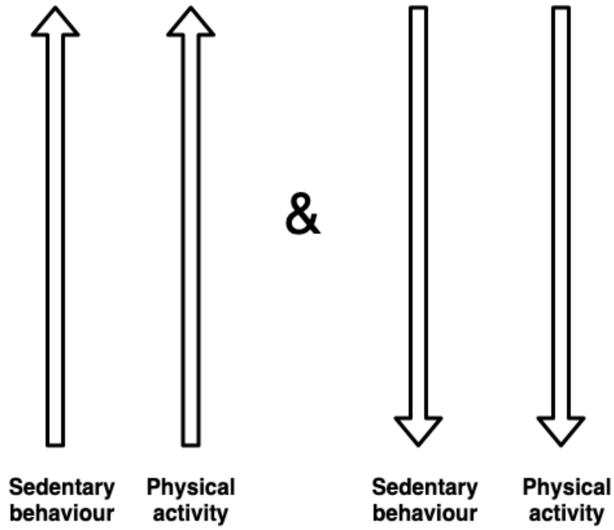

Figure 1. ActivityStat Hypothesis - Compensation mechanism between sedentary behaviour and physical activity

A systematic review of literature examining the ActivityStat hypothesis in heterogenous populations concluded that support for this hypothesis remains unclear (Gomersall et al., 2013). The ActivityStat hypothesis has not been widely tested among adolescents. However, Ting and colleagues (2015) found a compensatory effect between sedentary time and physical activity among Singaporean youth aged 13-15. In this study, daily patterns of physical activity were assessed consecutively for three weekdays and two weekend days using an accelerometer. After controlling for gender, a moderate positive association was observed between moderate-to-vigorous physical activity and sedentary time on weekdays ($r = 0.346$, $p < 0.001$).

Paravidino and colleagues (2016) found evidence of a possible compensation mechanism between physical activity intensity and energy expenditure among a sample of overweight young males in the Brazil; that is, one session of higher intensity physical activity lead to lower mean energy expenditure on each of the subsequent five days. This crossover study involved three intervention protocols. The control protocol involved monitoring the energy expenditure of 24 males aged 11-13 for six days via accelerometer. The moderate and vigorous intervention protocols were identical, aside from a 60-minute exercise session (moderate intensity and vigorous intensity, respectively) scheduled on the first day of monitoring. Each participant participated in all three intervention protocols with 21 days between each protocol. Participants were blinded to the order of the protocols. Mean daily energy expenditure from the second to the sixth day of monitoring (inclusive) was lower during the moderate and vigorous intervention protocols compared to the control protocol, supporting the ActivityStat hypothesis.

Evidence in support of the ActivityStat hypothesis has also been observed among younger children. Frémeaux and colleagues (2011) examined the impact of school-time activity on total physical activity among children aged 8-10. Physical activity was measured using an accelerometer for three consecutive weeks at four different time points throughout the school year. Counterintuitively, children who recorded more physical activity during school hours did not record more total weekly physical activity, suggesting that greater school-time physical activity was compensated for by less physical activity at other times of the day. This finding supports an earlier study which found that daily physical activity was similar between children who engaged in high and low volumes of physical activity in school (Wilkin, Mallam, Metcalf, Jeffery, & Voss, 2006).

In the context of the present study, the ActivityStat hypothesis predicts that gambling and physical activity are positively associated. Evidence of compensation between these two behaviours is limited; however, a positive association has been identified between problem gambling and competitive sports among Israeli high school students (Gavriel-Fried et al., 2015). This finding is congruent with results from Chaumeton and colleagues (2011), who identified a positive association between gambling and physical activity frequency among Grade 8 males in Oregon. Interestingly, the ActivityStat hypothesis was not discussed in either of these studies.

2.2.2.2 Displacement Hypothesis

In contrast to the ActivityStat hypothesis, the displacement hypothesis posits that sedentary behaviour and physical activity displace each other; greater time spent being sedentary results in less time for physical activity, and vice versa (Mutz, Roberts, & van Vuuren, 1993). The rationale for this hypothesis (represented in Figure 2) is the reality of finite time in a day; at any given moment, individuals may be either sedentary or physically active, but not both simultaneously (Mannell, Kaczynski, & Aronson, 2005; Mutz et al., 1993).

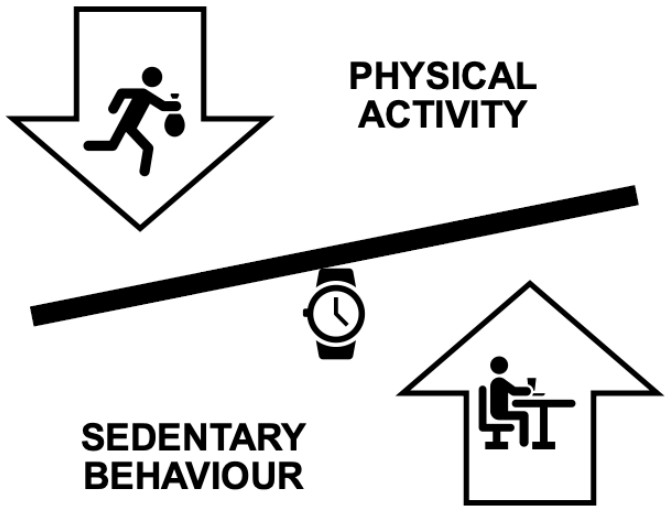

Figure 2. Displacement mechanism between sedentary behaviour and physical activity

To the best of our knowledge, the displacement hypothesis has not yet been tested in the context of gambling. However, some previous research examining other sedentary behaviours tentatively supports the displacement hypothesis (Gomes et al., 2017; Tammelin, Ekelund, Remes, & Näyhä, 2007). For instance, computer usage and watching television have been shown to be associated with multiple risky health behaviours, including insufficient physical activity (Carson, Pickett, & Janssen, 2011; Melkevik et al., 2010). Television viewing was inversely associated with physical activity among a sample of Canadian adolescents (Koezuka et al., 2006). In addition, Baggett and colleagues (2010) analyzed six days of accelerometer data collected from roughly 7,000 Grade 8 girls, and concluded that, on a given day, every additional minute of MVPA was associated with 1.85 fewer minutes of inactivity, suggesting that MVPA displaces inactivity. This is consistent with earlier evidence of an inverse association between physically active leisure time and time spent watching television or playing video games (Mannell et al., 2005; Tammelin et al., 2007). As well, a moderate displacement effect was observed between screen media use and physical activity among adolescent girls aged 12 to 18 in Spain (Valencia-Peris et al., 2016). Elsewhere, a recent systematic review and meta-analysis found an overall negative association between sedentary behaviours (including computer time, homework time, Internet time, reading, screen time, and time spent playing video games) and the physical activity of young people under the age of 18 (Pearson, Braithwaite, Biddle, van Sluijs, & Atkin, 2014). However, while significant, the authors acknowledged that the magnitude of this association was small (r = -0.108, 95% CI = - 0.128, -0.087).

Somewhat stronger support is provided by a longitudinal study by Graham et al. (2014). The primary objective of this study was to identify correlates of physical activity among adolescent females, both cross-sectionally and longitudinally. Among a sample of 352 female adolescents in Minnesota, screen time was inversely associated with MVPA at baseline. This association was observed again after six months of follow up, with approximately two 30-minute blocks fewer of screen time corresponding to one 30-minute block more of MVPA.

Evidence for the displacement of physical activity by sedentary behaviour is ultimately inconclusive. As asserted by Biddle and colleagues (2003), there are many ways in which adolescents can be sedentary and not all sedentary behaviours are necessarily associated with physical activity in the same manner. “Productive” sedentary behaviours, such as reading or doing homework, have been associated with higher levels of physical activity among high school students, as has working at a computer (Feldman, Barnett, Shrier, Rossignol, & Abenhaim, 2003; Koezuka et al., 2006). This finding suggests that sedentary behaviours should not be unanimously classified as detrimental to physical activity and suggests that another mechanism (perhaps a compensation mechanism, as previously described) for the association between certain types of sedentary behaviours and physical activity may be at work.

In the context of the present study, we predict that gambling and physical activity are negatively associated, in line with the displacement hypothesis. While we did not find previous evidence suggesting specifically that sedentary gambling behaviours displace physical activity among adolescents, we selected the displacement hypothesis (versus the

ActivityStat hypothesis) as the foundation for our study objectives based on existing studies linking gambling with lower physical activity among adults (O'Brien Cousins & Witcher, 2007; Papineau et al., 2018), as well as research characterizing gambling as an important sedentary behaviour among youth (Ssewanyana et al., 2018).

We note that evidence for both the ActivityStat and displacement hypotheses remains inconclusive.

2.3 Gambling and Physical Activity: Differences between Males and Females

The gambling literature has consistently shown that males gamble more than females (Forrest & McHale, 2012; Papineau et al., 2018; Wong, Zane, Saw, & Chan, 2013). Ellenbogen and colleagues (2007) collected data on gambling involvement from a sample of 5,313 Canadian adolescents aged 12-18 and found that male social gamblers (defined as those who scored between 0 and 1 on the DSM-IV-MR-J problem gambling severity scale) were more likely than female social gamblers to gamble on a weekly basis (OR: 1.93).[4] This finding is consistent with a recent study assessing the prevalence of land-based and online gambling among adults in New Jersey in which the highest frequency gamblers (those who gambled once a week or more) were predominantly male (Nower, Volberg, & Caler, 2017).

Ellenbogen, Derevensky, and Gupta (2007) also found that the prevalence of probable pathological gambling (defined as score of 4 or greater on the problem gambling severity scale) was higher among males than females (6.3% of males versus 1.5% of females). An earlier study of 13,549 students in grades 7, 9, 10, and 12 living in Atlantic provinces of Canada reported a similar trend; problem gambling (defined as daily gambling or weekly gambling and a South Oaks Gambling Screen score of 2+) was three times more likely among males than females (Poulin, 2000). In addition to gambling more frequently and having more gambling problems, males are also more physically active than females

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[4] Confidence intervals and *p*-value were not reported in this study.

across the life course, as repeatedly demonstrated by numerous studies (Armstrong et al., 2018; Carson, Staiano, & Katzmarzyk, 2014; Cheah et al., 2016; Colley et al., 2017, 2011; Lee, Kim, & Paik, 2017; Park & Kim, 2008; Renato Azevedo et al., 2007; Riddoch et al., 2004; Ridgers, Timperio, Crawford, & Salmon, 2013; Sagatun, Kolle, Anderssen, Thoresen, & Søgaard, 2008; Wickel & Belton, 2016).

We did not find previous studies examining gender as a potential effect measure modifier of the association between gambling (status or modality) and physical activity. However, we hypothesize that any gambling-related decline in physical activity would be greater among males than among females due to higher levels of both gambling and physical activity among males. If gambling displaces physical activity, male gamblers would experience a larger decrease in their physical activity compared to their female counterparts because they spend more time gambling. As well, gambling-related decreases in the physical activity of female gamblers (even those whose gambling engagement is similar to male gamblers) may be limited by "floor effects" because females are less physically active than males to begin with, further contributing to possible gender differences in the association between gambling and physical activity.

2.4 Other Factors Associated with Physical Activity

Several factors have been consistently found to be associated with physical activity in empirical studies, including age, race/ethnicity, years lived in Canada, socioeconomic status, Body Mass Index category, screen time, homework time, and season. Thus, these variables will be included as covariates in the present study (Braga, Farrokhyar, & Bhandari, 2012; VanderWeele & Shpitser, 2011).

2.4.1 Age

In adolescent populations, literature has consistently demonstrated that physical activity declines with increasing age (Armstrong et al., 2018; Brodersen, Steptoe, Boniface, & Wardle, 2007; Corder et al., 2017; Park & Kim, 2008; Parker, Salmon, Brown, Villanueva, & Timperio, 2018; Riddoch et al., 2004). A 10-year cohort study of 300 youth in the United Kingdom found that physical activity fell progressively from 9 to 15 years of age (Metcalf, Hosking, Jeffery, Henley, & Wilkin, 2015). This declining trend has previously been observed in multiple countries (Borraccino et al., 2009).

The association between gambling and age appears to be directly associated, with older adolescents on the verge of young adulthood reporting more gambling than younger adolescents. Delfabbro, King, and Griffiths (2014) conducted a longitudinal investigation of gambling behaviour among 256 adolescents in Australia. They documented a rapid increase in gambling participation rates from mid-adolescence to young adulthood. This finding was echoed by a study of adolescents in New Zealand, in which both general gambling and the number of different gambling activities increased with age (Rossen et al., 2011).

2.4.2 Race/Ethnicity

Race/ethnicity has been associated with physical activity, with higher physical activity typically observed among individuals who identify as White, as opposed to another racial-ethnic group. Data from the 2009–2010 Canadian Health Behaviour in School-aged Children Study found that Canadian youth who described their racial-ethnic backgrounds as European and North American reported higher levels of physical activity compared to those who described themselves as East and Southeast Asian, Latin American, or African (Kukaswadia, Pickett, & Janssen, 2014). Similar findings have been reported in other Western countries (Armstrong et al., 2018; Brodersen et al., 2007; Kandula & Lauderdale, 2005; Liu, Bennett, Harun, & Probst, 2008).

Although research on gambling behaviour among racialized groups is often limited by small numbers of participants in many racial-ethnic groups (G. M. Barnes, Welte, & Tidwell, 2017), associations between gambling and broad racial-ethnic groups have been found with individuals identifying as “White” being broadly less likely to gamble compared to ethnic minority groups, including Indigenous Canadians (Kowatch, 2017), Black and Hispanic Americans (Alegría et al., 2009; G. M. Barnes, Welte, Hoffman, & Tidwell, 2009; Volberg, 1994; Welte, Barnes, Wieczorek, & Tidwell, 2004), and individuals of Asian descent (Chan, Zane, Wong, & Song, 2015; Chiu & Woo, 2012). It has been suggested that gambling may serve as a coping mechanism against racism (Currie et al., 2013).

2.4.3 Years Lived in Canada

Literature examining the physical activity of adolescent immigrants generally does not seem to support the 'Healthy Immigrant Effect' – the idea that newcomers to Canada are healthier than native Canadians upon arrival and that their health declines to a comparable level over time (De Maio, 2010). Conversely, young newcomers to Canada have been found to be less physically active than their Canadian-born counterparts, with this discrepancy narrowing as time since immigration increases (Kukaswadia et al., 2014).

This trend has also been observed in the United States context. Ross, Larson, Graham, and Neumark-Sztainer (2014) compared moderate-to-vigorous physical activity among 2,039 United States-born and foreign-born adolescents. Levels of self-reported moderate-to-vigorous physical activity were significantly lower among foreign-born adolescents at the time of initial data collection, as well as after ten years of follow up. More recently, a secondary analysis of data from Wave 1 of the NEXT Generation Health Study (n=2,475) found that adolescents in the United States with immigrant parents were less likely to engage in vigorous physical activity than adolescents with parents born in the United States (W. Williams, Li, Haynie, & Simons-Morton, 2018).

Immigration status has also been associated with gambling prevalence and severity, with inconsistent results. In an Italian study, Canale and colleagues (2017) found that students who were born outside of Italy (those considered to be first-generation immigrants) had higher odds of being at-risk/problem gamblers than Italian-born students. In the United States, Wilson, Salas-Wright, Vaughn, and Maynard (2015) reported opposite findings: the prevalence of both gambling and problem gambling was lower among first-generation immigrants than among respondents who were born in the United States. However, as Canale et al. (2017) sampled adolescents and Wilson et al. (2015) sampled adults, these findings may not be directly comparable. Inconsistent findings regarding the association between immigration status and gambling across studies conducted in different countries may be attributable to different patterns of immigration in these countries.

2.4.4 Socioeconomic Status

Physical activity and socioeconomic status are generally positively correlated among adolescents, with adolescents from higher socioeconomic backgrounds engaging in more physical activity than their counterparts from lower socioeconomic backgrounds (Armstrong et al., 2018; Hanson & Chen, 2007; Lämmle, Worth, & Bös, 2012; Liu et al., 2008; Park & Kim, 2008; Sagatun et al., 2008). Borraccino and colleagues (2009) observed this association in a multi-national study of adolescents from 32 countries. Limited disposable income in a family may prevent adolescents from participating in organized physical activities due to high enrollment and equipment fees (CIBC-KidSportTM Report, 2014).

Socioeconomic status and gambling have also been linked among adolescents. Adolescents with greater access to money have been found to be more involved in gambling (Wallisch, 1993). However, higher socioeconomic status has been identified as a protective factor against problem gambling (here defined as gambling resulting in adverse consequences for individuals, families, and communities) among adolescents (Dowling et al., 2017). In a nationally-representative random-digit-dialing telephone survey (n=2,241) of young adults in the United States aged 14-21, Welte and colleagues (2008) found that youth from higher socioeconomic backgrounds were less likely to have gambling problems than youth from lower socioeconomic backgrounds, despite being more likely to have gambled in the past year. This is consistent with data from the 2013-2014 Health Behaviour in School-aged Children Survey revealing that students with lower socioeconomic status were more likely to be at-risk/problem gamblers than students from more affluent families (Canale et al., 2017).

2.4.5 Body Mass Index Category

In a longitudinal study of patterns and determinants of objectively measured moderate-to-vigorous physical activity among adolescents, an increase in Body Mass Index was associated with a decrease in moderate-to-vigorous physical activity (Li et al., 2016).

