SOCIAL CONSEQUENCES OF OBESITY AMONG CANADIAN YOUTH

by

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Abstract

Background: The prevalence of obesity is increasing in all segments of our society. While research exists on the physical consequences of obesity, the social implications of childhood obesity require study. Those who are obese are visibly different from their peers and are more likely to experience physical and verbal abuse when compared with their normal weight peers.

Objectives: The objectives of the two studies comprising this thesis were to examine, 1) the temporal sequence between adiposity class and bullying involvement, and, 2) to determine whether the relationship between adiposity class and weapon carrying is mediated by bullying.

Methods: *Objective 1.* Participants were administered the *Health Behaviour in School-Age Children* Survey (HBSC) in 2006 and 2007. Study outcomes were self reports of: 1) physical bullying victimization and perpetration, and 2) relational bullying victimization and perpetration. Relationships between adiposity and the four forms of bullying were investigated in separate analyses using a repeated measures design. *Objective 2.* A cross-sectional analysis of the health experiences of 7877 Canadian children (11-15 years) using the 2006 HBSC survey was conducted. Relationships between adiposity status and weapon carrying were evaluated using multi-level logistic regression. Mediation by bullying involvement was assessed using standard methods.

Results: *Objective 1.* Adiposity class was shown to precede bullying involvement, with obese males reporting 2-fold increases in both physical and relational victimization, while obese females reported 3-fold increases in perpetration of relational bullying. *Objective 2*. Results suggest that overweight and obese males report increased odds of weapon carrying compared to their normal weight peers. Among obese males, partial mediation of this relationship was observed by acts of: physical victimization, relational victimization and physical perpetration. No such relationships were observed among female students.

Conclusions: *Objective 1.* Our study demonstrates the importance of adiposity status as a determinant of poor interpersonal relationships. These findings are congruent with previous cross-sectional studies, and confirm that obese youths are at increased risk of social consequences attributable to their appearance. *Objective 2.* Overweight and obese male students appear to be more likely to carry weapons for defensive and offensive purposes, a behavior mediated in part by bullying involvement.

Co-Authorship

This thesis presents the work of Atif Kukaswadia in collaboration with his advisors, Dr. William Pickett, Dr. Wendy Craig and Dr. Ian Janssen.

Manuscript 1: *Obesity as a Determinant of Two Forms of Bullying in Ontario Youth*. The study was based on a previous study performed by Dr. Janssen, Dr. Craig and Dr. Pickett. The idea of examining the focal relationship between adiposity class and bullying involvement using the longitudinal sample was Dr. Pickett's. The idea of using a repeated measures design was Dr. Miu Lam's. The writing of the manuscript, statistical analysis and interpretation of the results were the work of Atif Kukaswadia, with editorial feedback provided by Dr. Pickett, Dr. Craig and Dr. Janssen.

Manuscript 2: *Bullying involvement as a mediator of weapon carrying in obese youth*. The idea of using the *HBSC* to study weapon carrying among youth was Dr. Pickett's. The idea of testing bullying involvement as a mediator was Dr. Craig's. Atif Kukaswadia performed the statistical analyses, interpreted the results and wrote the manuscript with conceptual and editorial feedback from Dr. Pickett, Dr. Craig and Dr. Janssen.

Atif Kukaswadia wrote the other chapters of the thesis (introduction, background and literature review, general discussion and appendices), with editorial feedback and advice from Dr. Pickett.

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Glossary of Key Variables

Body Mass Index	BMI, or Body Mass Index, is a ratio of height to weight used to classify individuals as normal weight, overweight or obese. Units: kg/m^2
Physical Bullying	This is when a perpetrator causes harm to the victim through activities such as kicking, punching or pushing
Relational Bullying	This is when someone spreads malicious rumours or lies about the victim or can also include withdrawing friendship and social exclusion
Weapon Carrying	In this thesis, weapon carrying was defined as carrying either: 1) brass knuckles, 2) mace/pepper spray, 3) firearms or 4) sticks/clubs at school in the previous 30 days.

Chapter 1
Introduction

1.1 General Overview

Obesity is a rising problem in all segments of our society, and affects the young, the old and crosses racial and economic boundaries. Consequences of obesity can range from direct physical problems, including diabetes and musculoskeletal pain, to psychological symptoms, such as decreased self-esteem and depression. These adverse health outcomes may not manifest for several years. Of more immediate concern are the social ramifications of excess adiposity, such as discriminatory behaviours.

Two of the most notable discriminatory behaviours experienced by young people are bullying and weapon carrying. Bullying is a common problem in school-aged children, with approximately 36% of Canadian students involved in bullying as victims, 39% as perpetrators and 20% as both (1,2). *Physical bullying* is when a perpetrator causes harm to the victim through activities such as kicking, punching or pushing, while *relational bullying* is when someone spreads malicious rumours or lies about the victim and may also include withdrawing friendship and social exclusion (2).

Weapon carrying is an emerging social phenomenon in Canada. Seventeen percent of boys and four percent of girls reported carrying a weapon in 2006, with the vast majority carrying a knife (61% and 72% respectively (1)). Those involved in bullying are also more likely to carry weapons (3,4), with those who are victimized likely to use weapons defensively, while those who are perpetrators likely to use weapons as a means of intimidation (2,3).

Novel hypotheses that have been suggested are that; 1) adiposity is a potential determinant of interpersonal violence, such as bullying behaviour; and 2) this relationship emerges during developmental periods such as adolescence (2,5).

To account for the impact of excess adiposity on social interactions, Lerner proposed that the physical attributes of a person affects their psychosocial development and functioning (6). This model, entitled the "Dynamic Interaction Model," proposes that an individuals' appearance will affect how others react and respond to them in social contexts, affecting their self-esteem, self-concept and how they then act towards others. This basic theory underlies much of the work in this thesis.

One of the more notable studies that has linked adiposity and interpersonal violence was performed by Janssen *et al.* (2). This study found that overt and indirect bullying increased with increasing BMI (2). One limitation of this study was that it was cross-sectional in nature and thus could not demonstrate temporality. A second limitation is that it did not examine any consequences of bullying. Hence, my thesis was developed with two objectives: 1) to determine whether adiposity precedes interpersonal violence, thus extending the cross-sectional findings of Janssen *et al.* (2); and 2) to determine whether bullying involvement mediates the relationship between adiposity status and weapon carrying in youth.

Results from this thesis could inform the content of interventions aimed at reducing interpersonal violence, potentially making them more effective, while also adding to the understanding of the origins of youth violence. Given the long-term intrapersonal and interpersonal problems that can result from involvement in interpersonal violence, it is important that the underlying mechanisms that place individuals at risk of such violence, in this case adiposity status, are investigated.

1.2 Societal Importance

Increased adiposity class is accompanied by increased risks of numerous direct and indirect health consequences. By expanding our knowledge of obesity as part of the origins of youth violence, teachers and healthcare professionals can better deal with obesity as a warning sign for outcomes as diverse as interpersonal violence, psychosomatic complaints and depression (7).

This study is important for several reasons: 1) underlying causes of interpersonal violence among youth are not fully understood, and novel studies are required to investigate these etiological relationships; 2) adiposity has been suggested as a possible determinant in recent cross-sectional analyses; these findings require confirmation in longitudinal analyses; 3) interventions surrounding the prevention of bullying require a solid evidence base. My thesis provides new information that informs part of the content of such interventions.

1.3 Objectives and Hypothesis

This study investigates the associations between adiposity and interpersonal violence in children. Our specific objectives were to learn more about the relationships between adiposity and bullying, then adiposity and weapon carrying behaviour. This is a manuscript-based thesis and is organized as follows:

1.3.1 Manuscript 1: Obesity as a Determinant of Two Forms of Bullying in Ontario Youth

The objective of this manuscript was to confirm the findings of Janssen *et al.* (2), who found, cross-sectionally, that students who were obese or overweight were more likely to be involved in physical bullying than their normal weight peers, both as victims and perpetrators.

The current manuscript builds on these results by evaluating this relationship via a longitudinal analysis. Using the 2006 and 2007 Ontario subsample of the *Health Behaviour in School Aged Children* Survey, the relationships between the exposure (adiposity) in 2006 and the outcomes (physical and relational bullying) in 2007 were evaluated, and it was hoped that a temporal relationship between the variables could be confirmed. It was hypothesized that those that are obese at baseline are more likely to become victims or perpetrators of either form of bullying than their normal weight peers.

1.3.2 Manuscript 2: Bullying Involvement as a Mediator of Weapon Carrying in Obese Youth

The objective of this second manuscript was to examine the relationship between adiposity and weapon carrying in youth. Using the 2006 *Health Behaviour in School Aged Children* Survey, associations between adiposity and weapon carrying were evaluated. After controlling for school, home and neighbourhood factors separately, the impact of bullying as a mediator was assessed using Sobel's test of mediation. It was hypothesized that the focal relationship between adiposity status and weapon carrying is mediated by bullying involvement.

1.4 Thesis Organization

This thesis conforms to the Queen's University School of Graduate Studies and Research guideline "General Forms of Thesis" (8). The second chapter is a review of the literature surrounding interpersonal violence and its relationship with adiposity in this population. The third chapter of the thesis is brief description of the methods used, including the HBSC survey methodology and statistical methods employed. The fourth chapter is Manuscript 1, which analyzes the relationship between adiposity and two forms of bullying (physical and relational) in a longitudinal sample of school children in Ontario. This manuscript is in submission form for the journal *Obesity*. The fifth chapter is Manuscript 2, which investigates the relationship between adiposity and weapon carrying behaviour cross-sectionally in a sample of Ontario school children, and bullying involvement as a mediator of this relationship. This manuscript is in submission form for the journal *Pediatrics*. Chapter 6 contains a summary of both studies, and is followed by a general discussion and conclusions.

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Chapter 2
Background and Literature Review

2.1 Introduction

The purpose of this chapter is to introduce the child obesity problem in Canada, as well as its possible relation to interpersonal violence. In this context, “child” will refer to those in school ranging from 7 to 17 years of age, and will be used synonymously with “children,” “youth,” and “school-aged children”.

It has been shown that children as young as those in elementary school show a preference for those who appear physically similar to them, stigmatizing those who do not fit their preconceived notions of “normalcy” (1). Those who are obese are visibly different from their peers and thus are more likely to experience ostracization, physical and verbal abuse when compared with their normal weight peers, and this has been supported in the literature (2-5). These discriminatory behaviors can develop in youth and continue into adulthood, putting overweight and obese youths at increased risk for poor psychosocial adjustment during the growth period.

This review will summarize the literature surrounding adiposity and the key outcomes (bullying and weapon carrying) (Figure 1). First, the current obesity epidemic will be reviewed. Second, an analysis of the literature surrounding bullying, specifically, weight-based teasing, will be conducted. Third, weapon carrying will be investigated. Fourth, these three themes will be discussed and their relationship to each other considered. Finally, gaps in the literature and directions for future research will be identified. Those who are obese have been shown to be consistently more likely to be involved in both physical and relational bullying compared to their normal weight peers (2-5). This review will summarize previous research that has led to that assertion.

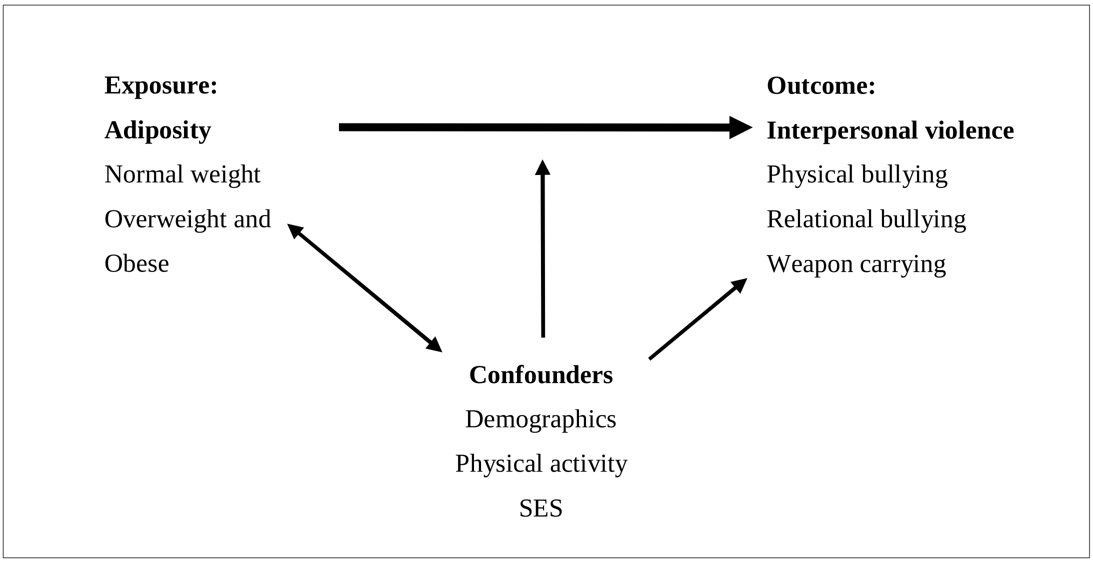

Figure 1: Conceptual model of the relationship between adiposity and interpersonal violence

2.2 Adiposity in youth

Overweight and obesity are growing issues for all sections of our society, affecting both genders and crossing lines of race, culture and SES. It is a multi-faceted problem, with implications ranging from direct physical consequences to discrimination by others. Of particular interest in this thesis is the extent to which adiposity affects interpersonal relationships. In this section, four themes will be discussed: 1) measurement of adiposity, 2) the scope of the obesity epidemic in Canada, 3) the physical and psychological consequences of excess adiposity and finally, 4) the social consequences of excess adiposity.

2.2.1 Measurement of adiposity

Body mass index (BMI) is a ratio of height to weight, and is a commonly used method of evaluating a person's health risks based on their physical characteristics (6). Adult cut-offs for overweight and obese are 25 kg/m^2 and 30 kg/m^2 respectively and are primarily related to the added risk of mortality that accompanies excess weight (7). Health risks increase in a curvilinear fashion as BMI increases, and while these standard cut-points exist for adults, these are not appropriate for children since children vary through the growth period (8).

As a result, a separate set of cut offs have to be determined for youths that take into account their changing bodies. Cole *et al.* conducted a cross-national survey that took data from several countries (9). Thus, these BMI values are culture-and-nation-independent, and were designed using growth curve modeling to pass through the adult BMI values for overweight (25.0 kg/m^2) and obesity (30.0 kg/m^2) at entry into adulthood at exactly 18.0 years of age (Figure 2) (9). These cutoffs were endorsed by the International Obesity Task Force and are used widely (10).

Adiposity status was determined by student self report for both manuscripts in this thesis. Validation for this method of data collection has been performed and despite the slight underestimation of BMI, it has been found that using self-reported BMI is a reliable method of examining the relationship between body weight classification and later outcomes (11-13). These measures are commonly used when providing population-level estimates of the prevalence of obesity due to the ease with which they can be acquired compared to other measures such as skin fold testing and dual energy X-ray absorptiometry.

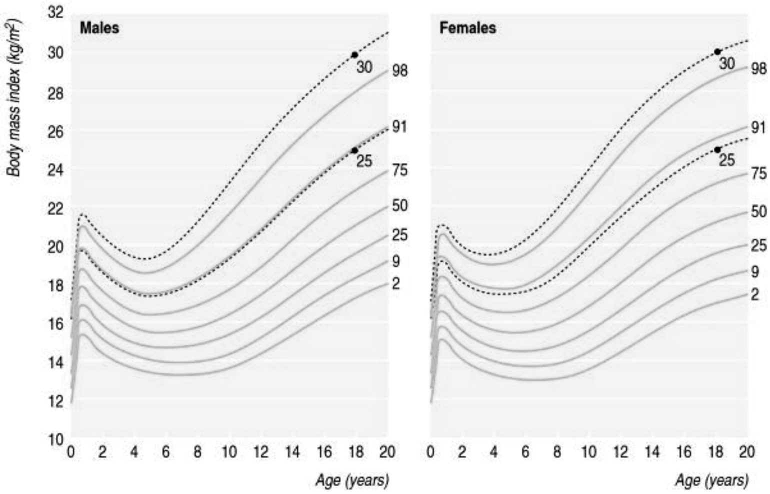

Figure 2: Internationally determined growth curves for children from ages 0 to 20. The solid lines indicate percentile distribution, while the dashed lines passing through 25 kg/m^2 and 30 kg/m^2 represent cut-offs for overweight and obese respectively. From Cole *et al.* (2000)

2.2.2 The prevalence of obesity in Canada

The prevalence of being overweight or obese is increasing in both the US and Canada (14,15). In Canada, being overweight or obese is very common, with a 2004 national survey finding that 18% of youths were overweight, while 8% were obese (16). From the years 1981 to 1996, the percentage of 7 – 13 year old boys classified as overweight in Canada increased from 11% to 33%, while the prevalence of being overweight among 7 – 13 year old girls increased from 13% to 27% in Canada (14). In the same time period, the percentage of obese boys and girls rose from 2% to 10% and 2% to 9% respectively (14). These represent two to five-fold increases, and occurred during adolescence, when children are very sensitive to the views and opinions of others. This recent increase highlights the importance of studying the physical, psychological and, particularly the social consequences of excess adiposity.