Furthermore, in a cross-sectional survey of 137,593 youth from 34 countries, physical activity levels were consistently lower among overweight than among normal weight youth (Janssen et al., 2005).

Associations between greater Body Mass Index category and greater participation in gambling activities have been observed in adults (Lam & Mok, 2017). Body Mass Index category as a predictor of gambling behaviour has not widely been studied among adolescents. However, overweight Body Mass Index category has been associated with riskier decision making among adolescents, as measured by the Iowa Gambling task (Lensing & Elsner, 2017).

2.4.6 Screen Time

Inverse associations between screen time and physical activity have been reported in previous literature (Eisenmann, Bartee, & Wang, 2002; Gainforth et al., 2013; Graham et al., 2014; Sisson, Broyles, Baker, & Katzmarzyk, 2010). This is in line with the displacement hypothesis described previously.

The present recreational screen time recommendation for Canadian adolescents is two hours or less per day (Tremblay et al., 2016). However, many adolescents exceed this recommendation. An international study of 11,434 children and adolescents between the ages of four and 17 years of age conducted by Atkin et al. (2014) found that two thirds of participants accumulated more than two hours of screen time per day. This finding was subsequently supported by data from the 2015 Canadian Community Health Survey, suggesting that nearly 70% of young Canadians between the ages of 12 and 17 exceed two hours of screen time per day (Statistics Canada, 2015b). In Ontario, the percentage of students who reported more than three hours per day of sedentary screen time – one full hour beyond the recommendation – increased from 57% in 2009 to 64% in 2017 (Boak, Hamilton, Adlaf, Henderson, & Mann, 2018). Given that online gambling primarily involves time on a computer, we expect a positive association between online gambling and screen time. Thus, screen time is considered an important variable that may affect the association between gambling status and physical activity.

2.4.7 Homework Time

Homework is a common sedentary behaviour during adolescence (Marshall, Biddle, Sallis, Mckenzie, & Conway, 2002; Pearson, Haycraft, Johnston, & Atkin, 2017). Adolescents have cited homework time, including studying and completing assignments outside of school hours, as a barrier to physical activity because it reduces time available for physical activity (Allison, Dwyer, & Makin, 1999; Dwyer et al., 2006; Leatherdale & Wong, 2008; Tremblay, LeBlanc, Janssen, et al., 2011).

2.4.8 Season

Physical activity patterns of adolescents have been shown to vary throughout the year. Studies examining seasonal differences in physical activity of young people (conducted in both hemispheres) have generally found that adolescents tend to be less physically active during the winter compared to other times of the year (Badland, Christian, Giles-Corti, & Knuiman, 2011; Carson & Spence, 2010; Merchant, Dehghan, & Akhtar-Danesh, 2007; Tucker & Gilliland, 2007; Wagner, Keusch, Yan, & Clarke, 2019).

2.5 Theoretical Model: Gambling and Physical Activity

The hypothesis that sedentary behaviours displace physical activity and vice versa provides a theoretical framework for how gambling might be associated with physical activity among adolescents. Our review of the literature identified other factors ("covariates") that may influence physical activity, including age, race/ethnicity, years lived in Canada, socioeconomic status, Body Mass Index category, screen time, homework time, and season. Several of these covariates – age, race/ethnicity, years lived in Canada, socioeconomic status, and Body Mass Index category – have also been found to be associated with gambling, and may therefore confound the association between gambling and physical activity. As described in Section 2.3, the magnitude of association between gambling and physical activity may differ for males and females. The model to be tested in the present study is shown in Figure 3.

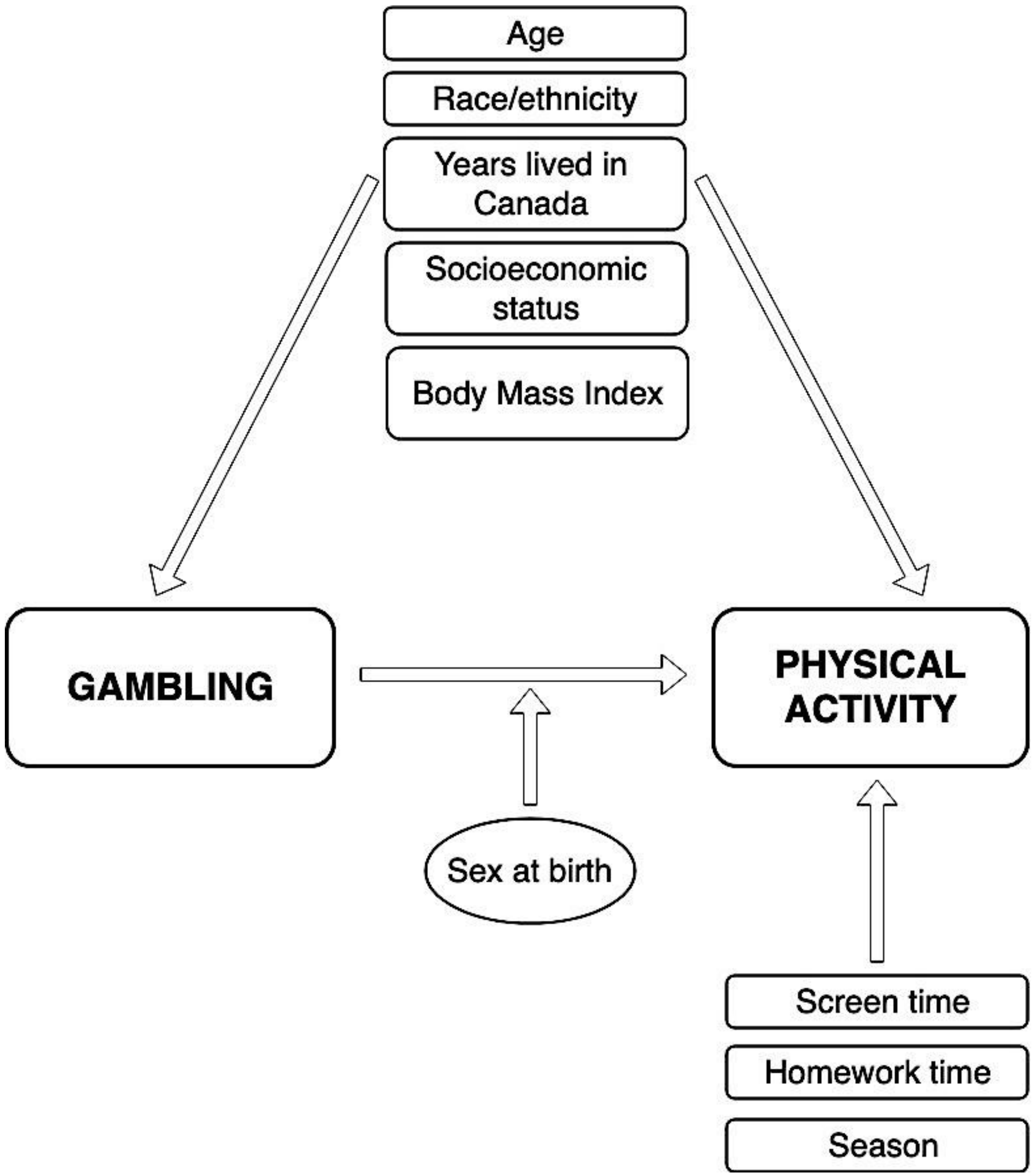

Figure 3. Model to be tested[5]

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[5] Sex at birth, rather than gender, is included in the model because we were not able to use gender in the present study due to sparse gender categories, as described in the study limitations in Chapter 5.

2.6 Study Significance

Given that regular and adequate physical activity is essential for optimal health, it is important to identify factors that may be contributing to low levels of physical activity among adolescents (Tremblay et al., 2016; World Health Organization, 2018a). While gambling has been acknowledged as a sedentary behaviour that may have health implications for young people (Petry & Weinstock, 2007), the sedentary nature of gambling and its potential impact on physical activity has not been a major focus of prior research. Furthermore, while differences between online and land-based gamblers have been previously investigated (Edgren, Castrén, Alho, & Salonen, 2017; Elton-Marshall et al., 2016; Estévez et al., 2017; Wijesingha et al., 2017), studies assessing whether online gamblers are less likely than land-based gamblers to be physically active are limited and pertain only to adults (Papineau et al., 2018). Given structural similarities between online gambling and other frequently studied screen-time sedentary behaviours that are prevalent among youth (e.g., social-networking sites, computer or video games) (Sampasa-Kanyinga & Lewis, 2015), investigation of differential associations between gambling modalities and physical activity among adolescents is warranted.

In an attempt to address these knowledge gaps, the present study will examine whether gambling is another type of sedentary behaviour that may contribute to low levels of physical activity among adolescents (displacement hypothesis). Gambling will also be examined by modality (land-based gambling versus online gambling). The findings are expected to further elucidate the role of gambling in the lives of adolescents (in the context of physical activity) and may inform public health interventions aimed at increasing physical activity among this population. Increasing physical activity of adolescents is important, given that lifelong patterns of sedentary behaviour and physical activity are often established during adolescence (Biddle, Pearson, Ross, & Braithwaite, 2010; Malina, 1996; Telama et al., 1997).

Finally, our study will contribute to what is currently known about the association between sedentary behaviours and physical activity. As previously mentioned, evidence for both the ActivityStat and displacement hypotheses remains inconclusive, and neither have been examined in the context of gambling.

Chapter 3

3 Methods

This chapter has three main sections. First, a brief overview of the methods used by the 2017 Ontario Student Drug Use and Health Survey (OSDUHS) is provided. Full methodology is described elsewhere (Boak et al., 2018). Following the introduction to the 2017 OSDUHS is a description of key variables of interest for the present study. The chapter will conclude with details regarding the analyses conducted in order to address the objectives outlined in Chapter 1.

3.1 Ontario Student Drug Use and Health Survey

The present study is a secondary analysis of data from the 2017 Ontario Student Drug Use and Health Survey (OSDUHS), a cross-sectional survey of Grade 7 to 12 students enrolled in publicly funded Ontario schools. The OSDUHS is an initiative of the Centre for Addiction and Mental Health (CAMH) and is partially funded by the Ontario Ministry of Health and Long-Term Care. The survey is administered every two years by York University's Institute for Social Research (ISR).

Since 1977, the primary purpose of the OSDUHS has been to monitor epidemiological trends in the mental and physical health, substance use, and risk behaviours of Ontario adolescents over time. Over the past 42 years, OSDUHS findings have had implications for public health monitoring, education, prevention, and public policy. The 2017 OSDUHS was the 21st cycle of the survey.

3.1.1 Target Population

The OSDUHS targets students enrolled in four publicly funded school sectors: English language public, English language Catholic, French language public, and French language Catholic schools.[6] This target population of students captures 91% of all adolescents aged 12-18 years in Ontario (Statistics Canada, 2015a).

3.1.2 Sampling

A disproportionately stratified (region by school level), 2-stage (school, class) cluster sampling design was used. Ontario was divided into ten mutually-exclusive regions: (1) Greater Toronto Area, (2) Northern Ontario, (3) Western Ontario, (4) Eastern Ontario, (5) Durham Region, (6) York Region, (7) Peel Region, (8) City of Ottawa, (9) Leeds-Grenville-Lanark District, and (10) Haliburton-Kawartha-Pine-Ridge District.[7]

Each region contained two school levels: (1) elementary/middle schools (Grade 7 and Grade 8) and (2) secondary schools (Grades 9-12).

3.1.2.1 Stage 1: School Selection

Schools were drawn from the Ontario Ministry of Education 2013/2014 school enrolment database (most recently available at the time of survey design). Within each region-by-school level stratum, a probability proportionate-to-size selection of schools was drawn via systematic selection. Individual schools were then selected via systematic sampling (every *n*th school after a random start) without replacement. In total, 285 schools were selected. In the event of a school declining to participate or closing prior to the survey being administered, a replacement school was randomly selected from the same region-by-school level stratum.

3.1.2.2 Stage 2: Class Selection

One class per target grade was randomly selected within each recruited school. Classes were subsampled without replacement and with equal probability from a grade-stratified

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[6] Each county in Ontario usually has English and French public schools and English and French Catholic schools.

[7] Although regions (5)-(10) are geographically within regions (1)-(4), they were treated as independent regions by the 2017 OSDUHS.

list of classes provided by the school. Classes unable to participate were replaced by other randomly selected classes in the same grade at the same school.

3.1.2.3 Oversampling

Schools were oversampled in Northern Ontario (due to its sparse population), as well as in Durham Region, York Region, Peel Region, City of Ottawa, Leeds-Grenville-Lanark District, and Haliburton-Kawartha-Pine-Ridge District. Oversampling in these six regions was sponsored by the corresponding regional public health units who wished to increase the precision of their regional estimates.

In oversampled public health regions, two classes per grade (instead of one) were sampled in each elementary/middle school, effectively doubling the number of Grade 7 and Grade 8 students. In oversampled public health regions with sparse secondary student populations, an additional class per grade was also sampled in each secondary school (two Grade 9 classes, two Grade 10 classes, etc.).

3.1.3 Exclusion Criteria

Altogether, excluded groups (as outlined below) represented 9% of the Ontario student population.

3.1.3.1 School Exclusions

Private schools, schools in First Nations communities, schools on military bases, and schools in remote regions were excluded. Middle/elementary schools with fewer than 30 students in grades 7 and 8 combined and secondary schools with fewer than 80 students in grades 9-12 combined were also excluded, as were secondary schools without all four grades (9-12).

3.1.3.2 Class Exclusions

Special education and English as a Second Language classes were excluded. Classes with fewer than four students were also excluded.

3.1.3.3 Student Exclusions

Students who were institutionalized in a hospital or correctional facility, students who were home-schooled, and students who did not have a working knowledge of either English or French were excluded.

3.1.4 Recruitment and Data Collection Procedures

The OSDUHS is a self-administered, in-school survey in a two-column, pencil-and-paper booklet format. The 2017 iteration of the survey was administered by ISR staff during regular class periods between November 2016 and June 2017. Prior to data collection, permission to survey students was requested from the Director of Education of each school board and was contingent on the decision of a research review committee (if applicable).[8] Following school board approval, principals of sampled schools were invited to participate. Recruited principals provided ISR with a grade-stratified list of schools from which to subsample classes. All students in subsampled classes (whose teachers had agreed to participate) were eligible to complete the survey.

3.1.4.1 Consent

The OSDUHS employs active, "opt-in" consent procedures. Active, written consent from all participating students and their parents or guardians was required. Students were provided with consent forms well in advance of the survey administration date. Consent forms were available in English, French, Spanish, Portuguese, Russian, and Mandarin. Parental consent was not required if the student was eighteen or over.

3.1.5 OSDUHS Administration

To reduce operational costs, a single administration date was selected by each school and all selected classes within a given school completed the OSDUHS on this day. No "make up" dates were scheduled. Absences and late permission forms were not accommodated.

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[8] School selection took place prior to school board recruitment.

Participation in the OSDUHS was anonymous and voluntary. ISR field staff instructed students to not to place their names anywhere on the questionnaire. The average survey completion time was 33 minutes.

Teachers were given the option to remain in the classroom or leave for the duration of the survey. Teachers who chose to remain were asked to refrain from circulating the room in order to maintain student privacy.

3.1.6 Compensation

Schools and students were not compensated for their participation. However, if permitted by the school board, teachers of participating classes received a $15 gift card to a chain restaurant as a token of appreciation for their assistance.

3.1.7 Ethics Approval

The OSDUHS protocol was approved by research ethics boards at CAMH, York University, and by research review boards within each participating school board (if applicable).

3.1.8 The 2017 OSDUHS Questionnaire

The OSDUHS covers a variety of topics, including mental and physical health, substance use, and risk behaviours. Many items in the survey were derived from valid measures that have previously been used in other student surveys.[9]

The OSDUHS does not use item branching, opting instead for inclusive response options.[10] This strategy reduced navigational errors and also protected students' privacy. Students reporting numerous sensitive behaviours would take longer to answer additional

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[9] Use of existing survey items has two advantages: 1) validity and reliability has already been established and 2) enhanced comparability.

[10] For example, response categories of "Never used", "Did not currently use", or "Did not know what a drug was" allowed non-users of a drug to respond to all questions.

questions if skip patterns had been used. Inclusive response options ensured comparable completion time, reducing the risk of disclosure.

Four distinct versions of the questionnaire were administered to minimize student burden, while also maximizing coverage of topics: Elementary/middle school - Form A (130 items), Elementary/middle school - Form B (115 items), Secondary School - Form A (179 items), Secondary School - Form B (152 items). Roughly 50% of survey items were considered “core” items and were included across all four versions. Elementary/middle school questionnaires contained fewer questions and excluded selected topics.

The questionnaire was available in both English and French. French-language schools (both levels) completed a French translation of Form A.[11] In English-language classrooms, Form A and Form B were distributed alternately to students, resulting in two roughly balanced samples.[12]

The 2017 OSDUHS questionnaire was suitable for a Grade 7 reading level.

3.1.8.1 2017 OSDUHS Response Rate

The response rate of selected schools and selected classes within schools was 61% and 94%, respectively. Invitations were extended to 353 schools (285 initial selections and 68 replacements). In total, 214 schools accepted (174 initial selections and 40 replacements). A sensitivity analysis (conducted by CAMH) identified no substantial differences in drug use measures between initially selected schools and replacement schools. Schools who declined to participate commonly cited a lack of time or prior commitment to other research projects.

Within participating schools, 764 classes participated in the survey, resulting in 18,773 eligible students. Of the 18,773 eligible students, 7,177 were precluded from participating

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[11] Form B was not translated.