2.2.3 Physical and psychological consequences of excess adiposity

Excess adiposity can have effects on the physical health of the individual, and also in determining a healthy mental state. There are direct health risks associated with excess adiposity, such as cardiovascular and metabolic problems, musculoskeletal pain and increased blood pressure (8,17,18). In addition, children who are obese also suffer from psychological ailments, including decreased self-esteem (11) as well as symptoms consistent with depression (19). While the chronic conditions of obesity such as cardiometabolic disease and osteoarthritis may not develop for several years, this thesis is particularly concerned with more acute social factors associated with childhood obesity. Childhood obesity has been associated with increased risk taking behaviour, including solvent abuse and use of illicit drugs (18). In addition, obese youths may be discriminated against by their peers as early as preadolescence (2,20). Motivations behind these social behaviours are poorly understood, and may be driven by societal values.

2.2.4 Social consequences of excess adiposity

Obese individuals may suffer from stigmatization through the life span from their peers (2-5), family members (21), and even the medical community (21). These social stigmas occur despite the fact that childhood obesity is a highly prevalent condition (14,15), that is caused by several factors that are beyond a young persons control (e.g., genetics (22), parents' socioeconomic status (23), built environments (24)) and not merely a lack of personal willpower to engage in physical activity. These negative attitudes towards obese youths may manifest in antisocial interpersonal behavior (25), and are broad in scope, ranging from friendship choices (1,26), to romantic endeavors (5). These behaviours continue into adulthood, with obese adults reporting lower levels of acceptance and interpersonal discrimination (25). Validated measures of these antisocial constructs exist (13,27,28).

To account for the impact of excess adiposity on social interactions, Lerner proposed a theory by which the physical attributes of a person affects their psychosocial development and functioning in the “Dynamic Interaction Model” (29). This model proposes that an individuals’ appearance will affect how others react and respond to them in social contexts, affecting their self-esteem and subsequent self-concept. Empirical support exists for this theory (26). Decreased self-esteem has a negative impact on self-concept and leads to depressive symptoms in adolescents (11). Given the importance placed on physical attractiveness by society, adolescents who are considered physically unattractive are at high risk for developing a poor self-concept that may remain with them for their life. At a time when youth are particularly vulnerable to the views and opinions of others, this raises concerns for a healthy transition to adulthood (3). These interactions can manifest in many ways, and one manifestation of this is bullying.

2.3 Bullying

Bullying is a mechanism by which perpetrators establish dominance over their victims and tends to occur between individuals that know each other (30). This behaviour involves two major aspects: 1) there must be a power disparity between the victim and the perpetrator and 2) the behaviour must occur several times, with the intention of the perpetrator firmly establishing their authority over the victim (30). With repeated bullying, the perpetrator solidifies their power over the victim, resulting in the victim feeling powerless to defend themselves from this aggressive behaviour. Bullying was operationally defined in the 2005/2006 Health Behaviours in School Aged Children Survey (HBSC), as:

> "**BEING BULLIED** is when another student, or a group of students, say or do nasty and unpleasant things to him or her. It is also bullying when a student is teased repeatedly in a way he or she does not like or when he or she is deliberately left out of things. But it is **NOT BULLYING** when two students of about the same strength or power argue or fight. It is also <u>not</u> bullying when the teasing is done in a friendly and playful way."(31)

This survey used questions developed by Olweus to evaluate bullying behaviours in youth (32). These questions have been shown to be accurate when estimating the prevalence of bullying in youth (33). Defined types of bullying are: physical, relational, verbal, cyber and sexual harassment. This thesis is concerned with physical and relational bullying. Previous longitudinal studies have examined these forms of bullying due to their high prevalence (2), especially since their prevalence differs markedly between males and females (4,5,30). *Physical bullying* is when a perpetrator causes harm to the victim through activities such as kicking, punching or pushing, while *relational bullying* is when someone spreads malicious rumours or lies about the victim and may also include withdrawing friendship and social exclusion (4).

In this section, two themes will be investigated: 1) the prevalence of, and gender differences in, bullying involvement; and 2) consequences of bullying involvement.

2.3.1 The prevalence of, and gender differences in, bullying involvement

Boys and girls differ significantly in the types of bullying that they are involved in. In Canada, boys are much more likely to be physically victimized, with 44% of boys reporting being physically victimized, compared to 32% of girls [$p<0.01$] (30). Girls are more likely to be perpetrators of relational abuse than boys (63% in girls vs 42% in boys [$p<0.001$] (30)), which includes behaviors such as spreading rumours and lies about each other, as well as exclusion from social activities and groups (4). It has been hypothesized that this is due to the perpetrators targeting that which is important to their gender, with boys valuing physical dominance and girls valuing close, intimate relationships. This is illustrated by girls experiencing higher levels of relational aggression (for example, spreading false rumours and social exclusion) (34), and boys experiencing higher levels of physical aggression.

Differences also exist in the duration of bullying once it starts. While Craig *et al.* found the same percentage of victims report being bullied for several years (23% in boys and girls), they also found that significantly more boys reported being bullied for a week or less (40% in boys compared to 23% in girls [$p < 0.01$] (30)). Even with these differences, both girls and boys are significantly more likely to victimize those that are obese or overweight physically compared to those of normal weight (2,4,35). Due to all of these factors, gender specific analyses of this topic are warranted, as gender is suspected to be an effect modifier for bullying involvement.

2.3.2 Consequences of bullying involvement

Bullying can lead to both physical and social problems if not addressed at an early stage. Some of the consequences of bullying include being in physical fights, being injured as a result of a physical fight, carrying a weapon, and carrying a weapon at school (36). This has been shown for both bullies and victims (36). While these problems may be considered acute in nature, the social ramifications of bullying involvement in youth can extend into adulthood.

Bullying involvement has been shown to increase the odds of poor social and emotional adjustment (37). In addition, children who bully others are more likely to be involved in other problem behaviours, such as underage drinking, smoking, as well as poor academic achievement (37,38). Perpetrators of bullying behaviours may continue to bully others as they age, in work and other situations, including sexual harassment and marital aggression (39). Perpetrators of bullying are also more likely to be involved in criminal behaviour in adolescence and adulthood

(36,40,41). These problems need to be addressed in youths. Risk factors for bullying involvement should be identified to prevent bullying from continuing through the lifespan.

2.4 Weapon Carrying

Weapon carrying is a dangerous behaviour, as well as a marker for later violent behaviours. Carrying a weapon at school can result in expulsion from schools (42), however, despite this, 17% of boys, and 4% of girls reported carrying weapons to school on the 2006 HBSC survey in Canada (27), although a decrease in the prevalence of weapon carrying and violent crimes has been observed in Canada since a peak in 1991 (43,44). The category of “weapons” is broad, and includes: knives, brass knuckles, mace/pepper spray, firearms and sticks/clubs. Some of these weapons could be used for non-offensive purposes, such as knives in rural environments. However, the remaining weapons clearly have dangerous offensive potential.

Highlighting the problems that can arise from weapon carrying at school are recent statistics from the Canadian Centre for Justice Statistics. The Centre estimates that 13% of all youth crimes occur on school property, and 7% of school crimes involve a weapon of some description (44). Weapon carrying in youth is a problem that can continue through the lifespan, burdening the legal and penal systems as these youths are at higher risks of incarceration and armed violence (45-47). In order to reduce weapon carrying at schools, and to prevent these later health problems from developing, potential determinants of weapon carrying need to be understood.

2.4.1 Risk factors for weapon carrying

Potential determinants of weapon carrying at school include: the school environment (48), bullying involvement (36,49), and the perception that other students are carrying weapons

(50). The latter factor may be motivated both by a perceived need for self-defense, and also the perception that weapon carrying is a normative behaviour (50). However, contradictory research exists, from a study using the National Longitudinal Study of Adolescent Health that found no effect of community-level factors on student weapon carrying (51). Individual-level factors, such as being threatened with a weapon, being robbed in school and fear for personal safety may be affecting the likelihood of weapon carrying among students (50).