[12] An assessment of this alternating distribution showed few differences between the Form A and Form B samples regarding demographics and drug use variables.

either due to a lack of consent (unsigned permission forms) or absence on the day of the survey administration. The remaining 11,596 students completed the survey (~62% response rate). This is not unusual for a school-based survey requiring active consent (Burkhalter, Cumming, Rynard, Schonlau, & Manske, 2018).

One-hundred sixty-one "low quality" cases were subsequently removed from the final dataset. A case was considered low quality if any of the following criteria were met: 1) missing value for sex; 2) reported use of a fictitious drug (this was used as a data quality check to identify individuals providing bogus responses); 3) reported use of a core illicit drug more than 40 times in the past year; 4) completion of only the demographic questions; and 5) completion of questionnaire with teacher assistance. The final sample of the 2017 OSDUHS —11,435 students from 214 schools in 52 school boards — is considered representative of the approximately 917,800 Grade 7-12 students enrolled in publicly funded Ontario schools.

3.2 The Present Study

The present study examined associations between gambling and physical activity among Ontario adolescents using generalized ordinal logistic regression. Ethics approval was not required because we conducted a secondary analysis of completely anonymous data, and no identifiable information was generated.[13]

3.2.1 Final Sample Size

As shown in Figure 4, questions about past-year gambling behaviour were only included in Form A of the questionnaire (both elementary/middle school and secondary school versions). Of the remaining 6,364 individuals who completed Form A, 655 were subsequently removed due to missing data for one or more variables of interest. The final analytic sample contained 5,709 individuals.

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[13] As per the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (2014), article 2.2 and 2.4.

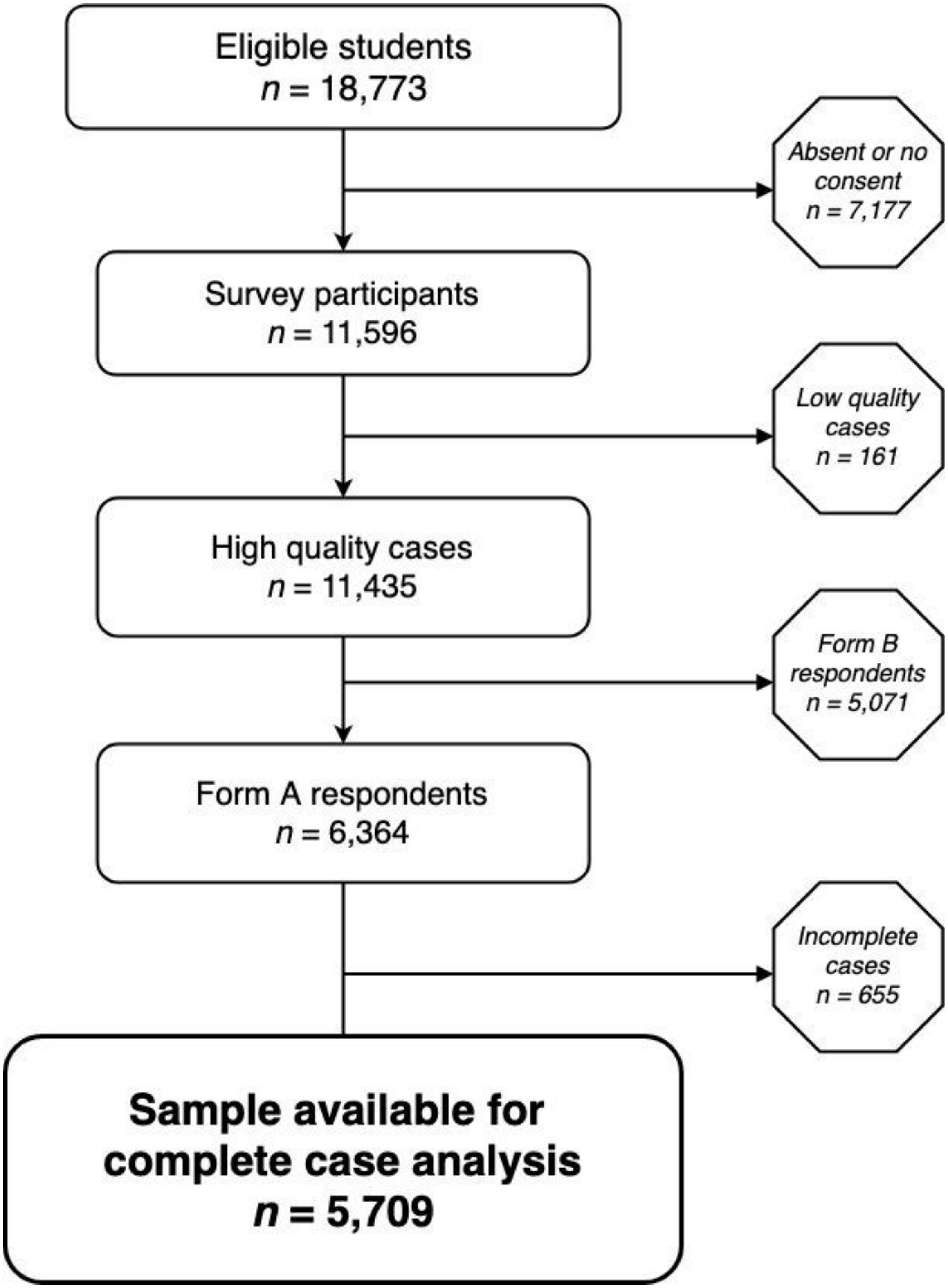

Figure 4. Derivation of final analytic sample for the present study (*n*=5,709)

3.2.2 Measurement of Study Variables

The following section describes the 2017 OSDUHS measures that were used in the present study. Any changes (i.e., collapsing of categories) are indicated. The unabridged measures can be found in Appendix A.

3.2.2.1 Physical Activity Level

Participants were asked to indicate the number of days in the past seven days they were physically active for a total of AT LEAST 60 MINUTES each day. Response options included a minimum of 0 days to a maximum of 7 days (8 response options total). This commonly used (Kukaswadia et al., 2014; Prochaska, Sallis, & Long, 2001; Tremblay, Warburton, et al., 2011; Trinh, Wong, & Faulkner, 2015), single-item measure facilitates assessment of compliance with current physical activity guidelines for adolescents and has been validated against accelerometer data (Scott, Morgan, Plotnikoff, & Lubans, 2015).

A 3-level ordinal variable was created based on previous studies examining physical activity as an ordinal outcome among young people (Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Feldman et al., 2003; Massougbodji, Lebel, & De Wals, 2018). Participants who did not meet the 60-minute physical activity threshold on any of the past 7 days were categorized as “INACTIVE” (coded as 0), while their peers who had participated in one to six days of physical activity within the past seven days were grouped and collectively categorized as “ACTIVE BELOW GUIDELINES” (coded as 1). Individuals who had engaged in at least 60 minutes of MVPA on each of the past 7 days were categorized as “ACTIVE AT OR ABOVE GUIDELINES” (coded as 2). These cut-points were consistent with those chosen by Coe et al. (2006).

3.2.2.2 Gambling Status

In order to determine past-year gambling status, each participant was asked the question “How often (if ever) in the LAST 12 MONTHS, have you done each of the following?” A list of gambling activities was then presented, including: a) betting money on CARD games, b) betting money on DICE games, c) betting money on other GAMES OF SKILL (such as pool, darts, chess, bowling), d) playing BINGO for money, e) betting money in SPORTS POOLs or FANTASY SPORTS, f) buying SPORTS LOTTERY tickets (such as Sports Select or Proline), g) buying any OTHER LOTTERY TICKETS at a store, including instant lottery (such as 6-49, Poker Lotto, scratch cards), h) betting money on VIDEO GAMBLING MACHINES, SLOT machines, or any other gambling machines, i) betting money at a CASINO in Ontario, j) betting money on results of a VIDEO GAME, k) betting money on a DARE or PRIVATE BET, l) betting money on POKER ONLINE, m) betting money on BINGO ONLINE, n) betting money on SPORTS BETTING ONLINE, o) betting money on OTHER ONLINE games, p) buying LOTTERY TICKETS ONLINE, and q) betting money in OTHER ways not listed above.[14] Beside each activity, the participants indicated the number of times they had participated in the activity within the past year on a designated line ("_____ times").[15] Participants were instructed to write "0" if they had not done an activity within the past year. A binary variable was created for each activity. Responses of zero were coded as 0, indicating that the student had not done the activity in the last 12 months. Missing items (participant did not provide a response) were coded as 0. All responses greater than 0 were coded as 1, indicating any past-year participation in the given gambling activity. A binary global gambling status variable was then derived from the individual binary gambling activity indicators. "GAMBLERS" were students who reported any participation in at least one gambling activity in the past twelve months (indicated by a response of 1). All other response combinations were coded as 0 ("NON-GAMBLERS"). This coding is in line with previous work employing a similar gambling measure (Elton-Marshall et al., 2016).

3.2.2.3 Gambling Modality

Gambling was also examined by gambling modality in the present study. Participants were categorized into three mutually-exclusive categories: "NON-GAMBLERS" (coded

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[14] We acknowledge that buying any type of lottery ticket at a store or online (activities F, G, and P), as well as betting money on a dare or private bet (activity K), may not be sedentary activities. About 23% of gamblers engaged *exclusively* in these types of activities. See Appendix E.

[15] Gambling frequency (total number of times gambled) is presented in Appendix D.

as 0), “LAND-BASED ONLY GAMBLERS” (coded as 1), and “ONLINE GAMBLERS” (coded as 2). “Land-based gambling” was defined as gambling that occurs offline and includes activities a) to k) (inclusive) and q) listed above. For this study, activity q), OTHER WAYS OF BETTING, was assumed to be land-based. “Online gambling” was defined as gambling that occurs online and includes activities l) to p) (inclusive) listed above. Three modality categories were created. The NON-GAMBLER category included those who had not participated in any gambling activity of any type in the past twelve months.[16] The LAND-BASED ONLY category included those who had participated in at least one land-based gambling activity, *but no online gambling activities*, within the past twelve months. Because few adolescents in our sample gambled exclusively online (n=22), the ANY ONLINE category included any student who had participated in at least one online gambling activity within the past twelve months and may include individuals who also participated in land-based gambling activities. This categorization is consistent with previous research examining online gambling among adolescents (Elton-Marshall et al., 2016; Wijesingha et al., 2017).

3.2.2.4 Sex

Sex was examined both as a confounder as well as a potential effect measure modifier of the association between gambling and physical activity. Participants were asked: “Were you born male or female?” “Male” was coded as 1 and “Female” was coded as 0.

3.2.2.5 Age

Participants were asked the question: “How old are you?” They indicated their current age (in years) from a pre-specified list of ages in one-year increments ranging from “ten years of age or younger” (coded as 10) to “twenty years or older” (coded as 20).

[16] This category was identical to the NON-GAMBLER group identified during the creation of the gambling status variable.

3.2.2.6 Race/Ethnicity

Participants were asked to self-identify with the question: “Which of the following groups best represents your background?” Options included: White, Chinese, South Asian, Black, Aboriginal, Filipino, Latin American, Central American, South American, Southeast Asian, West Asian or Arab, Korean, and Japanese. Respondents were given the option of selecting more than one racial-ethnic group, as well as an option to declare uncertainty about their background (“Not Sure”). Due to low numbers of students in many racial-ethnic groups (shown in Appendix G), students who selected only White were coded as 1, while all other responses and combination responses were coded as 0. This is consistent with previous literature (Wijesingha et al., 2017).

3.2.2.7 Years Lived in Canada

Consistent with previous research from the Healthy Behaviour of School Aged Children Study (Kukaswadia et al., 2014), years lived in Canada was assessed by the following question: “How long have you lived in Canada?” Response options included “All of my life”, “2 years or less”, “3 to 5 years”, “6 to 10 years”, and “11 years or longer.” Respondents self-identified into one of these five categories. Response options “2 years or less” and “3 to 5 years” were grouped into “5 years or less” (coded as 0). Response options “6 to 10 years” and “11 years or longer” were grouped into “More than 5 years” (coded as 1). Individuals who selected “All of my life” were coded as 2. This 5-year cut-point has been used elsewhere by recent Canadian studies examining the health of young newcomers to Canada (Lane, Farag, White, Nisbet, & Vatanparast, 2018; Vuksan et al., 2012).

3.2.2.8 Socioeconomic Status

In order to measure how students perceived their family socioeconomic standing, the youth version of the MacArthur Scale of Subjective Social Status was used (Goodman et al., 2001). This is a standard measure of youth socioeconomic status that has been validated among youth from a variety of racial-ethnic and socioeconomic backgrounds (Brown et al., 2008; Goodman et al., 2003; Karvonen & Rahkonen, 2011).

Participants were asked to indicate their family's socioeconomic status on a "ladder" of numbered boxes, with 1 at the bottom ("Worst off") and 10 at the top ("Best off") with the question: "Imagine this ladder below shows how Canadian society is set up. At the top of the ladder are the people who are the "best off" – they have the most money, the most education, and the jobs that bring the most respect. At the bottom are the people who are "worst off" – they have the least money, little education, no jobs or jobs that no one wants. Now think about your family. Please check off the numbered box that best shows where you think your family would be on this ladder." In the present analyses, socioeconomic status was treated as a continuous variable.

3.2.2.9 Body Mass Index Category

Participants were asked to indicate their height without shoes in centimeters ("What is your current height without shoes?") and their weight without shoes in kilograms ("What is your current weight without shoes?") from a list of response options. Options for height were provided in 2 and 3 cm increments (from "4 feet 4 inches/132 cm or less" to "6 feet 6 inches/198 cm or more"), and also reported in the corresponding number of feet and inches. Options for weight were reported in 2-kg intervals and also reported in pounds (from "80 pounds/ 36 kg or less" to "281 pounds/127 kg or more"). The Body Mass Index (BMI) of each participant was calculated by dividing their weight in kilograms by their height in meters squared. For weight, the midpoint of each category was selected. Based on data from Freedman et al. (2015), biologically implausible Body Mass Index values for each year of adolescence were re-coded as "missing."

For each respondent, Body Mass Index category was determined using age- and sex-specific cut-offs for thinness, overweight, and obesity developed by the International Obesity Task Force (Cole & Lobstein, 2012).

3.2.2.10 Screen Time

Participants were asked to report their daily screen time with the question: "In the LAST 7 DAYS, about how many hours a day, on average, did you spend watching TV/movies/videos, playing video/computer games, texting emailing, or surfing the Internet in your free time?" Response options included "None", "Less than 1 hour a day", “1 to 2 hours a day”, “3 to 4 hours a day”, “5 to 6 hours a day”, 7 or more hours a day” and “Not sure.” The lower three categories were combined into “2 hours a day or less” and the higher three categories were combined into “More than 2 hours a day.” “Not sure” remained its own category to reduce missing data. This categorization corresponds to the current Canadian guidelines for screen time for children and adolescents (Tremblay et al., 2016).

3.2.2.11 Homework Time

Weekly homework time was assessed with the question: “On average, how much time do you spend doing homework each week outside of school?” Response options included “No homework at all”, “Less than 1 hour per week”, “About 1 to 2 hours per week”, “About 3 to 4 hours per week”, “About 5 to 6 hours per week”, and “About 7 or more hours per week.”

3.2.2.12 Season

Season of survey administration was derived from the month during which each participant completed the survey. Students were asked to write the month and day on their surveys. Months were coded sequentially (January=1, February=2, etc.). “Fall” was coded as 1 and included responses collected in November and December 2016. “Winter” was coded as 2 and included January, February, and March 2017. “Spring” was coded as 3 and included April, May and June 2017.

3.2.3 Statistical Analyses

3.2.3.1 Descriptive Analyses

3.2.3.1.1 Sample Characteristics

To understand the characteristics of the sample, frequency distributions for binary and categorical variables (physical activity level, gambling status, gambling modality, sex, race/ethnicity, Body Mass Index category, years lived in Canada, screen time, homework time, geographic region, season) were computed. The mean and standard deviation were calculated for continuous variables (age and socioeconomic status).

3.2.3.1.2 Bivariate Associations

Preliminary insight into associations between variables included in the study was obtained via weighted cross-tabulations. Physical activity level was cross-tabulated with each categorical or binary explanatory variable and covariate. Categorical and binary explanatory variables and covariates were also cross-tabulated with each other. Associations between variables were tested using a second-order design-adjusted Rao-Scott Pearson chi-square test (converted into an F-statistic). This test measures how well the observed distribution of data fits with the distribution that would be expected if the two variables were independent. A significant test statistic indicates that the null hypothesis of independence is rejected.

3.2.3.2 Generalized Ordinal Logistic Regression Analyses

Ordinal variables are so named because they have an inherent order. Given one or more independent variables (explanatory variables, covariates), ordinal logistic regression predicts values of an ordinal dependent variable (outcome). First described by McCullagh (1980), ordinal logistic regression models are essentially a series of collapsed logistic regression models that report the odds of a higher category of the ordinal outcome versus an equivalent or lower category at each possible outcome cut-point (i.e., for a three-level ordinal outcome with levels 1, 2, and 3, there would be two cut-points: 3, 2 versus 1 and 3 versus 2, 1).

3.2.3.2.1 Proportional Odds Assumption

Ordinal logistic regression assumes that for a given explanatory variable, the odds of a higher ordinal outcome versus an equivalent or lower ordinal outcome remain the same, regardless of the outcome cut-point examined. Otherwise stated, this assumes that the coefficient of each explanatory variable and covariate in the model is uniform across all levels of the ordinal outcome variable.