One of the major determinants of weapon carrying in youth is being in a physical fight. Physical fighting has been consistently associated with increased odds of weapon carrying, with those involved in fights having 2.02 times the odds of carrying a weapon (95% CI: 1.56-2.63) (52), although contradictory evidence does exist from a similar study reporting that those involved in fights have 0.87 times the odds of weapon carrying (no 95% CI given) (51). In addition, those who carry weapons are more likely to be injured while fighting. This finding is consistent across cultures, countries and genders (45,47).

2.5 How do adiposity, bullying and weapon carrying relate?

Evidence has consistently shown that obese youths have higher risks of victimization by bullying compared to their normal weight peers. There are also marked sex differences in involvement; males are more vulnerable to physical victimization, while females are more vulnerable to relational victimization (2-5). These discriminatory behaviours are due to those who are obese not meeting physical ideals set by peers and society at large. Involvement in bullying can have wide ranging consequences, which can impact psychological, emotional and social development in youth.

Some of the possible health effects of bully-victimization include decreased self-esteem (11) and increased reporting of symptoms consistent with depression (19). A potential coping mechanism that youths may employ to protect themselves from bullying is weapon carrying (36,49). A study performed in the US using the 2002 *Health Behaviour in School Aged Children* survey showed that youths bullied weekly have 1.6 times the odds of weapon carrying in school (95% CI: 1.2-2.2) compared to those not bullied, and perpetrators of bullying behaviour show 3.2 times the odds of weapon carrying (95% CI: 2.3-4.3) (36,37). This observed increase in odds of weapon carrying in school occurred regardless of whether the student was bullied in or outside of school (36). For victims, this is likely for protection (36). A strength of the study by Nansel *et al.* was that it was also able to investigate the effects of bullying involvement outside of the school environment in addition to bullying within schools. Those who were bullied away from school were more likely to carry weapons, more likely to be involved in physical fights, and more likely to be injured from their fight involvement (36). This is hypothesized to be a result of decreased adult supervision.

This potential coping strategy is concerning as youths caught carrying weapons on school property risk suspension (42). More importantly, weapon carrying during adolescence is indicative of violent offenses in young adulthood (e.g., armed violence) and is predictive of future incarceration (45-47). It is currently unknown whether adiposity is an independent predictor of weapon carrying, or if this relationship is mediated by bullying involvement. If obese youths are resorting to weapon carrying as a result of bullying involvement, then motivations that underlie this behavior need to be understood and prevented.

2.6 Summary and directions for future research

There is an obesity epidemic occurring in the Western world. Childhood obesity could later result in a multi-faceted problem for our healthcare system; with implications ranging from an increased burden on our healthcare system to psychological symptoms for those affected by interpersonal violence. Two gaps identified in the literature include: 1) the lack of prospective cohort studies that can evaluate temporality between obesity and interpersonal violence, 2) comorbid determinants of excess adiposity.

A shortcoming of the current obesity literature is that most studies are cross-sectional in nature (36). As a result, temporality between obesity and later social outcomes, such as bullying, cannot be determined. For example, isolated youths may be victimized more, but they may also be avoiding others for fear of victimization (37). This would not be clear from a cross-sectional analysis.

A combination of factors is suspected to be responsible for increases in adiposity among our youth, with increased inactivity (4,53) and unhealthy dietary patterns (18,54,55) suspected to be main risk factors for later obesity. These factors have also been investigated longitudinally, showing that these factors individually predict increased later obesity (56). However, these factors are also intertwined with other potential risk factors, including SES, ethnicity and urban/rural status. These clusters of risk factors need to be investigated to tease out their potential effects, or determine if they act as part of a larger factor. This has particular significance for public health researchers; as if this is found to be true, then interventions need to be expanded to consider these factors in tandem and not in isolation. Knowing the clusters of risk factors associated with excess adiposity may also help develop a better understanding for the psychosocial outcomes that may occur.

One of the potential outcomes of excess adiposity is interpersonal violence (4,5). While previous research has examined adiposity and bullying cross-sectionally, further research is required looking at adiposity as a predictor of later bullying involvement. Bullying and weapon carrying both have very serious consequences, and being able to better understand why these issues occur will help inform public health professionals and educators. Using newly developed statistical techniques that allow us to sample and analyze data accurately from individuals in widely disparate walks of life, these relationships can be evaluated.

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Chapter 3
Methods

The purpose of this chapter is to describe the *Health Behavior in School-Aged Children* Survey, as well as the statistical methods used in this thesis.

3.1 The *Health Behaviour in School-Age Children Survey* (HBSC)

The *HBSC* survey is an international survey coordinated by the World Health Organization that aims to measure the health of youth in developed countries on dimensions of health behaviours, outcomes and social resources. Currently, there are 41 different European, North American and other countries involved in the *HBSC* survey. The research within this thesis involved analysis of data from both the 2005/06 Canadian *HBSC*, and the 2005/06 - 06/07 longitudinal *HBSC* Ontario subsample.

3.1.1 The Canadian *HBSC* Survey Procedures

Two separate *HBSC* surveys were used in this thesis and will be dealt with in turn. The Canadian national *HBSC* survey sampled 9672 students from 188 schools across all provinces and territories. A systematic, single-stage cluster sampling approach was employed to select classes of students from across Canada. As per the international *HBSC* protocol (1), the sample is self-weighting. The number of classes in specific schools was estimated based on: the number of teachers, the number of grades, the total number of students and enrolment by grade. The first three factors were sampled at the school level, while the last was sampled at the provincial level. Classes were systematically selected based on the school jurisdiction, province, language, public/Roman Catholic designation, community size and location. This gave each class an approximately equal chance of being selected. The schools in the national sample were selected to be representative of the Canadian population of youth aged 11-15 years. Youth in private, special needs or those who were home-schooled were excluded from the sample. In addition, youth that were institutionalized, incarcerated or homeless were not sampled.

The longitudinal subsample was a convenience sample of 17 Ontario schools sampled during the administration of the national *HBSC* survey. Of these schools, 16 were followed up in 2007 (one withdrew due to a student death the week of the survey). Youth in Ontario who were participating in the follow-up survey were assigned a unique identifier to ensure that they could be followed up at Time 2 (2006/07). This was kept at the school, in the principals' offices.

3.1.2 Ethical Approval of the Survey

The Queen's University Research Ethics Board approved the study. Consent was also sought from the school board and each individual school. The study used an active consent procedure for acquiring parental consent, in which parents or guardians were sent letters asking for consent. Finally, the child's consent to participate in the study was acquired. Approximately 74% of students in the sample participated, and only 10% of students declined to participate or spoiled the questionnaire. Other non-participants were students who failed to return the parental consent form, who did not receive parental consent or who were absent on the day the survey was administered.

Teachers administered the 40-minute pen and paper survey during class time, typically within the classroom setting. The students sealed unsigned surveys in envelopes themselves, thus ensuring the anonymity of their responses.

3.1.3 Validity and Reliability

The main variables under study for this thesis include: body mass index, bullying involvement and weapon carrying. All questions have been piloted for face validity and focus groups were administered the questions to ensure that the target population could understand the questions.

The questions used for assessing BMI relied on student self-report of height and weight. Brener *et al.* have shown that BMI is underestimated in this population, and this may bias our effect estimates towards the null (2).

The HBSC bullying questions were developed originally by Olweus and have been shown to provide accurate estimates of prevalence (3). These questions have been shown to be internally consistent, and are appropriate for use across cultures (4). Two specific forms of bullying were investigated in both manuscripts. Physical bullying perpetration was assessed through a single question: "*I hit, kicked, pushed, shoved around, or locked another student(s) indoors.*" Two questions were asked about relational bullying perpetration: 1) "*I have kept another student(s) out of things on purpose, excluded him or her from my group of friends, or completely ignored him or her,*" and 2) "*I spread false rumours about another student(s) and tried to make others dislike him or her.*" Affirmation of either or both of these relational bullying questions indicated relational bullying perpetration. Analogous questions were also used to assess victimization by the two forms of bullying, for a total of four measures of bullying involvement.

Finally, questions on the HBSC survey pertaining to weapon carrying were developed initially for the *Youth Risk Behavior Survey* and have demonstrated reliability (5). Two questions were asked about weapon carrying; one regarding the duration of weapon carrying, and the other about the type of weapon carried. Both referred to the school context. The second question was chosen in order to exclude knives from our analyses. Since knives can be carried for religious, cultural or recreational purposes, they were excluded from subsequent analyses.