In our study, meeting the proportional odds assumption indicated that the odds of being *active at or above guidelines & active below guidelines* versus *inactive* (cut-point 1) and the odds of being *active at or above guidelines* versus *active below guidelines & inactive* (cut-point 2) were equal. A more intuitive way to think of cut-point 1 and cut-point 2 is to consider them as the odds of being physically active versus inactive, and the odds of meeting or exceeding physical activity guidelines versus not meeting guidelines, respectively.

When the data are weighted, as was the case in the present study, an Adjusted Wald test is used to test whether the proportional odds assumption is valid (Williams, 2019). We found that our data violated the proportional odds assumption, precluding the use of standard ordinal logistic regression.[17]

Multinomial regression is often used when the proportional odds assumption is violated. However, this analytic technique produces a convoluted output and ignores the intrinsic ordering of the outcome variable. In contrast, generalized ordinal logistic regression retains the natural ordering of the outcome, and is less restrictive than standard ordinal logistic regression. First presented by Fu and subsequently updated by Williams, generalized ordinal logistic regression can estimate *partial proportional odds models* in which the proportional odds assumption is violated by some variables, while satisfied by others (Fu, 1999; Williams, 2006).

Due to our interest in predicting the odds of achieving specific levels of past-week physical activity (i.e., ordering was important), generalized ordinal regression was selected as the analytic strategy for the present study.

3.2.3.2.2 Testing the Association between Gambling and Physical Activity

The adjusted associations between (1) gambling status and physical activity, and (2) gambling modality and physical activity were examined using two separate multivariable generalized ordinal logistic regression models, addressing Objective 1 and Objective 2,

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[17] If even one variable in a multivariable model does not meet the proportional odds assumption, then the entire model violates the proportional odds assumption.

respectively. Generalized ordinal logistic regression models were computed using *gologit2*, a user-written Stata command (R. Williams, 2006).

To test the hypothesis that online gamblers are less physically active than non-gamblers and land-based gamblers (Objective 2, pertaining to gambling modality and physical activity), the model examining gambling modality was computed twice, once with non-gamblers as the reference category and once with land-based only gamblers as the reference category. Sex was examined as a potential effect measure modifier (on the multiplicative scale) of the association between both explanatory gambling variables and physical activity in two subsequent interaction models, jointly addressing Objective 3. Multiplicative interaction (or effect measure modification[18] on the multiplicative scale) is considered to be present when the ratio of odds of an outcome "Y" between subjects exposed and those not exposed to a risk factor "A" differs (is heterogeneous) as a function of a third variable "Z" (Szklo & Nieto, 2014, p. 189).

All multivariable models included sex, age, race/ethnicity, years lived in Canada, socioeconomic status, and Body Mass Index as covariates to control for confounding. These covariates were selected *a priori*, based on our review of empirical evidence (as described in Chapter 2). Screen time, homework time, and season were also included in the model based on literature identifying these variables as possible predictors of physical activity. The overall significance of each variable, adjusted for all other variables in the given multivariable model, was tested using an Adjusted Wald test.

3.2.3.3 Data Considerations

3.2.3.3.1 Survey Weights

Each student who completed the 2017 OSDUHS was assigned a survey weight corresponding to the number of individuals in the total population of Ontario Grade 7 to

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[18] Since the present study is an observational study, we acknowledge that "association modification" may be more appropriate terminology (Szklo & Nieto, 2014, p. 188).

12 students that he or she represented (Long & Freese, 2014). Every student in the sample represented about 80 students in Ontario with similar characteristics.

The final survey weight for each student was based on five components: (1) the probability of their school being selected, (2) the probability of their class being selected within their school, (3) an adjustment factor for student unit nonresponse, (4) a post-stratification adjustment factor to restore regional representation, and (5) a post-stratification factor adjustment to restore the sex-by-grade distribution based on student enrolment in 2014/2015 (most recently available numbers at the time).

Weighting allowed for the sample estimates obtained in our study to approximate the true characteristics of the student population of Ontario. All analyses included the "GSVY"[19] prefix which uses a robust variance estimator to obtain estimates with standard errors adjusted for stratification, clustering, and weights.

3.2.3.3.2 Missing Data

Missing data patterns were assessed prior to conducting statistical analyses. Percentage of missing data was low for most variables as seen in Table 1. About 89.7% (5,709) of the students who completed Form A of the OSDUHS had complete data for all variables included in this study (physical activity level, gambling status, gambling modality, sex at birth, age, race/ethnicity, years lived in Canada, socioeconomic status, Body Mass Index category, screen time, homework time, and season) and were retained in the analyses.

[19] Identical to the "SVY" prefix in Stata, but with support for generalized ordinal logistic regression (R. Williams, 2006).

Table 1. Per-variable missingness for all study variables using data from the 2017 Ontario Student Drug Use and Health Survey (*n*=764)

	No. of missing observations	% missing
Outcome		
Physical activity level	71	1.12
Explanatory variables		
Gambling status	0	0.00
Gambling modality	0	0.00
Potential effect measure modifier		
Sex at birth	0	0.00
Covariates		
Age	1	0.02
Race/ethnicity	51	0.80
Years lived in Canada	6	0.09
Socioeconomic status	155	2.44
Body Mass Index category	420	6.60
Screen time	39	0.61
Homework time	21	0.33
Season	0	0.00

Total number of cases=6,364
Total number of missing observations=764
Total number of complete cases=5,709

The two variables in our study with the highest percentage of missingness were Body Mass Index category (6.6%) and socioeconomic status (2.4%). For these variables, missing values themselves tend to predict missingness; low and high values of socioeconomic status are more likely to be missing, as is information about overweight and obesity (Aceves-Martins et al., 2018; Plenty & Mood, 2016; J. Wardle, Robb, & Johnson, 2002). This pattern of missingness is referred to as missing-not-at-random (MNAR). Because multiple imputation of data that is MNAR can result in asymptotically biased estimates, as evidenced by Papageorgiou, Grant, Takkenberg, & Mokhles (2018), the listwise deletion of incomplete cases (leading to a complete case analysis) was deemed acceptable for the present study.

Listwise deletion is less computationally complex than multiple imputation using complex survey data, and also reduces measurement error that may occur in mis-specified imputation models (Cheema, 2014). A complete case analysis facilitated by listwise deletion ensures that all responses are obtained from a common dataset, somewhat simplifying the discussion and interpretation of results (Enders, 2010). The limitations of listwise deletion, including reduced power and potentially biased estimates, are acknowledged. However, we do not expect this to have biased our findings considerably as overall and per-variable missingness was low.

3.2.3.3.3 Multicollinearity

The presence of collinearity was assessed by examining variance inflation factors (VIF) for each variable of interest. A cut-off of 5.0 was used (Rogerson, 2001). As presented in Appendix B, VIFs ranged from 1.02 to 1.17, indicating an acceptable level of collinearity in the present study.

Chapter 4

4 Results

This chapter begins with a presentation of frequency distributions of study variables and bivariate associations between study variables. Following these descriptive results, the results of bivariate and multivariable generalized ordinal logistic regression models predicting greater levels of physical activity are shown, grouped by study objective. Results presented in this chapter are weighted and pertain to a complete case analysis, in which only cases with complete data for all study variables was used (n=5,709).

The minimum significance level α was set at 0.05, so all confidence intervals reported in this chapter are 95% confidence intervals. All analyses were survey weighted and performed using Stata/IC 15.1 software (StataCorp, 2017).

4.1 Sample Characteristics

Characteristics of participating students pertaining to all study variables are presented in Table 2. The final analytic sample contained 5,709 individuals. About one fifth of the sample met physical activity guidelines. About 70% were active below the guidelines, and 9% were inactive. About 35% of students were past-year gamblers. Of the past-year gamblers, 32% were land-based only gamblers and just over 3% had gambled online. About half the sample was male (51%). The mean age of participating students was 15.2 years old (standard deviation$n$=1.8 years). Approximately 55% of the sample was White and 79% had lived in Canada their entire life. The mean family status in society was 6.9 on a 10-point scale (standard deviation$n$=1.7 points). Approximately 64% of the sample was classified as normal weight for their sex, age, and height. About 61% of the sample accumulated more than two hours of daily screen time. Time spent doing homework was roughly normally distributed, with approximately half of the students completing 1 to 4 hours per week. Finally, approximately one quarter of the sample completed the survey in the Fall, another quarter completed the survey in the Winter, and the remaining half completed the survey in the Spring.

Table 2. Characteristics of study participants, 2017 Ontario Student Drug Use and Health Survey (*n*=5,709) *

	n	**Weighted % or mean (*SD*)**	**Unweighted % or mean (*SD*)**
Outcome			
Physical activity level			
Inactive	488	9.8	8.6
Active below guidelines	4,021	68.8	70.4
Active at or above guidelines	1,200	21.4	21.0
Explanatory variables			
Gambling status			
Non-gambler	3,751	65.1	65.7
Gambler	1,958	34.9	34.3
Gambling modality			
Non-gambler	3,751	65.1	65.7
Land-based only	1,764	31.6	30.9
Any online	194	3.3	3.4
Potential effect measure modifier			
Sex at birth			
Female	3,277	48.8	57.4
Male	2,432	51.2	42.6
Covariates			
Age	5,709	15.2 (1.8)	14.7 (1.7)
Race/ethnicity			
Other	2,374	45.4	41.6
White	3,335	54.6	58.4
Years lived in Canada			
All of my life	4,772	78.8	83.6
> 5 years	656	15.5	11.5
≤ 5 years	281	5.7	4.9
Socioeconomic status	5,709	6.9 (1.7)	7.0 (1.6)
Body Mass Index category			
Underweight	562	8.6	9.8
Normal weight	3,777	63.9	66.2
Overweight	931	17.6	16.3
Obese	439	9.9	7.7
Screen time			
≤ 2 hours per day	1,985	33.7	34.8
> 2 hours per day	3,455	61.2	60.5
Not sure	269	5.1	4.7
Homework time			
No homework at all	334	6.8	5.9
< 1 hour per week	908	14.4	15.9
About 1 to 2 hours per week	1,598	27.3	28.0

	n	**Weighted % or mean (*SD*)**	**Unweighted % or mean (*SD*)**
About 3 to 4 hours per week	1,326	22.7	23.2
About 5 to 6 hours per week	787	14.8	13.8
≥ 7 hours per week	756	14.0	13.2
Season			
Fall	2,137	23.7	37.4
Winter	1,518	24.6	26.6
Spring	2,054	51.7	36.0

*Based on a complete case analysis

4.2 Bivariate Associations

4.2.1 Associations between Physical Activity and Each Explanatory Variable/Covariate

We examined associations between past-week physical activity and each explanatory variable and covariate separately (presented in Table 3). Significance was tested using a Pearson design-based F-test. No association was observed between gambling status and physical activity (p=0.106) or gambling modality and physical activity (p=0.350).

Sex at birth, race/ethnicity, years lived in Canada, Body Mass Index category, screen time, and homework time were significantly associated with physical activity. More males met or exceeded physical activity guidelines than females (29% of males compared to 14% of females) (p <0.001). Twenty-four percent (24%) of students who identified as White met or exceeded physical activity guidelines compared to 19% of students identifying as a different race (p <0.001). Twenty-two percent (22%) of students who had lived in Canada their entire lives met or exceeded physical activity guidelines, compared to only 14% of students who had lived in Canada for five years or less (p=0.021). Body Mass Index was inversely associated with greater physical activity (p=0.017), with more students who were underweight (24%) and normal weight (24%) meeting or exceeding physical activity guidelines than those who were overweight (15%) or obese (16%). An inverse association was also seen between screen time and physical activity (p <0.001); 29% of students who met screen time guidelines of 2 hours or less per day met physical activity guidelines in the week prior to the survey compared to just 17% of students who exceeded 2 hours of screen time per day. Twenty-four percent (24%) of students who completed no weekly homework at all met physically activity guidelines, compared to 17% of students who completed 7 or more hours of homework per week (p=0.030). No association was observed between season and physical activity (p =0.574).

Table 3. Weighted bivariate associations between physical activity and each of gambling status, gambling modality, sex at birth, race/ethnicity, years lived in Canada, Body Mass Index category, screen time, homework time, and season using data from the 2017 Ontario Student Drug Use and Health Survey (*n*=5,709) *

	Physical activity level[1]			
	Inactive	**Active below guidelines**	**Active at or above guidelines**	**Chi-square test of independence[2]**
Gambling status				***p*=0.106**
Non-gambler	10.7	68.9	20.4	
Gambler	8.0	68.7	23.3	
Gambling modality				***p*=0.350**
Non-gambler	10.7	68.9	20.4	
Land-based only	7.5	69.1	23.4	
Any online	12.8	65.0	22.2	
Sex at birth				***p* <0.001**
Female	13.7	72.4	13.9	
Male	6.0	65.4	28.6	
Race/ethnicity				***p* <0.001**
Other	13.9	67.4	18.7	
White	6.3	70.0	23.7	
Years lived in Canada				***p*=0.021**
All of my life	8.2	69.8	22.0	
> 5 years	13.8	64.8	21.4	
≤ 5 years	19.7	66.0	14.3	
Body Mass Index category				***p*=0.017**
Underweight	6.9	68.7	24.4	
Normal weight	9.0	67.4	23.6	
Overweight	14.6	70.1	15.3	
Obese	8.6	75.5	15.9	
Screen time				***p* <0.001**
≤ 2 hours per day	6.2	64.6	29.2	
> 2 hours per day	12.1	70.7	17.2	
Not sure	4.6	74.2	21.2	
Homework time				***p*=0.030**
No homework at all	9.4	66.2	24.4	
< 1 hour per week	8.3	68.9	22.8	
About 1 to 2 hours per week	6.4	70.9	22.7	
About three to four hours per week	9.0	66.4	24.6	
About 5 to 6 hours per week	10.9	72.9	16.2	

	Physical activity level[1]			
	Inactive	**Active below guidelines**	**Active at or above guidelines**	**Chi-square test of independence**[2]
≥ 7 hours per week	17.9	65.4	16.7	
Season				***p*=0.574**
Fall	10.0	67.2	22.8	
Winter	8.1	70.9	21.0	
Spring	10.5	68.5	21.0	

[1]Weighted row percentages
[2]*p*-values of Pearson design-based F-statistic
* Based on a complete case analysis

4.2.2 Associations between Explanatory Variables and Covariates

Our preliminary data exploration also involved examining bivariate associations among all explanatory variables and covariates. Several significant bivariate associations were found (cross-tabulations are presented in Appendix C). Both land-based and online gamblers were more likely to be male than female (p <0.001). Land-based and online gamblers also accumulated more daily screen time (p <0.001) and less weekly homework time than non-gamblers (p=0.012). More females than males were classified as underweight for their age and height, whereas more males than females were classified as obese for their age and height (p=0.026). Students in higher Body Mass Index (BMI) categories accumulated more daily screen time than students in low BMI categories (p =0.032). Finally, females and students who had lived in Canada for five years or less spent more time each week doing homework than males and students who had lived in Canada for longer than five years, respectively (both p <0.001). No other bivariate association was significant.

4.3 Results from Multivariable Models

4.3.1 Proportional Odds Assumption

Recall from Chapter 3 that ordinal logistic regression assumes that the coefficient of each explanatory variable and covariate in the model is uniform across all levels of the ordinal outcome variable. In order to determine if ordinal logistic regression was appropriate for our data, Wald tests were used to ascertain if the proportional odds assumption was met for every variable in our study.

In the final multivariable generalized ordinal logistic regression models (to be presented in Section 4.3), one covariate in our study (race/ethnicity) violated the proportional odds assumption, so we chose generalized ordinal logistic regression as our analytic method because it relaxes the proportional odds assumption, as previously described in Section 3.2.3.2.1.

The proportional odds assumption was met for all other explanatory variables and covariates in the study; that is, for a given value of the explanatory variable/covariate, the odds of being physically active versus inactive equaled the odds of meeting or exceeding physical activity guidelines versus not meeting the guidelines. Therefore, the odds ratios presented in this chapter will be interpreted as simply the odds of *greater physical activity*.

4.3.2 Unadjusted Associations

Bivariate generalized ordinal logistic regression analyses were conducted to examine the unadjusted association between physical activity and each explanatory gambling variable, as well as the unadjusted associations between physical activity and each covariate. Odds ratios of the unadjusted association between each explanatory variable/covariate and physical activity are presented in Table 4.

Students who gambled did not differ from students who did not gamble regarding their past-week physical activity (p=0.067). Despite a significant group comparison between land-based only gamblers and non-gamblers (OR: 1.26, CI: 1.00[20]-1.58, p=0.048), gambling modality as a whole was also not significantly associated with physical activity (p=0.144).