3.2 Statistical Analysis

Two major statistical methods were employed in this thesis: multi-level logistic regression and mediation analysis. All estimates of association in this thesis were calculated using multi-level logistic regression which provided odds ratio estimates. In addition, the potential mediating effect of bullying on the relationship between adiposity and weapon carrying was considered.

3.2.1 Multi-level modeling

Much of the research surrounding health behaviours in school-aged children uses information derived from several schools within a geographical area, such as a school board, province or state. It is expected that the students within a school will be more similar than those between schools, and this would result in clustering of the data. Clustering will erroneously reduce the standard error and result in a higher likelihood of incorrectly rejecting the null hypothesis if not accounted for (Type 1 error) (6).

Multi-Level Modeling is a statistical technique that controls for the effects of clustering, as well as allowing the examination of variables at multiple levels (7). As a result, environmental and individual level variables can be considered in tandem when developing a model, adding considerably to the statistical robustness of the model. It must be noted here that traditional multi-level modeling was not employed in this thesis, where higher order factors are used to predict individual level effects. Instead, a multi-level framework was employed to control for the clustering of our data.

Both manuscripts controlled for clustering at two levels. A between-students level was considered, which compared a student to their peers, and a between-schools level was considered. In addition, for the first manuscript, students were administered the test at two separate points in time. In order to control for the effects of time and changing levels of covariates, a repeated measures analysis strategy was employed, forming a within students level for the multi-level model. Thus the first manuscript contains three levels: a within students level, a between students level and finally a between schools level. While the repeated measures approach did allow for us to control for the effects of time, it cannot demonstrate temporality between the exposure (obesity status) and outcome (bullying involvement).

All analyses were performed using SAS version 9.1.3 and the PROC GLIMMIX procedure (SAS Institute Inc., Cary, NC). A major strength of this procedure is that it allowed for random effects to be considered at the various levels, as opposed to fixed effects.

3.2.2 Mediation

Mediation is a mechanism by which variables that affect an exposure-outcome relationship can be examined (8). Mediation can be used to explain how “external physical events take on internal psychological significance” (9). For example, the impact of a management training program on worker satisfaction may be mediated by employee attitudes towards management (10). Figure 1 illustrates simple mediation. For this thesis, the outcome variable was weapon carrying behaviour at school, the independent variable was adiposity status, and bullying involvement was the mediating variable.

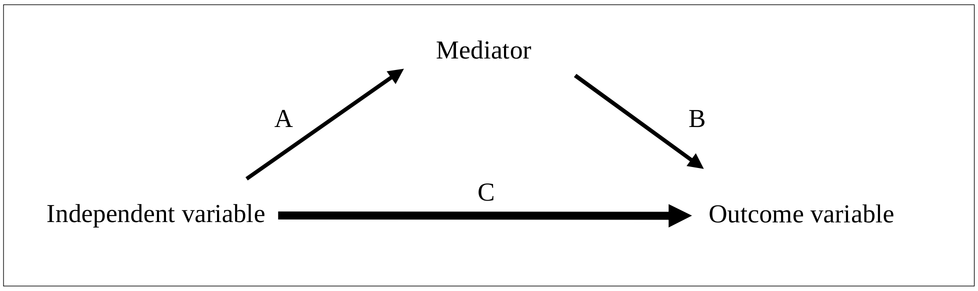

Figure 1: A single mediator model (illustration from Baron and Kenny, 1986 (9))

In order for indirect or mediated effects to be considered, three conditions must be satisfied:

1. The exposure must be significantly associated with the outcome (i.e. Path C)
2. The independent variable must significantly affect the mediating variable (i.e. Path A)
3. The mediator must significantly affect the outcome variable, while controlling for the effects of the independent variable (i.e. Path B)

If these criteria are met, then Sobel’s test of mediation can be conducted, and the result will show whether the mediation suspected is statistically significant (11). Perfect mediation occurs when a relationship between two variables disappears upon the inclusion of a third variable (10), while Sobel’s test evaluates whether the mediation observed is statistically significant. Mediation is distinct from the concept of a confounder, as a mediating variable can be part of the causal chain, while a confounder cannot.

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Chapter 4
Manuscript 1: Obesity as a Determinant of Two Forms of Bullying in Ontario Youth

This manuscript conforms to the specifications for submission to the peer-reviewed journal *Obesity*.

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Running head: Temporality between obesity and bullying

Abbreviations: HBSC, *Health Behaviour in School-Aged Children Survey*; BMI, body mass index; OR, odds ratio; RR, relative risk; CI, confidence interval.

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Abstract

Negative stigma and discriminatory behavior may stem from socially undesirable `appearances, such as excess adiposity. These social attitudes may manifest as bullying behavior. Previous cross-sectional studies have shown that overweight and obese youths are more likely to be involved in bullying. Here, we examine relationships between obesity and bullying in a longitudinal analysis. We studied the health experiences of 1738 youth from 17 Ontario high schools. Participants were administered the *Health Behaviour in School-Age Children* Survey in 2006 and then again in 2007. Study outcomes were self reports of: 1) physical bullying victimization and perpetration, and 2) relational bullying victimization and perpetration. Relationships between adiposity and the four forms of bullying were investigated in separate analyses. Focal relationships between adiposity and bullying experiences were evaluated using a repeated measures multi-level logistic regression that accounted for clustering at the school level.

We found that obese males reported 2-fold increases in both physical and relational victimization, while obese females reported 3-fold increases in perpetration of relational bullying. In addition, excess adiposity was shown to precede bullying involvement in this study. Among those free of bullying at baseline (2006), significant increases in perpetration of relational bullying were reported by obese females in 2007 ($p = .02$). Our study demonstrates the importance of adiposity status as a determinant of poor interpersonal relationships. These findings are congruent with previous cross-sectional studies, and confirm that obese youths are at increased risk of social consequences attributable to their appearance.

Introduction

Interpersonal violence is a contemporary adolescent health problem and novel research is required to examine its determinants. Adolescents involved in interpersonal violence during their youth are more likely to be violent during adulthood (1,2). Of more immediate interest, is how antisocial behaviors can be established as early as pre-adolescence (3) or even preschool (4), and manifest themselves in various forms of bullying. This may affect a child's self-esteem and subsequent self-concept during their adolescent years.

Bullying is a common problem in the Canadian school system, with approximately 25 - 27% of students involved in bullying as victims, 24 - 32% as perpetrators and 19 - 21% as both (5). Of particular concern are physical and relational forms of bullying due to their high prevalence among males and females respectively (5). Physical bullying includes behaviors such as punching, kicking and shoving. Relational bullying includes spreading false rumors or social exclusion (6).

The physical appearance of children is one of many possible determinants of bullying experiences (3,6). These etiological relationships can be explained through the "Dynamic Interaction Theory" proposed by Lerner (7). This model suggests that an individual's appearance, and particularly their adiposity status, affects how others react and respond to them in social contexts, possibly through behaviors such as bullying. Relationships between obesity and bullying have been demonstrated in cross-sectional analyses of adolescent populations (6,8,9). There is a need for longitudinal confirmation of these cross-sectional findings.

The current analysis explored the temporal sequence between adiposity status and reports of bullying. Based upon the past cross-sectional work (6,8), we hypothesized that males who are obese at baseline would be more likely to become victims and perpetrators of physical bullying, and that obese females would be more likely to be relationally victimized. In theory, increased adiposity would make obese youths targets for physical bullying; however, it would also help those involved in physical bullying dominate their peers at key developmental stages of life. For relational bullying, increased adiposity status poses no advantage, but children could still be victimized for not meeting physical ideals (7).

Methods and Procedures

Survey and Study Population

Health Behaviour in School-Aged Children (HBSC) is an international survey conducted in affiliation with the World Health Organization (10). The survey examines the health, well-being, and health behavior experiences of adolescents between the ages of 11 to 15 across member nations (41 nations in 2006) (5). The 2006 Canadian HBSC involved 186 schools and 9672 students (for a full description, see Boyce *et al.* (5)). Seventeen schools in Ontario agreed to a special follow-up study in 2007. Of these, 16 schools were surveyed again in 2007 (one withdrew due to a student death), making 2031 students available for longitudinal analyses. The present study focused on these 2031 students: 293 were further excluded based on; missing height and weight data (n = 271), no date of birth information (n = 15), implausible height information (n = 2) or implausible changes in heights or weights (n = 5), leaving a final sample of 1738 students (85.6%).