Males had higher odds of greater physical activity than females (OR: 2.47, CI: 1.97-3.09, p <0.001), while older students had lower odds of greater physical activity than younger students (OR: 0.80, CI: 0.75-0.84, p <0.001). White students had higher odds of meeting physical activity guidelines (OR: 1.35, CI: 1.12-1.63, p <0.001), as well as higher odds of being physically active at all (OR: 2.39, CI: 1.66-3.43, p <0.001), compared with students of another racial-ethnic background. Compared to students who had lived in Canada their entire lives, students who had lived in Canada for five years or less had lower odds of greater physical activity (OR: 0.45, CI: 0.23-0.86, p=0.016). Students who rated themselves as being high on the socioeconomic status "ladder" had higher odds of greater physical activity (OR: 1.15, CI: 1.07-1.25, p <0.001) than students who perceived their socioeconomic status as low. Students with both overweight and obesity had lower odds of greater physical activity compared to their normal weight peers (OR: 0.58, CI: 0.47-0.71, p <0.001 and OR: 0.74, CI: 0.59-0.94, p=0.013, respectively). There was no significant association between underweight status and physical activity (p=0.415). Exceeding 2 hours of screen time per day was associated with lower odds of greater physical activity compared to accumulating 2 hours or less (OR: 0.49, CI: 0.39-0.61, p <0.001). Weekly homework time as a whole was found to be significantly associated with physical activity (p <0.001), but no group comparisons were significant when "No homework at all" was used as the reference category (as shown in Table 4). When the reference category was changed to "7 or more hours per week," students who accumulated "less than 1 hour per week" (OR: 1.88, CI: 1.38-2.55, p <0.001), "about 1 to 2 hours per week" (OR: 1.99, CI: 1.50-2.64, p <0.001), and "about 3 to 4 hours per week" (OR: 1.97, CI: 1.46-2.64, p <0.001) had higher odds of greater physical activity. Season was not associated with physical activity (p=0.713).

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[20] Inclusion of extra decimal places reveals that this lower bound is marginally greater than 1 (1.001538).

Table 4. Results from bivariate generalized ordinal logistic regression models measuring the unadjusted association between physical activity and each explanatory variable and covariate using data from the 2017 Ontario Student Drug Use and Health Survey (*n*=5,709) *

	Odds ratio predicting greater physical activity	**95% CI**	**Overall significance of variable**[1]
Gambling status			***p*=0.067**
Non-gambler	*Reference*		
Gambler	1.23	0.99, 1.54	
Gambling modality			***p*=0.144**
Non-gambler	*Reference*		
Land-based only	1.26*	1.00, 1.58	
Any online	1.00	0.39, 2.53	
Sex at birth			***p* <0.001**
Female	*Reference*		
Male	2.47***	1.97, 3.09	
Age	0.80***	0.75, 0.84	***p* <0.001**
Race/ethnicity✣			***p* <0.001**
Other	*Reference*		
White	2.39***†	1.66, 3.43	
	1.35**††	1.12, 1.63	
Years lived in Canada✣			***p* <0.001**
All of my life	*Reference*		
> 5 years	0.57†	0.32, 1.02	
	0.95††	0.71, 1.27	
≤ 5 years	0.45*	0.23, 0.86	
Socioeconomic status	1.15***	1.07, 1.25	***p* <0.001**
Body Mass Index			***p* <0.001**
Normal weight	*Reference*		
Underweight	1.11	0.86, 1.44	
Overweight	0.58***	0.47, 0.71	
Obese	0.74*	0.59, 0.94	
Screen time			***p* <0.001**
≤ 2 hours per day	*Reference*		
> 2 hours per day	0.49***	0.39, 0.61	
Not sure	0.76	0.54, 1.06	
Homework time			***p* <0.001**
No homework at all	*Reference*		
< 1 hour per week	0.97	0.53, 1.77	
About 1 to 2 hours per week	1.03	0.57, 1.87	
About three to four	1.02	0.57, 1.82	

	Odds ratio predicting greater physical activity	**95% CI**	**Overall significance of variable**[1]
hours per week			
About 5 to 6 hours per week	0.68	0.35, 1.31	
≥ 7 hours per week	0.52	0.27, 1.00	
Season			***p*=0.713**
Fall	*Reference*		
Winter	1.00	0.71, 1.40	
Spring	0.92	0.73, 1.16	

[*] $p < 0.05$, [**] $p < 0.01$, [***] $p < 0.001$; specific p-values for group comparisons not shown
[1] *p*-values of Adjusted Wald test for overall significance in the model
✣This variable or one category of this variable violates the proportional odds assumption
[†] Odds ratio of being “Active at or above guidelines & Active below guidelines” vs. “Inactive”
[††] Odds ratio of being “Active at or above guidelines” vs. “Active below guidelines & Inactive”
* Each bivariate model was based on a complete case analysis

4.3.3 Adjusted Associations

Results of analyses conducted to assess the three study objectives are sequentially described below.

4.3.3.1 Objective 1: Gambling Status and Physical Activity

To measure the association between gambling status and physical activity (Objective 1), a multivariable generalized ordinal logistic regression model predicting greater physical activity was fitted with gambling status as the key explanatory variable. Covariates in this model included sex, age, race/ethnicity, years lived in Canada, socioeconomic status, Body Mass Index, screen time, homework time, and season. Full results are presented in Table 5.

No difference was observed in the physical activity of students who gambled and students who did not gamble (p=0.297). After adjusting for all other covariates in the model, males remained more physically active than females (OR: 2.61, CI: 1.93-3.53, p <0.001), while older students remained less physically active than younger students (OR: 0.81, CI: 0.77-0.85, p <0.001). While White students had higher odds of being physically active (at any level) versus inactive (OR: 2.04, CI: 1.46-2.86, p <0.001) compared to students of another racial-ethnic background, their odds of meeting or exceeding physical activity guidelines versus being active below guidelines did not differ significantly (p=0.059). Therefore, race/ethnicity violated the proportional odds assumption.

Years lived in Canada as a whole was significantly associated with physical activity in this adjusted model (p <0.001), but no group comparisons were significant (as shown in Table 5). Further analyses revealed that the choice of reference group affected the significance of group comparisons, as well as whether or not this variable violated the proportional odds assumption. After changing the reference category to adolescents who had lived in Canada for five years or less at the time of survey administration, adolescents who had lived in Canada for their entire lives had higher odds of being physically active versus inactive (OR: 1.90, CI: 1.08-3.33, p=0.025), but there was no difference in the odds of meeting or exceeding guidelines versus not meeting guidelines between these two groups (p=0.170). Adolescents who had lived in Canada for more than five years (but less than their entire lives) did not differ from adolescents who had lived in Canada for five years or less in terms of their past-week physical activity (*p*=0.250).

Higher socioeconomic status corresponded to higher odds of greater physical activity (OR: 1.08, CI: 1.01-1.15, *p*=0.019). Students who were overweight had lower odds of greater physical activity compared to students who were normal weight (OR: 0.61, CI: 0.50-0.74, *p* <0.001). Compared to meeting the guidelines, exceeding current screen time guidelines of 2 hours per day was associated with lower odds of greater physical activity (OR: 0.53, CI: 0.43-0.66, *p* <0.001). Students who completed about three to four hours of homework per week had higher odds of greater physical activity than students who reported completing no homework at all in a week (OR: 1.49, CI: 1.04-2.14, *p*=0.029). Season was not associated with physical activity (*p*=0.645).

Table 5. Results from a multivariable generalized ordinal logistic regression model measuring the association between gambling status and physical activity (2017 Ontario Student Drug Use and Health Survey, *n*=5,709)

	Odds ratio predicting greater physical activity	**95% CI**	**Overall significance of variable**[1]
Gambling status			***p*=0.297**
Non-gambler	*Reference*		
Gambler	1.15	0.88, 1.49	
Sex at birth			***p* <0.001**
Female	*Reference*		
Male	2.61***	1.93, 3.53	
Age	0.81***	0.77, 0.85	***p* <0.001**
Race/ethnicity✣			***p* <0.001**
Other	*Reference*		
White	2.04***†	1.46, 2.86	
	1.19††	0.99, 1.44	
Years lived in Canada			***p* <0.001**
All of my life	*Reference*		
> 5 years	0.95	0.72, 1.25	
≤ 5 years	0.61	0.36, 1.05	
Socioeconomic status	1.08*	1.01, 1.15	***p*=0.019**
Body Mass Index category			***p* <0.001**
Normal weight	*Reference*		
Underweight	1.28	0.99, 1.64	

	Odds ratio predicting greater physical activity	**95% CI**	**Overall significance of variable**[1]
Overweight	0.61***	0.50, 0.74	
Obese	0.89	0.64, 1.24	
Screen time			***p* <0.001**
≤ 2 hours per day	*Reference*		
> 2 hours per day	0.53***	0.43, 0.66	
Not sure	0.86	0.62, 1.20	
Homework time			***p*=0.029**
No homework at all	*Reference*		
< 1 hour per week	1.05	0.74, 1.49	
About 1 to 2 hours per week	1.27	0.87, 1.85	
About three to four hours per week	1.49*	1.04, 2.14	
About 5 to 6 hours per week	1.20	0.81, 1.79	
≥ 7 hours per week	0.96	0.64, 1.44	
Season			***p*=0.645**
Fall	*Reference*		
Winter	1.09	0.83, 1.43	
Spring	1.09	0.91, 1.31	
Gambling status by sex[2]			***p*=0.447**
Gambler × male	0.80	0.46, 1.42	

* p <0.05, ** p <0.01, *** p <0.001; specific p-values for group comparisons not shown

[1] *p*-values of Adjusted Wald test for overall significance

[2] Ratio of odds ratios, obtained from a separate multivariable model that included the interaction term *gambling status x sex*, adjusting for age, race/ethnicity, years lived in Canada, socioeconomic status, Body Mass Index category, screen time, homework time, and season

✜This variable or one category of this variable violates the proportional odds assumption

† Odds ratio of being “Active at or above guidelines & Active below guidelines” vs. “Inactive”

†† Odds ratio of being “Active at or above guidelines” vs. “Active below guidelines & Inactive”

4.3.3.2 Objective 2: Gambling Modality and Physical Activity

Objective 2 was to measure the association between gambling modality and physical activity. To address this objective, a second multivariable generalized ordinal logistic regression model was fitted to predict higher physical activity with gambling modality as the explanatory variable (Table 6). Covariates again included sex, age, race/ethnicity, years lived in Canada, socioeconomic status, Body Mass Index, screen time, homework time, and season.

Gambling modality was not associated with physical activity (p=0.402) and no group comparisons were significant. Neither land-based only (p=0.222) nor online gamblers (p=0.708) had significantly higher odds of greater physical activity compared to non-gamblers. When the reference category was changed to land-based only gamblers, there was, similarly, no significant difference in the odds of higher physical activity for online gamblers (p=0.408).

As expected, associations between covariates and physical activity were largely the same as those found when gambling status was examined as the primary explanatory variable (Objective 1). Males had higher odds of greater physical activity compared to females (OR: 2.62, CI: 1.94-3.55, p <0.001), and older students had lower odds of greater physical activity compared to younger students (OR: 0.81, CI: 0.77-0.85, p <0.001). White students, compared to students of another racial-ethnic background, were twice as likely to be physically active (OR: 2.04, CI: 1.45-2.86, p <0.001). Years lived in Canada as a whole was significantly associated with physical activity in this adjusted model (p <0.001), but no group comparison was significant. Students who perceived their socioeconomic status to be higher had higher odds of greater physical activity (OR: 1.08, CI: 1.02-1.15, p=0.015), as compared with students who perceived themselves to be less privileged. Students who were overweight for their age, sex, and height had lower odds of greater physical activity compared to students who were normal weight (OR: 0.61, CI: 0.50-0.75, p <0.001). More than two hours of screen time per day was associated with lower odds of greater physical activity compared to two hours of screen time per day or less, supporting the displacement hypothesis (OR: 0.53, CI: 0.43-0.67, p <0.001). Completing about three to four hours of homework per week was associated with higher odds of greater physical activity compared to students who reported completing no homework at all (OR: 1.49, CI: 1.04-2.13, p=0.030). Season was not associated with physical activity (p=0.645).

Table 6. Results from a multivariable generalized ordinal logistic regression model measuring the association between gambling modality and physical activity (2017 Ontario Student Drug Use and Health Survey, *n*=5,709)

	Odds ratios predicting greater physical activity	95% CI	Overall significance of variable[1]
Gambling modality			***p*=0.402**
Non-gambler	*Reference*		
Land-based only	1.18	0.90, 1.54	
Any online	0.87	0.43, 1.78	
Sex at birth			***p* <0.001**
Female	*Reference*		
Male	2.62***	1.94, 3.55	
Age	0.81***	0.77, 0.85	***p* <0.001**
Race/ethnicity[✣]			***p* <0.001**
Other	*Reference*		
White	2.04***[†]	1.45, 2.86	
	1.20[††]	1.00, 1.43	
Years lived in Canada			***p* <0.001**
All of my life	*Reference*		
> 5 years	0.95	0.72, 1.25	
≤ 5 years	0.62	0.38, 1.02	
Socioeconomic status	1.08*	1.02, 1.15	***p*=0.016**
Body Mass Index category			***p* <0.001**
Normal weight	*Reference*		
Underweight	1.27	0.99, 1.64	
Overweight	0.61***	0.50, 0.75	
Obese	0.89	0.64, 1.24	
Screen time			***p* <0.001**
≤ 2 hours per day	*Reference*		
> 2 hours per day	0.53***	0.43, 0.67	
Not sure	0.86	0.62, 1.20	
Homework time			***p*=0.024**
No homework at all	*Reference*		
< 1 hour per week	1.05	0.74, 1.50	
About 1 to 2 hours per week	1.27	0.88, 1.84	
About three to four hours per week	1.49*	1.04, 2.13	

	Odds ratios predicting greater physical activity	95% CI	Overall significance of variable[1]
About 5 to 6 hours per week	1.20	0.81, 1.78	
≥ 7 hours per week	0.95	0.64, 1.42	
Season			***p*=0.649**
Fall	*Reference*		
Winter	1.09	0.83, 1.43	
Spring	1.09	0.91, 1.31	
Gambling modality by sex[2]			***p*=0.072**
Land-based only × male	0.73	0.40, 1.33	
Any online × male	3.13*	1.06, 9.25	

[*] $p < 0.05$, [**] $p < 0.01$, [***] $p < 0.001$; specific p-values for group comparisons not shown
[1] *p*-values of Adjusted Wald test for overall significance
[2] Ratio of odds ratios, obtained from a separate multivariable model that included the interaction term *gambling modality x sex*, adjusting for age, race/ethnicity, years lived in Canada, socioeconomic status, Body Mass Index category, screen time, homework time, and season
✣This variable or one category of this variable violates the proportional odds assumption
[†] Odds ratio of being “Active at or above guidelines & Active below guidelines” vs. “Inactive”
[††] Odds ratio of being “Active at or above guidelines” vs. “Active below guidelines & Inactive”

4.3.3.3 Objective 3: Sex as an effect measure modifier of the association between gambling status and physical activity, and the association between gambling modality and physical activity

Our third objective was to determine whether interaction on the multiplicative scale is present between (a) gambling status and sex; and (b) gambling modality and sex in models predicting physical activity. In order to address this objective, we computed a generalized ordinal logistic regression model with a sex-gambling status interaction term and another model with a sex-gambling modality interaction term. Interaction models controlled for the same covariates as were included in the main effects models (previously discussed): age, race/ethnicity, years lived in Canada, socioeconomic status, Body Mass Index category, screen time, homework time, and season. The interaction term for gambling status by sex (2x2 interaction) is presented in Table 5 and the interaction terms for gambling modality by sex (3x2 interaction) are presented in Table 6.

We found that 44% of males in our sample (n=1078) reported gambling at least once in the past twelve months compared to only 25% of females (n=880). Broken down by modality, 39% of males (n=919) and 24% of females (n=845) in the sample were land-based only gamblers, whereas only 5% of males (n=159) and 1% of females (n=35) had gambled online.

The prevalence of physical activity by sex was previously presented in Table 3. Almost 29% of males reported being active at or above guidelines in the week prior to the study compared to just 14% of females. Conversely, only 6% of males reported being inactive during this time compared to 14% of females. A greater proportion of females than males were active below guidelines (72% versus 65%).

No evidence of multiplicative interaction was found between either gambling explanatory variable and sex (gambling status by sex, p=0.447, gambling modality by sex, p=0.072). As shown in Table 6, while a statistically significant interaction was observed between the presence of any online gambling and male sex (p=0.039), the global test of interaction (Adjusted Wald test) between gambling modality and sex was not significant (p=0.072).

Chapter 5

5 Discussion

This chapter sequentially discusses primary findings pertaining to each study objective. Secondary findings (i.e., the observed relationship between each covariate and physical activity) are then discussed. Following a discussion of study findings, we address study strengths, limitations, and implications for future research and public health interventions.

5.1 Primary Findings

This study aimed to examine the association between gambling and physical activity among Ontario students using data from the 2017 Ontario Student Drug Use and Health Survey. The sedentary nature of many gambling activities has been theorized as a gambling-related harm, but research in this area remains limited and focused on populations of older adults (Anzalone, 2013; Burge et al., 2004; Langham et al., 2016; O'Brien Cousins & Witcher, 2007; Pietrzak et al., 2007; Subramaniam et al., 2015).

5.1.1 Association between Gambling Status and Physical Activity

The first objective was to measure the association between gambling status and physical activity. Because many gambling activities are largely sedentary (i.e., involve considerable periods of sitting), we hypothesized that gamblers would be less physically active than non-gamblers.[21] Based on the displacement hypothesis positing that time spent engaging in sedentary gambling activities displaces time for physical activity (Mutz et al., 1993), we expected that gambling would be inversely associated with physical activity.

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[21] While gambling was operationalized as a sedentary behaviour for the purposes of this study, we acknowledge that some gambling may not necessarily involve sitting, such as scratching a lottery ticket. See Appendix E and Appendix F.