Survey Methods

Body Mass Index and Obesity Classification

In order to calculate body mass index (kg/m^2) (11), heights and weights were provided by self-report. While standard BMI cut-points exist for adults, these are not appropriate for children (12). Cole *et al.* have proposed an international set of growth curves appropriate for children that are culture-and-nation-independent (11). Children were classified as normal weight, overweight or obese based on age-and-sex specific half-year cut points; endorsed by the International Obesity Task Force (13). Such measures of self-reported BMI in children are consistently associated with later health outcomes, despite slight underestimation of BMI, especially among girls (14-16).

Bullying

The HBSC bullying questions were developed originally by Olweus and have been shown to provide accurate estimates of prevalence (17). These questions are internally consistent, and are appropriate for use across cultures (18). Cut-off values for these questions were determined based on prior research and theoretical hypotheses showing that frequent bullying has different health consequences to occasional bullying (17). Children were asked questions about both perpetration and victimization of bullying behavior, with possible cut-offs of: *"never"*, *"once or twice"*, *"2 or 3 times a month"*, *"once a week"* or *"greater than once a week"*. As per existing precedents (17), bullying involvement was dichotomized ("*less than once a month*" vs. "*greater than or equal to 2 or 3 times a month*"); the latter category is indicative of serious cases of bullying (10).

Two specific forms of bullying were investigated. Physical bullying <u>perpetration</u> was assessed through a single question: "*I hit, kicked, pushed, shoved around, or locked another student(s) indoors.*" Two questions were asked about relational bullying <u>perpetration</u>: 1) "*I have kept another student(s) out of things on purpose, excluded him or her from my group of friends, or completely ignored him or her,*" and 2) "*I spread false rumours about another student(s) and tried to make others dislike him or her*." Affirmation of either or both of these relational bullying questions indicated relational bullying perpetration. Analogous questions were also used to assess <u>victimization</u> by the two forms of bullying, for a total of four measures of bullying involvement.

Covariates

Several potential confounders were considered in the analysis of focal relationships between adiposity and bullying. These included measures of: gender, life satisfaction, socio-economic status (SES), physical activity and "screen time" (19). All analyses were stratified by gender, as several studies have established that the sexes differ significantly in bullying involvement (3,6,20). Life satisfaction was measured using the Cantril Ladder (10). Life satisfaction is a proxy measure of psychosocial resources (21). These may impact a student's ability to cope with bullying victimization, or resist becoming a perpetrator of bullying behavior. Socio-economic status was measured via the Family Affluence Scale, a composite and validated score of material wealth, characterized using existing guidelines (10,22). Physical activity was measured through ordinal response categories for the number of days in a week with more than 60 minutes of moderate to vigorous physical activity. This was characterized as either; "*less than 30 minutes a day*," "*30-60 minutes a day*" or "*greater than 60 minutes a day*." While physical activity levels tend to be over-reported, reports of the number of days with 60 minutes of more physical activity are generally accurate (23). Screen time is the sum of self-reported time spent watching television, playing video games and using a personal computer daily. While screen time may be underestimated, previous studies have shown that these underestimates are minimal (19).

Statistical Analyses

Descriptive analyses were performed to profile the study population by sex, adiposity class and bullying involvement at Time 1 (2006) and Time 2 (2007). Second, a repeated measures multi-level logistic regression model was employed to quantify associations between adiposity and bullying involvement. This was performed using SAS version 9.1.3 and the PROC GLIMMIX procedure (SAS Institute Inc., Cary, NC).

The multi-level model consisted of three levels: 1) within students, 2) between students and 3) between schools. Students were administered the test at two time points. Using a repeated measures approach, any changes between Time 1 and Time 2 for each individual student could be controlled. This formed the “within students” level of the multi-level model. The second level controlled for any variation between students. Finally, the third level considered clustering that may occur within schools. Since schools may have students of similar backgrounds, this may impact our findings due to students within a school being more similar than those in other schools.

A backward elimination process with a 10% change in effect estimate criteria was used to identify covariates to be retained in the model (24). Thus, the adjusted model controlled for screen time and life satisfaction. Age (25,26) and family affluence status (3,27) were also forced into the adjusted models based on literature-based precedents. All odds ratios and 95% confidence intervals were estimated using the normal weight group as the referent group.

Third, an exploratory sub-analysis was conducted among children who reported that they were free of the bullying outcome of interest (measured in 2007) at baseline (2006). Incident cases of each type of bullying in 2007 were identified and contrasted across baseline adiposity groups. Analyses involved cross-tabulations and Fisher’s Exact Test.

Results

Table 1 profiles the demographic characteristics of the study sample. At both time points approximately one-quarter of males and one-seventh of females were overweight or obese. Sixteen percent of males changed BMI category between Time 1 and 2, while only ten percent of females change BMI category in the same time period. Interactions between adiposity class and year of survey administration were found to be statistically non-significant, and were not further considered.

Prevalence of bullying

Males reported higher levels of bullying involvement than females for: physical victimization (2006; 4.4% vs. 1.6%), physical perpetration (2006; 5.3% vs. 0.9%) and relational perpetration (2006; 5.1% vs. 2.6%). At Time 1, females reported higher levels of relational victimization than males (10.8% vs. 6.9%, Table 2). Similar results were found at Time 2.

Adiposity and bullying

Among males, increased odds of bullying involvement were observed in association with higher adiposity class for physical victimization and perpetration, though neither of these represented significant increases with increasing adiposity class ($p = .17$ and $.30$ respectively). Trends towards significance were observed for relational victimization among males ($p = .07$).

Overweight and obese females reported 1.29 (0.58 - 2.86) and 2.98 (1.03 - 8.61) times the relative odds of relational bullying perpetration respectively, and this trend tended towards significance ($p = .06$) (Table 3). No other significant trends were identified among females.

Incident cases of bullying

Among those free of bullying in 2006, no significant differences in the proportion of incident cases of bullying were reported by males in 2007 by adiposity class (Table 4). However, trends were seen for physical victimization, with 3.0% of normal weight youth who were not victimized at Time 1 experiencing victimization at Time 2. This rose to 3.8% and 7.5% among overweight and obese males respectively (Table 4). Among females, significant differences were found for relational perpetration, with the highest levels reported among the obese ($p = .02$, Table 4).

Discussion

This study confirmed that obese males experienced 2-fold increases in odds of victimization due to two major forms of bullying. Obese females reported weaker yet similar increases in odds of victimization. In addition, obese females reported 3-fold increases in relational perpetration. These findings are congruent with previous cross-sectional studies (6,8,9) and confirm that obese children are at risk for social consequences attributable to their appearance, consistent with Lerner's Theory of Planned Behavior (7).

Our study findings are important as increased involvement in bullying is associated with other forms of interpersonal violence as children grow and develop. Victimization due to bullying can lead to engaging in and being injured from physical fights, and weapon carrying for self defence (28). Perpetration of bullying behavior can manifest in adolescence and adulthood in forms such as sexual harassment and marital aggression (29). In addition to this, perpetrators of bullying are also more likely to be involved in criminal behavior (2,28,30) . Thus, these relationships have long-term health and social consequences, especially during critical periods of the life course.

Important gender differences were observed in our findings. Boys and girls differ significantly in the types of bullying that they participate in. In Canada, boys are much more likely to be bullied physically, while girls are more typically involved in relational bullying (31,32). This may be attributable to perpetrators targeting that which is important to their peer group, with boys valuing physical dominance over their peers and girls valuing close, intimate relationships (33). Both girls and boys are significantly more likely to victimize those that are obese or overweight physically compared to those of normal adiposity status, and this was observed in this study for obese youth (3,6). Interventions aimed at such differences have shown mixed receptiveness to anti-bullying interventions by gender, with some studies showing no differences following interventions (34), and others favoring either girls (35,36) or boys (37). However, clearly such differences exist in experiences with bullying by gender.

This study has several strengths. First, the repeated measures design represents a basic form of longitudinal analysis, while most existing studies are cross-sectional in nature (6,8,9). Second, past longitudinal studies of this issue have been conducted previously in the very young (elementary students aged 7.5 to 8.5) (3). Results from adolescents (our study) and the younger context (past studies) are consistent. Hence, obese youth may face bullying experiences throughout key developmental periods. Third, our study controlled for several established confounders (10,22,26,27), using validated methods and measures (14-17,38). Fourth, since the HBSC survey instrument has been standardized internationally, study results are potentially reproducible in other countries, as well as at a provincial level within Canada.

Limitations of this study warrant comment. The sample size available was somewhat modest for some analyses, with few incident cases of bullying occurring among those free of the outcome at baseline. This limited us from conducting a conventional cohort analysis. The time period under observation was also short, and at 1-year perhaps had insufficient latency to observe effects. Key variables under study were self-reported, and while extensive validation work has been performed (14-17,38), self report bias is still an issue. In addition, cultural variations were not taken into account. Different cultures have differing views on interpersonal violence, and this is can play a major role in bullying behavior (14,26,39,40). These limitations may collectively affect the generalizability of the study to other youth populations.