Contrary to our hypothesis, we did not find any association between gambling status and physical activity among Ontario adolescents. Again framing gambling as a sedentary behaviour, this is inconsistent with previous studies identifying an inverse association between sedentary behaviour and physical activity among adolescents (Baggett et al., 2010; Carson et al., 2011; Gomes et al., 2017; Koezuka et al., 2006; Pearson et al., 2014; Tammelin et al., 2007; Valencia-Peris et al., 2016). Our findings are also incongruent with studies that observed a positive association between gambling and physical activity among adolescents (Chaumeton et al., 2011; Frémeaux et al., 2011; Gavriel-Fried et al., 2015; Paravidino et al., 2016; Wilkin et al., 2006).

The absence of an association between gambling and physical activity in our study may be because adolescents are not engaging in sedentary gambling activities (such as card games or online gambling) frequently enough for these activities to have any impact on their physical activity (Shead, Hodgins, & Scharf, 2008). We were not able to ascertain the frequency at which adolescents gambled beyond the number of times they gambled in the past year. Due to low numbers of adolescents who gambled more than a handful of times, adolescents who might have gambled almost daily were equated with adolescents who gambled just once in the past year, diluting the exposure in our study. Any potential differences between the physical activity of adolescents who gambled more frequently versus those who gambled less frequently would not have been captured. It may be that only considering the presence or absence of gambling behaviour is insufficient to detect an association between gambling and physical activity. We acknowledge this as an important limitation of our study. Thus, in future research it will be important to examine gambling in relation to physical activity using a more precise measure of frequency than that available in the OSDUHS.

Another possibility is that gambling and physical activity may overlap among specific adolescent sub-populations. Chaumeton and colleagues (2011) observed a positive association between gambling (defined as having bet at least $1 in the three months prior to the study) and physical activity among a sample of Grade 8 boys in Oregon. Similarly, in their investigation of gambling and physical activity among a sample of Israeli high school students, Gavriel-Fried, Bronstein, and Sherpsky (2015) found that higher gambling frequency was associated with participation in competitive sports. These findings suggest that adolescents who are involved in sports could be physically active *while gambling*.

5.1.2 Association between Gambling Modality and Physical Activity

The second objective in our study was to measure the association between gambling modality and physical activity. Specifically, we were interested in whether land-based gamblers and online gamblers differed from each other and from non-gamblers in terms of their physical activity. We hypothesized that online gamblers would be less physically active than both land-based only gamblers and non-gamblers because it is a screen-based activity, while land-based gambling does not involve screen time.

Our study findings did not lend support for this hypothesis. We did not find an association between gambling modality and physical activity; the odds of greater physical activity for online gamblers compared to land-based gamblers and non-gamblers were not significantly different. The lack of association between gambling modality and physical activity may again be somewhat explained by the limitations of our gambling measure in that it did not capture the frequency of gambling behaviours or time spent gambling. Interestingly, as discussed below, students who exceeded recreational screen time guidelines had lower odds of greater physical activity compared to students who met these guidelines (2 hours of recreational screen time or less per day). However, it is notable that screen time was measured in hours per day, while gambling behaviour was only assessed as any gambling during the last year. Overall, in future research it will be essential to assess the frequency of and time spent engaging in both online and land-based gambling with more precision than simply the number of times gambling occurred during the past year in relation to physical activity. It will also be important to differentiate between sedentary and non-sedentary gambling.

5.1.3 Presence of Effect Measure Modification by Sex

Our third objective was to examine whether sex modifies the main effect of (a) gambling status and (b) gambling modality in corresponding models predicting physical activity.

We hypothesized that gambling might lower the physical activity of males more than that of females due to higher gambling engagement among males than among females (i.e., more time spent gambling resulting in less time for physical activity), and lower levels of physical activity among females in general.

Contrary to this hypothesis, we found no evidence that the effect of gambling status on physical activity and gambling modality on physical activity varies by sex. This suggests that the association between gambling status and gambling modality and physical activity is not significantly different between males and females.

While sex was not found to be an effect measure modifier of the association between gambling (status and modality) and physical activity in our study, the main effect of sex on physical activity was highly significant (p <0.001), consistent with previous research. Male students were more physically active than their female counterparts, a trend that has been consistently reported across previous studies (Armstrong et al., 2018; Carson et al., 2014; Cheah et al., 2016; Colley et al., 2017, 2011; Lee et al., 2017; Renato Azevedo et al., 2007; Riddoch et al., 2004; Ridgers et al., 2013; Wickel & Belton, 2016). It has been suggested that greater levels of physical activity among males might be attributable to higher self-efficacy among males (Graham et al., 2014; Park & Kim, 2008). Unfortunately, self-efficacy for physical activity was not measured in the 2017 OSDUHS, and we were therefore unable to incorporate it into our analyses. However, Spence and colleagues (2010) observed both higher self-efficacy and higher physical activity among males in a regionally diverse sample of 4,779 children and youth from Alberta in Grade 7-10.

When the prevalence of gambling was explored by sex, we found higher prevalence of both land-based and online gambling among males than among females (p <0.001) (Sections 4.2.2 and 4.3.3.3). This gender discrepancy is consistent with other recent studies of gambling among Canadian adolescents utilizing survey data (Elton-Marshall et al., 2016; Wijesingha et al., 2017).

Due to low numbers of female gamblers in our sample, our study may have lacked sufficient statistical power to detect interactions by sex, particularly when examining gambling modality by sex where only 35 females (approximately 1% of females in our sample) reported gambling online in the past 12 months.

5.2 Secondary Findings

As described in Chapter 2, our review of the literature identified several factors that may be related to physical activity, including age, race/ethnicity, years lived in Canada, socioeconomic status, Body Mass Index category, screen time, homework time, and season. Findings pertaining to our study are described for each factor below.

5.2.1 Age

We found that older adolescents were less physically active than younger adolescents. Research has demonstrated that physical activity declines with increasing age, beginning in childhood and continuing throughout adolescence (Brodersen et al., 2007; Farooq et al., 2018; Park & Kim, 2008; Sallis, Prochaska, & Taylor, 2000). This age-related pattern of decline in physical activity among adolescents has been consistently documented across numerous cross-sectional and longitudinal studies using both self-report and objective measures of physical activity (Colley et al., 2017; Corder et al., 2017; Dumith, Gigante, Domingues, & Kohl, 2011; Metcalf et al., 2015; Parker et al., 2018).

Gyurcsik and colleagues (2006) collected data on perceived intrapersonal, interpersonal, institutional, community, public policy, and physical environmental barriers to physical activity from 291 high school students in the mid-western United States. On average, they found that students in older grades perceived more barriers to physical activity than students in younger grades. In Ontario, physical education class is only mandatory until Grade 9. As adolescents get older, they may prioritize part-time jobs, volunteer commitments, significant others, and care of younger siblings (etc.) over being physically active outside of school.

Another possible explanation for the age-related decline in physical activity is an increase in autonomy that occurs as young people mature. Parents may play a role in the physical activity of younger adolescents by registering them in organized sports, encouraging them to be active outside, or by being physical active themselves (Christofaro et al., 2018; Dorsch, Smith, & Dotterer, 2016; Hellstedt, 1990; Ornelas, Perreira, & Ayala, 2007; Padaki et al., 2017; Stefansen, Smette, & Strandbu, 2018; Trost et al., 2011). However, as adolescents age and gain more control over how they spend their leisure time, those who do not intrinsically enjoy being physically active or who have lost interest in physical activity might adopt more sedentary pursuits. In a study of 384 Australian adolescents aged 12-15, Rachele and colleagues (2015) found an inverse association between self-reported meeting of physical guidelines and self-reported autonomy.

5.2.2 Race/Ethnicity

White students in our sample had higher odds of being physically active versus inactive compared to students of other racial-ethnic backgrounds. This finding aligns with existing Canadian data. Kukaswadia, Pickett, and Janssen (2014) found higher levels of physical activity among Canadian youth who described their racial-ethnic backgrounds as European and North American compared to those who described themselves as East and Southeast Asian, Latin American, or African.[22] Racial/ethnic discrepancies in physical activity have also been reported among adolescent populations in other Western countries (Armstrong et al., 2018; Brodersen et al., 2007; Kahlin, Werner, Romild, & Alricsson, 2009; Kandula & Lauderdale, 2005; Sallis et al., 2000; Strugnell, Renzaho, Ridley, & Burns, 2015).

Interestingly, no difference was seen in the odds of meeting physical activity guidelines versus not meeting guidelines for White students compared to students of other racial-ethnic backgrounds. Thus, while White students may be more physically active compared to students of another racial-ethnic background, they do not differ in terms of whether they meet the physical activity guidelines of 60 minutes of MVPA daily.[23] Perhaps

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[22] This study used data from the Canadian Health Behaviour in School-Aged Children survey and had a larger sample size than the OSDUHS (unweighted *n*=22,786), making it possible to examine racial-ethnic categories in more detail.

[23] Recall from Chapter 4 that race/ethnicity violated the proportional odds assumption.

physically active students from diverse ethnic backgrounds participate in organized sports at comparable levels to White students (Strandbu, Bakken, & Sletten, 2019).

5.2.3 Years Lived in Canada

Compared to adolescents who had lived in Canada for five years or less at the time of survey administration, we found that adolescents who had lived in Canada for their entire lives had higher odds of being physically active versus inactive. This finding does not support the notion of a *healthy immigrant effect* at work among adolescent newcomers to Canada in the context of physical activity.

It is possible that differences in organized sport participation between youth who have recently immigrated to Canada and Canadian-born youth may somewhat explain differences in total physical activity between these two groups. Some research has found participation in youth organized sport to be a major component of overall youth physical activity (Ng, Rintala, Hutzler, Kokko, & Tynjälä, 2017; Patton et al., 2016; Vella et al., 2016; Wickel, 2007). Language difficulties, unfamiliarity with rules, and prejudice from peers have been identified as barriers that discourage recent adolescent newcomers to Canada from participating in organized sports (Doherty & Taylor, 2007). Unfortunately, the OSDUHS did not assess perceived barriers to physical activity. Thus, in future research it will be important to assess whether perceived barriers to physical activity explain lower levels of physical activity for adolescents who have recently moved to Canada.

No differences were found between the levels of physical activity of adolescents who had immigrated to Canada more than five years prior to the survey and those of adolescents who had lived in Canada their entire lives. This suggests that physical activity may increase with years lived in Canada as adolescents settle into their new environment. Our findings again closely echo those of Kukaswadia and colleagues (2014), who found that youth who immigrated to Canada within the last 1-2 years were less likely to achieve 60 minutes of MVPA on at least 4 days of the week than Canadian-born youth. As time since immigration increased beyond 1-2 years, the difference in the physical activity of adolescents who had immigrated to Canada and Canadian-born adolescents became insignificant.

5.2.4 Socioeconomic Status

Higher perceived family socioeconomic status was associated with higher odds of physical activity among adolescents, consistent with previous data. In a nationwide, school-based study of 6,684 Canadian youth in Grades 6-10, those who perceived their family socioeconomic status to be lower had comparably lower levels of self-reported physical activity than those who perceived their family socioeconomic status to be higher (Janssen, Boyce, Simpson, & Pickett, 2006).

It may be that students from higher socioeconomic backgrounds are afforded more opportunities for physical activity. For example, due to registration fees, organized sports may be only accessible to students whose families have disposable income. Similarly, in a study conducted in Portugal, Paula Santos and colleagues (2016) examined a sample of 509 adolescents aged 13-20 years old, and found that adolescents in families from higher socioeconomic statuses were more engaged in organized sports than adolescents in families from lower socioeconomic statuses. Students from lower socioeconomic backgrounds may also be required to work part-time, reducing time available for physical activity (Hirschman & Voloshin, 2007).

5.2.5 Body Mass Index Category

Adolescents who were categorized as being overweight had lower odds of physical activity compared to adolescents of normal weight in our study. It is possible that students who are overweight might be self-conscious about the way they look while exercising and consequently avoid situations that involve being physically active (Stankov, Olds, & Cargo, 2012). They may also lack the confidence to engage in sports (Stankov et al., 2012). While we were not able to examine degree of body consciousness or self-efficacy pertaining to physical activity in our study, previous research has posited that these constructs may partially explain an inverse association between physical activity and Body Mass Index (Allison et al., 1999; Dwyer et al., 2012; Zabinski, Saelens, Stein, Hayden-Wade, & Wilfley, 2003).

While we conceptualized Body Mass Index category as a predictor of physical activity for the purposes of our study, we acknowledge that the relationship between Body Mass Index and physical activity is likely bidirectional. A recent longitudinal analysis of Canadian data from the Physical Health Activity Study Team project demonstrated a bidirectional association between Body Mass Index and physical activity. Specifically, as adolescents aged from 10 years to 13.5 years, sport participation predicted subsequent Body Mass Index, and vice versa (Cairney & Veldhuizen, 2017).

5.2.6 Screen Time

We found that adolescents who exceeded the recommended recreational screen time guidelines of two hours per day had lower odds of greater physical activity than adolescents who met the guidelines (Tremblay, Warburton, et al., 2011). This finding suggests that screen time as measured in this study, including watching TV/movies/videos, playing video/computer games, texting/emailing, or surfing the Internet in your free time, may displace physical activity and aligns with previous research in this area. For example, television viewing has previously been inversely associated with physical activity among Canadian adolescents (Koezuka et al., 2006). Among a nationally representative sample of adolescents in the United States aged 14-18, adolescents who watched more hours of television per week engaged in less physical activity (Eisenmann et al., 2002). More recently, an inverse association was seen between time spent engaging in screen-based activities and time spent being physically active (Graham et al., 2014). In this study, total screen time was negatively related to total physical activity and total MVPA. Thus, an important implication of this research is that efforts to increase physical activity among adolescents must focus on reducing the amount of time they spend in front of screens.

5.2.7 Homework Time

An interesting finding from our study is that adolescents who completed between 3 and 4 hours of homework per week had higher odds of engaging in physical activity than adolescents who completed no homework at all per week (in both fully adjusted models). The direction of this association was somewhat unexpected (in the context of the displacement hypothesis), as homework is a major time commitment that reduces time available for physical activity among adolescents (Leatherdale & Wong, 2008; Tremblay, LeBlanc, Kho, et al., 2011). However, our finding is congruent with previous work that reported a positive association between “productive” sedentary behaviours (such as doing homework) and physical activity among adolescents (Feldman et al., 2003; Koezuka et al., 2006). One possible explanation for this association is that young people who are able to self-regulate are more likely to be physically active, as well as more likely to engage in homework activities (Bembenutty & Karabenick, 1998; Cadime, Cruz, Silva, & Ribeiro, 2017; Hall & Fong, 2015; Herndon, 2011). Alternatively, it may be that young people in health-oriented family and school environments are encouraged to be diligent about both physical activity and homework for optimal health and academic outcomes.

5.2.8 Season

No association between season and physical activity was observed in this study. This is somewhat unexpected given the volume of evidence suggesting that adolescents tend to be less physically active during the winter (Carson & Spence, 2010; Nadeau, Letarte, Fratu, Waygood, & Lebel, 2016; Quante et al., 2017). In a 5-year longitudinal study of 1293 Montreal high school students, Bélanger and colleagues (2009) demonstrated that reported frequency of physical activity sessions were approximately 10.8% higher in spring and 11.4% higher in fall, compared to the winter. More recently, Kornides and colleagues (2018) examined data collected from 10,918 adolescents in the United States, and found that adolescents had two times higher odds of not meeting physical activity guidelines (at least 60 minutes of physical activity every day) in the winter, as compared to the summer, even after adjusting for age, weight status, and gender. Based on these findings, we expected to see lower levels of physical activity among students who completed the survey during the Winter compared to during the Fall or Spring. The lack of any such association in our study suggests that physically active students remain active throughout the Winter months, either in the form of outdoor activities (e.g., skiing, skating, snowshoeing) or by the use of indoor recreation facilities.

5.3 Study Strengths

The primary strength of our study is that it addresses a gap in knowledge. We believe that this is the first Canadian study to examine the association between gambling and physical activity among high school students, and adds to a small body of research (Chaumeton et al., 2011; Gavriel-Fried et al., 2015).

Another strength of our study is its large, representative sample of Ontario students. Inferences drawn from the results may be extrapolated to 91% of adolescents in Ontario (Boak et al., 2018). Additionally, the use of a standard measure of physical activity increases the comparability of our results (Prochaska et al., 2001). Our study may be used as a point of departure for future work examining the association between gambling behaviour and physical activity among young Canadians.

5.4 Study Limitations

5.4.1 Limitations Pertaining to the Study Measures

The major limitation of the present study is our measure of gambling, as previously described in Section 5.1.1. The OSDUHS did not gather information about how much time students had spent gambling, nor did it examine gambling frequency beyond the total number of gambling sessions in the past year. For the purposes of our study we collapsed information regarding past-year gambling frequency into a measure of whether students had gambled or not, and also whether or not they had gambled online (Elton-Marshall et al., 2016). A binary (presence/absence) measure of past-year gambling behaviour, lacking information regarding how frequently and for how long students gambled, may have limited our ability to detect an association between gambling and physical activity (Chaumeton et al., 2011; Gavriel-Fried et al., 2015).

Another limitation of our gambling measure is that the “online gambling only” category was grouped together with mixed gamblers (online + land-based) to create the “any online” category (Elton-Marshall et al., 2016). This was because very few adolescents in the sample reported gambling exclusively online (n=22). We were therefore not able to ascertain the unique association of online gambling with physical activity. Future research examining gambling as a sedentary behaviour should employ measures that capture frequency of gambling activities, as well as amount of time spent gambling for a more complete understanding of student gambling behaviour. For a better understanding of the association between online gambling and physical activity, researchers should attempt to recruit a sufficient sample of adolescents who gamble only online. Similarly, in order to more clearly delineate the nature of gambling, a distinction should be made between sedentary and non-sedentary gambling activities. We were unable to do this due to low numbers of students who exclusively participated in each type of gambling activity (See Appendix E).

Our use of sex at birth rather than an examination of gender is another limitation that should be mentioned. While we did consider using a more inclusive gender variable, we ultimately chose to use sex at birth due to low numbers of students identifying as a gender other than male or female or declining to answer (transgender: n=8, none of the above: n=31, prefer not to answer: n=25). The gender variable also had a considerable proportion of missing data (n=1,740). An alternative approach would have been to use the gender variable and to remove responses submitted by every student who identified as a gender other than male or female, as well as all missing values. However, this approach would have resulted in a significant number of observations being discarded (n=1804), considerably reducing the power of our study.

We encountered a similar problem of sparse categories with the Race/Ethnicity variable. Consistent with other studies of adolescents (Wijesingha et al., 2017), we dichotomized race/ethnicity into “White” and “Other.” [24] We acknowledge this as a limitation because it prevents us from making meaningful inferences about students in diverse ethnic groupings who do not identify as White. Over half of our sample was white (55%). The next largest category was “mixed race” at approximately 12%. The smallest category was Japanese (0.22%). Further differentiation of racial-ethnic groups was not feasible due to

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[24] We acknowledge that “Visible Minority Status” (as opposed to Race/Ethnicity) may be a more appropriate label for this information.

the make-up of our sample. We did not have sufficient numbers of participants in each racial-ethnic group to examine every group individually (as shown in Appendix G) and there were no meaningful or evidence-based ways to group the ethnicities. Further research examining the association between gambling and physical activity should focus on recruiting higher numbers of participants who identify as a racial-ethnic background other than White.

5.4.2 Limitations Pertaining to the Study Design

A major limitation of all cross-sectional research is that no causality can be inferred due to the simultaneous measurement of exposures and outcomes (Checkoway, Pearce, & Kriebel, 2007). Some variables we conceptualized in our model as predictors of physical activity may, in fact, be outcomes of physical activity. In particular, we cannot know whether gambling participation preceded the establishment of physical activity patterns or vice versa. As well, we could not ascertain whether Body Mass Index category preceded physical activity level and vice versa. We acknowledge the potential presence of reverse causality.

Another limitation of our study is its reliance on self-reported data. Compared to data that are measured directly, self-reported measures may be subject to response bias (van de Mortel, 2008). For example, social desirability bias, one type of response bias that is present when respondents wish to present themselves in a positive light can result in some characteristics being underreported, while others are overreported (van de Mortel, 2008).

In particular, Body Mass Index category may have been subject to response bias. Previous literature has shown that the prevalence of obesity (compared to other Body Mass Index categories) among adolescents tends to be lower when Body Mass Index is based on self-reported weight and height versus when they are measured directly (Sherry, Jefferds, & Grummer-Strawn, 2007). One explanation for this discrepancy is the tendency for adolescents to overestimate their height and underestimate their weight (Brettschneider, Rosario, & Ellert, 2011; Gorber, Tremblay, Moher, & Gorber, 2007; Rasmussen, Eriksson, & Nordquist, 2007; Shiely, Hayes, Perry, & Kelleher, 2013). As

Body Mass Index was calculated using self-report measurements in the present study, the prevalence of overweight and obesity is likely underestimated (Rasmussen et al., 2007). There is some evidence of gender differences in weight and height reporting bias: adolescent girls have been found to under-report their weight to a larger extent than boys, regardless of actual body size (Brener, Mcmanus, Galuska, Lowry, & Wechsler, 2003; Rasmussen et al., 2007). Males tend to overestimate their height compared to females (DelPrete, Caldwell, English, Banspach, & Lefebvre, 1992).

We expect overall response bias in our study to be minimal, as efforts were made during OSDUHS data collection to maintain student anonymity and privacy. For example, teachers were asked to not circulate the classroom as the survey was being completed and responses completed with teacher assistance were discarded (Boak et al., 2018).

Aside from being prone to response bias, data for Body Mass Index category is typically missing-not-at-random, as mentioned in Section 3.2.3.3.2. Our use of complete data (i.e., listwise deletion of cases) may have biased our sample, as cases with missing values for body weight may have systematically differed from complete cases. For instance, missing responses for body weight are more common among females and individuals with higher Body Mass Indexes (Aceves-Martins et al., 2018). However, we expect that any bias introduced by the use of listwise deletion to be minimal as the percentage of missing data on Body Mass Index category was generally low (6.6%). An alternative approach would have been multiple imputation. However, this approach has also been shown to produce biased estimates when the data are MNAR (Papageorgiou et al., 2018).

Finally, we acknowledge that there might be some residual confounding present in our study due to unmeasured covariates. Some potentially important constructs related to gambling and/or physical activity in the literature were not assessed by the OSDUHS and therefore could not be included in the present study. For example, the OSDUHS also did not provide any information on parental and peer attitudes towards gambling or physical activity (Cheng, Mendonça, & Farias Júnior, 2014; Gupta & Derevensky, 1997). The OSDUHS also did not gather information about disability. Some types of disabilities may limit an individual's physical activity (Rimmer & Marques, 2012; Rimmer & Rowland, 2008).

5.5 Study Implications

5.5.1 Implications for Future Research

Ideally, future research should address the limitations of the present study. In order to more clearly evaluate the presence or absence of an association between gambling and physical activity among adolescents in Ontario, the present investigation should be replicated using a gambling measure that captures gambling frequency and time spent gambling. It may also be important to collect a sample with a sufficient number of participants who gamble online only, since this group was combined with mixed (land-based + online) gamblers due to low numbers in the present study (Elton-Marshall et al., 2016).

Research examining gambling and physical activity among adolescents should also strive to be more inclusive of diverse genders and racial groups. Transgender and non-binary youth, as well as youth from racialized ethnic groups should be targeted, either through studies examining these specific groups individually (i.e., a study of gambling and physical activity among transgender youth) or by increasing the sample size of general population studies to allow for meaningful subgroup analyses. Similarly, future studies examining possible effect modification by gender (as opposed to sex) should aim to recruit larger sample sizes in order to achieve sufficient statistical power to detect an effect. Longitudinal evidence is also needed to evaluate a possible displacement mechanism between sedentary behaviours and physical activity. An inverse association between screen time and physical activity, as found in the present study, is insufficient on its own to conclude that screen time displaces physical activity. Similarly, research examining a possible compensation mechanism (i.e., ActivityStat hypothesis, as described in Section 2.2.2.1) will also require longitudinal designs.

Given that online gambling may soon become more accessible to Ontario adolescents with arrival of provincial government-sanctioned private online gambling sites, revisiting the association between gambling modality and physical activity after the changes are implemented may be warranted. The estimates of gambling prevalence presented in this study serve as baseline gambling prevalence (i.e., prior to the changes announced in April 2019 by the Government of Ontario) to which future prevalence estimates may be compared.

Based on previous research characterizing gambling as a sedentary form of recreation (O'Brien Cousins & Witcher, 2007; Ssewanyana et al., 2018), the present study positioned gambling as a sedentary behaviour. However, the nature of gambling behaviour among youth warrants further investigation. Future studies should objectively measure the energy expenditure of youth while they gamble.

Finally, the present study examined the association between the presence or absence of gambling (total, online, and land-based) in the past-year and past-week physical activity. A next step would be to examine the association between specific types of gambling activities (i.e., card games or sports pools) and physical activity. Such subgroup analyses would require a larger sample of gamblers than that available to us via the 2017 OSDUHS.

5.5.2 Implications for Public Health Interventions

While the present study did not find an association between gambling and physical activity, our descriptive finding that only 1 in 5 adolescents in Ontario currently meet or exceed physical activity guidelines for optimal health (60 minutes of MVPA everyday) indicates that public health strategies aimed at increasing physical activity among this population are sorely needed. In particular, our study results suggest that interventions should target females and older students, as these groups were identified as having particularly low levels of physical activity, consistent with previous research (Armstrong et al., 2018; Colley et al., 2011; Corder et al., 2017; Park & Kim, 2008). One strategy to mitigate both the age-related decline in physical activity, as well as the gender gap, may be to mandate physical education classes in all four years of high school, instead of only Grade 9, for both males and females. Another helpful measure might be to offer tax deductions for participation in organized sports for older adolescents similar to those currently available for adolescents aged 16 and younger.

Our study also highlights the need for inclusive and culturally sensitive campaigns to increase physical activity among adolescents from racialized ethnic groups who are generally less physically active than students who identify as White. Another group to target is newcomers to Canada. Community organizations responsible for welcoming and settling newcomers should ensure that adolescents who have recently arrived in Canada are connected with culturally sensitive physical activity outlets. For example, many community pools offer designated "Women's Only" swims. A goal of these organizations should be to encourage adolescents who were physically active in their countries of origin remain physically active in Canada, and to assist adolescents who did not engage in physical activity prior to arriving in Canada to gradually incorporate physical activity into their daily lives.

Our finding that adolescents from lower socioeconomic backgrounds are less physically active suggests that public health campaigns that are centered around free or inexpensive methods of physical activity (active transportation, physically active chores, etc.) may be effective in increasing adolescent physical activity. The message that physically active leisure extends beyond organized sports, and that many tasks of daily living can be easily modified to include physical activity (i.e., walking or biking to school on some days of the week instead of taking the bus, engaging in physically active household chores, etc.) should be reinforced among adolescents.

Interventions are also needed to increase the physical activity of adolescents who are overweight, such as targeted programs that aim to cultivate higher levels of self-efficacy for physical activity (Park & Kim, 2008). However, given that many normal-weight adolescents in Ontario are also exhibiting low levels of physical activity, public health campaigns should emphasize that the health benefits of physical activity extended beyond weight control and that everyone should strive to be physically active, regardless of their Body Mass Index category (Wang et al., 2016).

A finding of particular public health importance was that recreational screen time over the recommended daily limit of two hours is inversely associated with physical activity. This tentatively supports the hypothesis that sedentary behaviours and physical activity displace each other. While further longitudinal research within this population is required before conclusions can be made about whether screen time displaces physical activity, our study provides evidence that public health campaigns focused on minimizing recreational screen time may an effective strategy in promoting physical activity among adolescents. More broadly, limiting screen time may also benefit adiposity, mental health, and quality of life, as evidenced by a recent systematic review of reviews (Stiglic & Viner, 2019).

In addition to low levels of physical activity, the prevalence of gambling among adolescents should also be addressed. Our study provided further evidence that gambling among young people is a relatively common phenomenon. Initiatives such as the Youth Gambling Awareness Program (by the YMCA) are needed to educate youth on the considerable social and psychological harms posed by gambling. Furthermore, gambling education campaigns should also be targeted at parents and teachers, as previous studies have found that these authority groups do not widely perceive adolescent gambling as an important risk behaviour (Campbell, Derevensky, Meerkamper, & Cutajar, 2011; Derevensky, St-Pierre, Temcheff, & Gupta, 2014; Felsher, Derevensky, & Gupta, 2003). In physical education class, gambling-related harms should be prominently and frankly addressed. Finally, at the policy level, it may be important to tighten restrictions regarding the dissemination and content of gambling advertising. For instance, gambling advertisements geared towards young adults that also appeal to underage youth could be restricted ((Gainsbury et al., 2016; H. Wardle, 2019).

5.6 Conclusion

This study examined the association between gambling and physical activity among a representative sample of Ontario adolescents. Contrary to our hypothesis that gambling and physical activity would be inversely associated, no association was found between (a) gambling status and physical activity or between (b) gambling modality and physical activity. Therefore, we did not find evidence of a displacement mechanism linking gambling behaviours and physical activity. In part, this may be due to lack of information on the frequency and time spent gambling. Further research is required on these aspects of gambling, as is a clearer distinction between sedentary and non-sedentary gambling.

The proportion of adolescents meeting current physical activity guidelines was low overall, consistent with prior assessments (Colley et al., 2017). Furthermore, we found that females, older students, students from racialized groups, newcomers to Canada, and students of lower socioeconomic status may be less likely to be physically active. These groups should therefore be targeted by public health interventions to increase physical activity. Our study also suggests that reducing recreational screen time among adolescents may be an effective strategy to increase physical activity in this population. As well, given that a sizeable proportion of Ontario adolescents reported having gambled at least once in some form during the year prior to the 2017 OSDUHS, public health interventions aimed at reducing gambling among high school students are needed.

While gambling and physical activity were not found to be associated among adolescents in this study, both represent important public health concerns. From a public health standpoint, it is particularly important that researchers continue studying factors that may influence the physical activity of young people, such as gambling. Given that lifelong patterns of physical activity are often established during adolescence (Biddle et al., 2010; Malina, 1996; Telama et al., 1997), increasing physical activity of adolescents is expected to have far-reaching public health benefits.

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Appendices

Appendix A. 2017 Ontario Student Drug Use and Health Survey Measures

PAST-WEEK PHYSICAL ACTIVITY (TO DERIVE PAST-WEEK PHYSICAL ACTIVITY LEVEL)

I2. **On how many of the LAST 7 DAYS were you physically active for a total of AT LEAST 60 MINUTES each day? Please add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time. (Some examples are brisk walking, running, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball, football.) Please include both school and non-school activities.**

1 ☐ 0 days
2 ☐ 1 day
3 ☐ 2 days
4 ☐ 3 days
5 ☐ 4 days
6 ☐ 5 days
7 ☐ 6 days
8 ☐ 7 days

PAST-YEAR GAMBLING (TO DERIVE STATUS AND MODALITY)

L1. How often (if ever) in the LAST 12 MONTHS, have you done each of the following? (Write "0" if you have not done it.)

a) Bet money on CARD games? _______ times

b) Bet money on DICE games? _______ times

c) Bet money on other GAMES OF SKILL (such as pool, darts, chess, bowling)? _______ times

d) Played BINGO for money? _______ times

e) Bet money in SPORTS POOLS or FANTASY SPORTS? _______ times

f) Bought SPORTS LOTTERY tickets (such as Sports Select or Proline)? _______ times

g) Bought any OTHER LOTTERY TICKETS at a store, including instant lottery (such as 6-49, Poker Lotto, scratch cards)? _______ times

h) Bet money on VIDEO GAMBLING MACHINES, SLOT machines, or any other gambling machines? _______ times

i) Bet money at a CASINO in Ontario? _______ times

j) Bet money on results of a VIDEO GAME? _______ times

k) Bet money on a DARE or PRIVATE BET _______ times

l) Bet money on POKER ONLINE? _______ times

m) Bet money on BINGO ONLINE? _______ times

n) Bet money on SPORTS BETTING ONLINE? _______ times

o) Bet money on OTHER ONLINE games? _______ times

p) Bought LOTTERY TICKETS ONLINE? _______ times

q) Bet money in OTHER ways not listed above? _______ times

SEX AT BIRTH

A2. Were you born male or female?

1 ☐ Male
2 ☐ Female

AGE

A1. How old are you?

- 10 ☐ 10 years of age or younger
- 11 ☐ 11 years
- 12 ☐ 12 years
- 13 ☐ 13 years
- 14 ☐ 14 years
- 15 ☐ 15 years
- 16 ☐ 16 years
- 17 ☐ 17 years
- 18 ☐ 18 years
- 19 ☐ 19 years
- 20 ☐ 20 years or older

RACE/ETHNICITY

A8. Which of the following best describes your background? (You may choose more than one category.) Are you...?

- a ☐ **White** (for example, British, French, Italian, Portuguese, Ukrainian, Russian, Israeli)
- b ☐ **Chinese**
- c ☐ **South Asian** (for example, East Indian, Pakistani, Bangladeshi, Sri Lankan)
- d ☐ **Black** (African, Caribbean, North American)
- e ☐ **Aboriginal** (First Nations, Inuit, Métis, non-status Indian)
- f ☐ **Filipino**
- g ☐ **Latin American, Central American, South American** (for example, Mexican, Brazilian, Chilean, Guatemalan, Venezuelan, Colombian, Argentinian, Salvadoran, Costa Rican)
- h ☐ **Southeast Asian** (for example, Vietnamese, Cambodian, Indonesian, Malaysian, Laotian)
- i ☐ **West Asian or Arab** (for example, Egyptian, Saudi Arabian, Syrian, Iranian, Iraqi, Lebanese, Afghan, Palestinian)
- j ☐ **Korean**
- k ☐ **Japanese**
- l ☐ Not sure

YEARS LIVED IN CANADA

A4. How long have you lived in Canada?

1 ☐ All of my life

2 ☐ 2 years or less
3 ☐ 3 to 5 years
4 ☐ 6 to 10 years
5 ☐ 11 years or longer

SOCIOECONOMIC STATUS

A20. Imagine this ladder below shows how Canadian society is set up. At the top of the ladder are people who are the "best off" – they have the most money, the most education, and the jobs that bring the most respect. At the bottom are the people who are "worst off" – they have the least money, little education, no jobs or jobs that no one wants.

Now think about your family. Please check off the numbered box that best shows where you think your family would be on this ladder.