School-based anti-bullying interventions have been shown to be effective overall, with recent studies showing estimated reductions of 13% to 37% (34,36,37), despite gender differences in receptiveness. These interventions have focused on increasing awareness surrounding bullying behaviours, empowering bystanders and providing support for victims (35-37). Targeting those at particularly high risk for bullying involvement may increase the effectiveness of interventions, as well as decreasing negative psychosocial consequences of bullying involvement. Particular focus should be paid to school level interventions, using techniques similar to those combating racism and gender discrimination, to reduce the prevalence of weight-based teasing. Promoting an environment where all body types are accepted is one avenue by which this psychologically damaging behavior can be reduced and hopefully eliminated.

Conclusion

Interpersonal violence can affect the healthy development of children as they transition to adulthood. Our study findings demonstrate the importance of physical appearance as a determinant of bullying experiences among Canadian youth. This research adds to the growing body of literature that shows that excess adiposity has consequences beyond direct physical health.

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HBSC is a World Health Organization/European Region collaborative study. International Coordinator of the 2005–2006 study: Candace Currie, University of Edinburgh, Scotland; Data Bank Manager: Oddrun Samdal, University of Bergen, Norway. The Canadian data bank manager is Matthew King, Queen's University, Kingston, Ontario, Canada. This publication reports data solely from the province of Ontario in Canada (Principal Investigators: Dr. William Boyce and Dr. William Pickett).

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Conflict of interest

None declared.

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Table 1. Profile of the Ontario longitudinal sample in 2006 (Time 1) and 2007 (Time 2)

Variable		**Time 1**		**Time 2**	
		N	(%)	**N**	(%)
Gender					
	Male	820	(47.2)	820	(47.2)
	Female	918	(52.8)	918	(52.8)
Adiposity Group					
Males	Normal Weight	625	(76.2)	607	(74.0)
	Overweight	148	(18.0)	168	(20.5)
	Obese	47	(5.7)	43	(5.2)
Females	Normal Weight	780	(85.0)	786	(85.6)
	Overweight	109	(11.9)	104	(11.3)
	Obese	29	(3.2)	28	(3.1)

Table 2. Profile of bullying involvement in the Ontario longitudinal sample at Time 1 and Time 2

Sex		Time 1 (2006)			Time 2 (2007)		
Type of bullying		Total	Number of cases	(%)	Total	Number of cases	(%)
Males							
Physical	Victimization	811	36	(4.4)	815	34	(4.2)
	Perpetration	809	43	(5.3)	813	42	(5.2)
Relational	Victimization	809	56	(6.9)	814	51	(6.3)
	Perpetration	808	41	(5.1)	813	47	(5.8)
Females							
Physical	Victimization	913	15	(1.6)	916	17	(1.9)
	Perpetration	912	8	(0.9)	916	14	(1.5)
Relational	Victimization	913	99	(10.8)	916	85	(9.3)
	Perpetration	911	24	(2.6)	917	40	(4.4)

Table 3. Results of repeated measures multi-level logistic regression analyses examining adiposity as a risk factor for bullying

		Crude Risk Ratio			Adjusted Risk Ratio[a]		
Sex		Normal Weight	Overweight	Obese	Normal Weight	Overweight	Obese
Type of Bullying		OR	OR (95% CI)	OR (95% CI)	OR	OR (95% CI)	OR (95% CI)
Males							
Physical	Victimization	1.00	1.39 (0.75 - 2.55)	2.46 (1.06 - 5.73)	1.00	1.09 (0.56 - 2.10)	2.07 (0.85 - 5.02)
	Perpetration	1.00	1.14 (0.65 - 2.03)	1.59 (0.67 - 3.79)	1.00	1.10 (0.61 - 2.00)	1.71 (0.70 - 4.18)
Relational	Victimization	1.00	1.41 (0.85 - 2.35)	2.10 (0.97 - 4.54)	1.00	1.24 (0.72 - 2.14)	2.11 (0.95 - 4.70)
	Perpetration	1.00	1.24 (0.71 - 2.14)	1.06 (0.39 - 2.86)	1.00	1.11 (0.63 - 1.96)	0.99 (0.35 - 2.75)
Females							
Physical	Victimization	1.00	0.25 (0.03 - 1.88)	2.00 (0.44 - 9.06)	1.00	0.24 (0.03 - 1.80)	1.32 (0.28 - 6.24)
	Perpetration	1.00	0.38 (0.05 - 2.88)	1.44 (0.18 - 11.7)	1.00	0.41 (0.05 - 3.20)	1.52 (0.17 - 13.3)
Relational	Victimization	1.00	0.85 (0.49 - 1.47)	2.08 (0.95 - 4.58)	1.00	0.73 (0.40 - 1.32)	1.76 (0.77 - 4.03)
	Perpetration	1.00	1.17 (0.54 - 2.55)	2.80 (1.01 - 7.75)	1.00	1.29 (0.58 - 2.86)	2.98 (1.03 - 8.61)

[a] adjusted risk ratios control for screen time, age, self-esteem and family affluence score

Table 4. Bullying involvement in 2007 among students free of that form of bullying in 2006

Sex		**Normal Weight**			**Overweight**			**Obese**			**Fisher's exact test**
Type of bullying		Total	Number of new cases	(%)	Total	Number of new cases	(%)	Total	Number of new cases	(%)	p-value
Males											
Physical	Victimization	572	17	(3.0)	156	6	(3.8)	40	3	(7.5)	.22
	Perpetration	569	26	(4.6)	151	5	(3.3)	38	2	(5.3)	.70
Relational	Victimization	559	26	(4.7)	145	6	(4.1)	41	2	(4.9)	1.00
	Perpetration	565	28	(5.0)	153	8	(5.2)	41	1	(2.4)	.86
Females											
Physical	Victimization	766	15	(2.0)	102	0	(0.0)	28	0	(0.0)	.43
	Perpetration	772	11	(1.4)	102	0	(0.0)	28	1	(3.6)	.25
Relational	Victimization	701	47	(6.7)	91	3	(3.3)	20	1	(5.0)	.43
	Perpetration	759	29	(3.8)	100	2	(2.0)	27	4	(14.8)	.02

Chapter 5
Manuscript 2: Bullying Involvement as a Mediator of Weapon Carrying in Obese Youth

This manuscript conforms to the specifications for submission to the peer-reviewed journal *Pediatrics*.

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Running head: Mediation of adiposity status-weapon carrying relationships

Abbreviations: BMI, body mass index; CI, confidence interval; HBSC, Health Behaviours in School-Aged Children; OR, odds ratio; RR, risk ratio.

Keywords: obesity, adolescence, youth, delinquency, violence, interpersonal violence

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Abstract

Purpose: Being overweight or obese are prevalent conditions among young people. These conditions may be accompanied by social consequences. Prejudicial attitudes towards those who are obese may manifest as antisocial interpersonal behaviors, such as bullying. While evidence links increased adiposity status with increased bullying, it is unknown whether this extends to more precarious behaviors such as weapon carrying. The purpose of this study was to evaluate relationships between adiposity status and risks for weapon carrying among Canadian school children, and to assess whether this relationship was mediated by reports of bullying.

Methods: We conducted a cross-sectional analysis of the health experiences of 7877 Canadian children (11-15 years) using the 2006 *Health Behaviour in School-Aged Children* (HBSC) survey. Relationships between adiposity status and weapon carrying were evaluated using multi-level logistic regression that accounted for school-level clustering. Evidence of mediation by bullying involvement was assessed using standard methods.

Results: Overweight (OR: 1.45, 95% CI 1.04-2.02) and obese (OR: 2.19, 95% CI 1.43-3.35) males reported higher rates of weapon carrying relative to normal weight males. Among obese males, there was partial mediation of this relationship by physical and relational bullying, either as a perpetrator or a victim. No evidence of a relationship between adiposity and weapon carrying was identified for female students.

Conclusions: Overweight and obese male students appear to be more likely to carry weapons for defensive and offensive purposes, a behavior mediated in part by bullying involvement.