10 ☐ **Best off**
09 ☐
08 ☐
07 ☐
06 ☐
05 ☐
04 ☐
03 ☐
02 ☐
01 ☐ **Worst off**

HEIGHT AND WEIGHT (TO DERIVE BODY MASS INDEX CATEGORY)

I11. What is your current height without shoes? Below is a list of heights in feet and inches, and the matching number in centimetres ("cm"). Please choose the height that is closest to yours.

☐ 4 feet 4 inches/ 132 cm **or less**
☐ 4 feet 5 inches/ 135 cm
☐ 4 feet 6 inches/ 137 cm
☐ 4 feet 7 inches/ 140 cm
☐ 4 feet 8 inches/ 142 cm
☐ 4 feet 9 inches/ 145 cm
☐ 4 feet 10 inches/147 cm
☐ 4 feet 11 inches/150 cm
☐ 5 feet 0 inches/ 152 cm
☐ 5 feet 1 inch/ 155 cm
☐ 5 feet 2 inches/ 157 cm
☐ 5 feet 3 inches/ 160 cm
☐ 5 feet 4 inches/ 163 cm
☐ 5 feet 5 inches/ 165 cm
☐ 5 feet 6 inches/ 168 cm
☐ 5 feet 7 inches/ 170 cm
☐ 5 feet 8 inches / 173 cm
☐ 5 feet 9 inches/ 175 cm
☐ 5 feet 10 inches/ 178 cm
☐ 5 feet 11 inches/ 180 cm
☐ 6 feet 0 inches / 183 cm
☐ 6 feet 1 inch/ 185 cm
☐ 6 feet 2 inches/ 188 cm
☐ 6 feet 3 inches/ 191 cm
☐ 6 feet 4 inches/ 193 cm
☐ 6 feet 5 inches/ 196 cm
☐ 6 feet 6 inches/ 198 cm **or more**

I12. What is your current weight without shoes? Below is a list of weights in pounds, and the approximate number in kilograms ("kg"). Please choose the weight that is closest to yours.

☐ 80 pounds/ 36 kg **or less**
☐ 81-85 pounds/ 37-39 kg
☐ 86-90 pounds/ 39-41 kg
☐ 91-95 pounds/ 41-43 kg
☐ 96-100 pounds/ 43-45 kg
☐ 101-105 pounds/ 46-48 kg
☐ 106-110 pounds/ 48-50 kg
☐ 111-115 pounds/ 50-52 kg
☐ 116-120 pounds/ 53-54 kg
☐ 121-125 pounds/ 55-57 kg
☐ 126-130 pounds/ 57-59 kg
☐ 131-135 pounds/ 59-61 kg
☐ 136-140 pounds/ 62-64 kg
☐ 141-145 pounds/ 64-66 kg
☐ 146-150 pounds/ 66-68 kg
☐ 151-155 pounds/ 68-70 kg
☐ 156-160 pounds/ 71-73 kg
☐ 161-165 pounds/ 73-75 kg
☐ 166-170 pounds/ 75-77 kg
☐ 171-175 pounds/ 77-79 kg
☐ 176-180 pounds/ 80-82 kg
☐ 181-185 pounds/ 82-84 kg
☐ 186-190 pounds/ 84-86 kg
☐ 191-195 pounds/ 87-88 kg
☐ 196-200 pounds/ 89-91 kg
☐ 201-205 pounds/ 91-93 kg
☐ 206-210 pounds/ 93-95 kg
☐ 211-215 pounds/ 96-98 kg
☐ 216-220 pounds/ 98-100 kg
☐ 221-225 pounds/100-102 kg
☐ 226-230 pounds/102-104 kg
☐ 231-235 pounds/105-107 kg
☐ 236-240 pounds/107-109 kg
☐ 241-245 pounds/109-111 kg
☐ 246-250 pounds/112-114 kg
☐ 251-255 pounds/114-116 kg
☐ 256-260 pounds/116-118 kg
☐ 261-265 pounds/118-120 kg
☐ 266-270 pounds/121-122 kg
☐ 271-275 pounds/123-125 kg
☐ 276-280 pounds/125-127 kg
☐ 281 pounds/127 kg **or more**

SCREEN TIME

I5. **In the LAST 7 DAYS, about how many hours a day, on average, did you spend watching TV/movies/videos, playing video/computer games, texting, emailing, or surfing the Internet in your free time?**

1 ☐ None
2 ☐ Less than 1 hour a day
3 ☐ 1 to 2 hours a day
4 ☐ 3 to 4 hours a day
5 ☐ 5 to 6 hours a day
6 ☐ 7 or more hours a day
7 ☐ Not sure

HOMEWORK TIME

A9a. **On average, how much time do you spend doing homework each week outside of school?**

1 ☐ No homework at all
2 ☐ Less than 1 hour per week
3 ☐ About 1 to 2 hours per week
4 ☐ About 3 to 4 hours per week
5 ☐ About 5 to 6 hours per week
6 ☐ About 7 or more hours per week

SEASON

BEFORE STARTING TO ANSWER THIS SURVEY, PLEASE INDICATE THE CURRENT TIME AND DATE.

TIME: ___ ___ : ___ ___ (For example, 10:05)

DATE: ___ ___ ___. ___ ___, 20___ ___ (For example, Dec. 05, 2016)

Appendix B. Collinearity Diagnostics for Covariates (Sex, Age, Race/Ethnicity, Years Lived in Canada, Socioeconomic Status, Body Mass Index Category, Screen Time, Homework, Season), *n*=5,709

Variable	VIF	SQRT VIF	Tolerance	R-Squared
sex	1.06	1.03	0.9409	0.0591
age	1.08	1.04	0.9255	0.0745
white	1.17	1.08	0.8558	0.1442
years_can	1.15	1.07	0.8705	0.1295
ses	1.05	1.02	0.9553	0.0447
bmi_cat	1.02	1.01	0.9816	0.0184
screen	1.02	1.01	0.9799	0.0201
hmwork	1.13	1.06	0.8844	0.1156
season	1.03	1.01	0.9718	0.0282
Mean VIF	1.08			

Appendix C. Cross-tabulations Pertaining to Significant Associations between Explanatory Variables and Covariates

GAMBLING STATUS AND SEX (*p* <0.001)

Gambling status	Sex at birth (male=1) Female	Male	Total
Non-gamb	.5593	.4407	1
	.746	.5602	.6508
	2397	1354	3751
Gambler	.355	.645	1
	.254	.4398	.3492
	880	1078	1958
Total	.488	.512	1
	1	1	1
	3277	2432	5709

Key: **row proportion**
column proportion
number of observations

```
Pearson:
  Uncorrected   chi2(1)         =  434.1508
  Design-based  F(1, 196)       =   32.7048     P = 0.0000
```

GAMBLING MODALITY AND SEX (*p* <0.001)

Gambling modality	Sex at birth (male=1) Female	Male	Total
Non-gamb	.5593	.4407	1
	.746	.5602	.6508
	2397	1354	3751
Land-bas	.3678	.6322	1
	.2382	.3902	.316
	845	919	1764
Any onli	.2333	.7667	1
	.0159	.0497	.0332
	35	159	194
Total	.488	.512	1
	1	1	1
	3277	2432	5709

Key: **row proportion**
column proportion
number of observations

```
Pearson:
  Uncorrected   chi2(2)         =  459.0015
  Design-based  F(1.86, 364.83) =   18.8210     P = 0.0000
```

SCREEN TIME AND GAMBLING MODALITY (*p* <0.001)

Screen time	Gambling modality Non-gamb	Land-bas	Any onli	Total
2 hours	.6931	.2832	.0236	1
	.3588	.302	.24	.3369
	1363	562	60	1985
More tha	.6097	.3498	.0405	1
	.5732	.6774	.7477	.6119
	2170	1156	129	3455
Not sure	.8645	.1275	.008	1
	.068	.0207	.0123	.0512
	218	46	5	269
Total	.6508	.316	.0332	1
	1	1	1	1
	3751	1764	194	5709

Key: **row proportion**
column proportion
number of observations

Pearson:
Uncorrected chi2(**4**) = **207.2850**
Design-based F(**3.38**, **662.92**) = **12.9069** P = **0.0000**

HOMEWORK TIME AND GAMBLING MODALITY (*p*=0.012)

Homework time	Gambling modality Non-gamb	Land-bas	Any onli	Total
No homew	.5997	.3595	.0409	1
	.063	.0777	.0842	.0683
	201	109	24	334
Less tha	.581	.3593	.0597	1
	.1286	.1638	.2594	.144
	559	302	47	908
About 1	.6559	.3027	.0413	1
	.2747	.2611	.3396	.2726
	1041	507	50	1598
About 3	.6411	.3309	.0279	1
	.224	.2381	.1915	.2274
	849	436	41	1326
About 5	.6828	.2936	.0235	1
	.1555	.1377	.105	.1482
	534	227	26	787
About 7	.7199	.2753	.0048	1
	.1543	.1215	.0204	.1395
	567	183	6	756
Total	.6508	.316	.0332	1
	1	1	1	1
	3751	1764	194	5709

Key: **row proportion**
column proportion
number of observations

Pearson:
Uncorrected chi2(**10**) = **147.5707**
Design-based F(**5.63, 1103.55**)= **2.7973** P = **0.0123**

BODY MASS INDEX CATEGORY AND SEX (*p*=0.026)

Body Mass Index category	Sex at birth (male=1) Female	Male	Total
Underwei	.6489	.3511	1
	.114	.0588	.0857
	397	165	562
Normal w	.475	.525	1
	.6225	.6557	.6395
	2140	1637	3777
Overweig	.4867	.5133	1
	.1755	.1764	.1759
	502	429	931
Obese	.4346	.5654	1
	.0881	.1092	.0989
	238	201	439
Total	.488	.512	1
	1	1	1
	3277	2432	5709

Key: **row proportion**
column proportion
number of observations

Pearson:
Uncorrected chi2(**3**) = **119.4549**
Design-based F(**1.60, 314.45**) = **4.0408** P = **0.0264**

SCREEN TIME AND BODY MASS INDEX CATEGORY (*p*=0.032)

Screen time	Body Mass Index category Underwei	Normal w	Overweig	Obese	Total
2 hours	.0898	.6753	.1697	.0653	1
	.3529	.3558	.3249	.2223	.3369
	187	1390	287	121	1985
More tha	.0847	.6358	.1705	.109	1
	.6048	.6083	.5932	.6745	.6119
	343	2229	594	289	3455
Not sure	.0708	.4486	.2815	.1992	1
	.0423	.0359	.0819	.1031	.0512
	32	158	50	29	269
Total	.0857	.6395	.1759	.0989	1
	1	1	1	1	1
	562	3777	931	439	5709

Key: **row proportion**
column proportion
number of observations

Pearson:
Uncorrected chi2(**6**) = **193.4935**
Design-based F(**3.99, 781.30**) = **2.6674** P = **0.0315**

HOMEWORK TIME AND SEX (*p* <0.001)

Homework time	Sex at birth (male=1) Female	Male	Total
No homew	.196	.804	1
	.0275	.1073	.0683
	113	221	334
Less tha	.3591	.6409	1
	.106	.1803	.144
	398	510	908
About 1	.4394	.5606	1
	.2455	.2984	.2726
	847	751	1598
About 3	.5385	.4615	1
	.2509	.2049	.2274
	844	482	1326
About 5	.5936	.4064	1
	.1803	.1176	.1482
	518	269	787
About 7	.6643	.3357	1
	.1899	.0915	.1395
	557	199	756
Total	.488	.512	1
	1	1	1
	3277	2432	5709

Key: **row proportion**
column proportion
number of observations

Pearson:
Uncorrected chi2(**5**) = **706.2515**
Design-based F(**2.53, 496.22**) = **14.9485** P = **0.0000**

HOMEWORK TIME AND YEARS LIVED IN CANADA (*p* <0.001)

Homework time	Years lived in Canada All of m	More tha	5 years	Total
No homew	.9018	.08	.0183	1
	.0782	.0353	.0218	.0683
	298	29	7	334
Less tha	.893	.0756	.0314	1
	.1632	.0704	.079	.144
	810	68	30	908
About 1	.797	.1356	.0674	1
	.2756	.239	.321	.2726
	1372	156	70	1598
About 3	.774	.1661	.0599	1
	.2233	.2442	.2379	.2274
	1086	166	74	1326
About 5	.7111	.2427	.0462	1
	.1337	.2326	.1195	.1482
	624	116	47	787
About 7	.7115	.1978	.0906	1
	.1259	.1785	.2208	.1395
	582	121	53	756
Total	.7881	.1546	.0573	1
	1	1	1	1
	4772	656	281	5709

Key: **row proportion**
column proportion
number of observations

Pearson:
Uncorrected chi2(**10**) = **350.5432**
Design-based F(**4.22, 826.75**) = **5.7903** P = **0.0001**

Appendix D. Examination of Gambling Frequency, All Activities (2017 Ontario Student Drug Use and Health Survey, *n*=5,709)

We explored gambling frequency as a continuous measure (total number of gambling sessions of any modality in the past year) and did not find significant evidence of an association between gambling and physical activity (adjusted for covariates).

pa_level	Odds Ratio	Std. Err.	t	P>|t|	[95% Conf.	Interval]
gamb_freq	1.003958	.0029689	1.34	0.183	.9981189	1.009831

Full frequency output is shown on the following page. Percentages are weighted.

gamb_freq	percentage	obs
0	66.15	3820
1	9.568	525
2	5.501	342
3	3.433	216
4	1.767	112
5	2.263	119
6	1.373	74
7	1.085	47
8	.6776	38
9	.4398	27
10	1.088	57
11	.4596	30
12	.5078	32
13	.3992	22
14	.555	21
15	.2593	17
16	.4998	14
17	.2893	9
18	.1991	13
19	.2657	6
20	.1414	8
21	.0856	7
22	.1154	8
23	.1222	9
24	.1357	8
25	.2045	11
26	.1055	4
27	.0624	7
28	.0052	1
29	.087	2
30	.1198	7
31	.0291	2

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32	.0151	1
33	.3445	7
34	.0117	1
35	.03	3
36	.0188	1
37	.0176	1
38	.0338	4
39	.0085	1
40	.0067	1
41	.0444	2
42	.0483	4
43	.01	1
44	0	0
45	.0541	3
46	.0174	3
47	.0203	1
48	.0241	1
49	0	0
50	.0292	3
51	.0453	5
52	.0151	1
54	.006	1
55	.0028	2
56	.0209	1
57	.0204	1
58	.0111	1
60	.0492	3
62	.0069	1
63	.01	1
66	.0144	1
67	.0053	1
68	0	0
71	.0148	1
75	.0084	1
77	.0073	1

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78	.0067	1
80	.0062	1
82	.0093	1
90	.0196	1
93	0	0
98	6.1e-04	1
99	.119	6
100	.0096	1
101	.0024	1
102	.0144	1
109	.0214	2
110	0	0
114	.0187	2
115	.0067	1
117	.0257	1
120	.0604	2
124	.4114	1
126	7.2e-04	1
127	.0171	1
131	.0173	1
145	.0272	1
167	.0958	1
171	.0065	1
198	.0054	1
207	.0958	1
208	.0189	1
212	0	0
215	.0106	1
229	.0092	1
407	0	0
472	0	0
Total	100	5709

Appendix E. Sample Characteristics – Participants per Gambling Activity (2017 Ontario Student Drug Use and Health Survey, *n*=5,709)

Participation per Gambling Activity	%*	*n**
Sedentary activities		
Betting money on CARD games	9.2	473
Betting money on DICE games	3.2	169
Betting money on other GAMES OF SKILL	7.4	387
Playing BINGO for money	4.2	259
Betting money in SPORTS POOLS or FANTASY SPORTS	9.7	456
Betting money on VIDEO GAMBLING MACHINES, SLOT machines, or any other gambling machines	3.5	183
Betting money at a CASINO in Ontario	0.3	15
Betting money on the results of a VIDEO GAME	7.2	391
Betting money on POKER ONLINE	0.9	34
Betting money on BINGO ONLINE	0.5	16
Betting money on SPORTS BETTING ONLINE	1.1	72
Betting money on OTHER ONLINE games	2.1	114
Betting money in OTHER ways not listed above	8.7	455
Non-sedentary activities		
Buying SPORTS LOTTERY tickets	1.9	101
Buying any OTHER LOTTERY TICKETS at a store	7.1	368
Betting money on a DARE or PRIVATE BET	11.4	720
Buying LOTTERY TICKETS ONLINE	0.3	17

*Percentages and subtotals listed above do not sum to 100 and 5,709, respectively, because many students participated in multiple activities (or none at all – not shown). Percentages are weighted.

Appendix F. Sample Characteristics, Student Gamblers – Participation in Sedentary and Non-Sedentary Gambling (2017 Ontario Student Drug Use and Health Survey, *n*=1,958)

Student Gambler Participation (Sedentary/Non-Sedentary/Both)	**%**	***n***
Only sedentary gambling activities	47.8	936
Only non-sedentary gambling activities	22.9	448
Both sedentary and non-sedentary gambling activities	29.3	574
TOTAL	**100**	**1,958**

Appendix G. Sample Characteristics – Participants per Racial-Ethnic Group (2017 Ontario Student Drug Use and Health Survey, *n*=5,709)

Racial-Ethnic Groups	%	n
White	54.6	3,335
Chinese	2.0	159
South Asian	5.5	373
Black	9.9	385
Aboriginal	0.6	57
Filipino	2.1	145
Latin American	2.4	98
Southeast	0.9	49
West Asian	6.6	234
Korean	0.6	20
Japanese	0.2	7
Not sure	2.9	199
Multiracial	11.7	648
Total	100	5,709

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