Introduction

Being overweight or obese are emerging health issues among children across the globe [1,2]. While chronic conditions associated with obesity such as cardiometabolic disease and osteoarthritis may not develop for several years, social consequences of obesity encountered by obese persons can begin as early as preadolescence [3,4]. Obese individuals may suffer from stigmatization from their peers [3,5-7], family members [8], and even the medical community [8]. For children, these social stigmas occur despite the fact that childhood obesity is a highly prevalent condition [1,2], that is caused by several factors that are beyond a young persons control (e.g., genetics [9], parents' socioeconomic status [10], built environments [11]) and not merely a lack of personal willpower to engage in physical activity. Negative attitudes towards obese youths may manifest in antisocial interpersonal behavior [12].

Bullying is one important negative interpersonal problem that may emerge from these social tendencies. Obese youths have higher risks of victimization compared to their normal weight peers. Males are suspect to physical victimization, which includes behaviors such as, kicking, punching and shoving another person, while females are suspect to relational victimization, which includes behaviors such as social exclusion and spreading lies about an individual [3,5-7]. Possible health effects of bully-victimization include decreased self-esteem [13] and increased reporting of symptoms consistent with depression [14].

A potential coping mechanism that youths may employ to protect themselves from bullying is weapon carrying [15]. This strategy is concerning as youths caught carrying weapons on school property risk suspension [16]. More importantly, weapon carrying during adolescence is a precursor to violent offenses in young adulthood (e.g., armed violence) and is predictive of future incarceration [17-19]. If obese youths are resorting to weapon carrying as a result of bullying involvement, then this is a behavior that needs to be understood and prevented.

To recognize the extent to which overweight and obese youths are bullied by their peers and to assess if this is associated with weapon carrying behavior, we analyzed data from the 2006 Canadian *Health Behaviour in School-Aged Children* (HBSC). This is a national survey of the health experiences of 9672 youth aged 11-15 from across Canada [20]. Specific objectives were to determine whether being overweight or obese is associated with increased odds of weapon carrying in youth, and whether this relationship is mediated by relational or physical bullying involvement. Our primary hypothesis was that rates of weapon carrying would be higher in obese youth, and that bullying involvement may indirectly account for the relationship between adiposity and weapon carrying, as weapons may be carried for offensive or defensive purposes [17].

Methods

Data Source

Health Behaviour in School-Aged Children (HBSC) is an international survey conducted in affiliation with the World Health Organization [21]. The Canadian arm of this survey was administered in 2006, and involved reports from a large and diverse sample of Canadian young people. The Queen's University General Research Ethics Board approved the Canadian HBSC survey protocol. Consent to participate was sought at the school board, school, parental and student levels.

Data were available from 186 schools, with 9672 students aged 11-15 years. This represents 74% of the total number of students sampled [20]. Of non-responding students, 10% deliberately spoiled their survey, and the remainder either did not obtain parental consent, failed to return the consent form or were absent on the date of administration [20]. The survey excluded those who were enrolled in private or special needs schools, as well as those who were home-schooled or incarcerated. In addition, 1685 students were excluded from this analysis based on missing heights or weights (n=1544) or missing date of birth information (n = 141). The final sample available for analysis was 7987 students (61.1%).

Overweight and Obesity (Primary Exposure)

Heights and weights were provided by self-report and used to calculate body mass index (BMI, kg/m^2) [22]. Participating children were either classified as normal weight, overweight or obese based on age and sex specific BMI values developed by Cole *et al.*[22]. These BMI values are culture-and-nation-independent, and were designed using growth curve modeling to pass through the adult BMI values for being overweight (25.0 kg/m^2) and obese (30.0 kg/m^2) at entry into adulthood at exactly 18.0 years of age[22]. These criteria have been endorsed by the International Obesity Task Force [23]. Despite slight underestimation of BMI, especially among girls, self-reported BMI is consistently associated with later adverse health outcomes [13,24,25].

Weapon Carrying (Primary Outcome)

The primary study outcome was any reported weapon carrying behavior in the previous 30 days. Weapons were chosen that were clearly for offensive or defensive purposes and included: 1) brass knuckles, 2) mace/pepper spray, 3) firearms and 4) sticks/clubs. Knives were (conservatively) excluded as they may be carried for non-aggressive purposes in some environments (e.g., hunting in rural areas). Questions on the HBSC survey pertaining to weapon carrying were developed initially for the *Youth Risk Behavior Survey* and have demonstrated reliability [26].

Bullying (Potential Mediator)

Two specific forms of bullying were investigated in this manuscript; physical bullying and relational bullying. Children were asked questions about both perpetration and victimization of bullying behavior, with possible cut-offs of: *"never", "once or twice", "2 or 3 times a month", "once a week"* or *"greater than once a week"*. As per existing precedents [27], bullying involvement was dichotomized, with the first two items corresponding to "*none or low involvement*" and the final three corresponding to "*regular involvement*." Both physical and relational bullying were characterized in this manner.

Physical bullying perpetration was assessed through a single question: "*I hit, kicked, pushed, shoved around, or locked another student(s) indoors.*" Two questions were asked about relational bullying perpetration: 1) "*I have kept another student(s) out of things on purpose, excluded him or her from my group of friends, or completely ignored him or her*," and 2) "*I spread false rumors about another student(s) and tried to make others dislike him or her*." A positive response to either of these two relational bullying questions indicated relational bullying perpetration. Analogous questions were used to assess victimization, such as in the case of physical victimization: "*I was hit, kicked, pushed, shoved around, or locked indoors.*" Questions about bullying have been shown to have internal consistency, as well as being appropriate for use across countries and cultures [28].

Other Covariates

Several covariates were considered as potential confounders based on previous literature and included measures of: age, gender, life satisfaction, socio-economic status, physical activity, "screen time," and perceived quality of the home, neighborhood and school environments. The sexes differ significantly in bullying involvement [3,6,29], and it was suspected that this would modify the relationship between bullying involvement and weapon carrying. Life satisfaction was measured using the Cantril Ladder [21]. Life satisfaction is a proxy measure for psychosocial resources [30], these may impact a student's ability to cope with bullying victimization, or resist becoming a perpetrator of bullying behavior. Socio-economic status was measured via the Family Affluence Scale, a composite and validated score of material wealth [21,31]. Physical activity was measured through ordinal response categories for the number of days in a week with more than 60 minutes of moderate to vigorous physical activity. This was characterized as either; "*less than 30 minutes a day*," "*30-60 minutes a day*" or "*greater than 60 minutes a day*." While physical activity levels tend to be over reported, reports of the number of days with 60 minutes of more physical activity are generally accurate [32]. Screen time is the sum of self-reported time spent watching television, playing video games and using a personal computer daily. While screen time may be underestimated, previous studies have shown that these underestimates are minimal [33]. Home, neighborhood and school environments were characterized using previously validated scales used in other HBSC studies [21].

Statistical Analysis

Focal relationships between adiposity status (normal weight, overweight and obese) and weapon carrying were evaluated using multi-level logistic regression that accounted for clustering at the school level. All statistical analyses were performed using SAS version 9.1.3 using the PROC GLIMMIX procedure (SAS Institute Inc., Cary, NC). A backwards elimination process with a 10% change in effect estimate criteria was used in the assessment of confounders [34]. All models were stratified by gender and controlled for: age, gender, life satisfaction, socio-economic status, physical activity, "screen time," and perceived quality of the home, neighborhood and school environments.

Each of the four forms of bullying (physical victimization and perpetration, relational victimization and perpetration) was characterized independently as a potential mediating factor. As per existing precedents [35,36], there was evidence of mediation if: 1) socially important increases in the focal relationship between adiposity class and weapon carrying (Path C; Figure 1) were found (OR > 1.5), 2) statistically suggestive ($p < .10$) relationships were observed for Paths B and C, and 3) statistically suggestive ($p < .10$) results were found for Sobel's test of mediation [35]. If inclusion of the suspected mediator in the multivariate model reduced the main effect to the null (OR = 1), this was interpreted as full mediation. If this reduction was smaller, partial mediation was present. Finally, multivariate models were created investigating the percentage change in effect estimates after including vs. not including each bullying measure, while controlling for other suspected confounders.

Results

Higher percentages of males than females reported weapon carrying (7.2% compared to 1.3%; $p<.0001$), and more males than females were found to be overweight (19.1% vs. 12.0%; $p< .0001$) and obese (7.3% vs. 3.9%; $p<.0001$) (Table 1). Each of the pathways necessary for mediation to occur was then assessed for strength and statistical significance of association (Figure 1). Odds ratios below are reported with 95% confidence intervals in brackets.

Path A: Adiposity status leading to bullying

No statistically significant relationships between adiposity status and bullying were found for overweight males (Table 2). Obese males were more likely to be involved in bullying as relational victims (OR: 1.52 (1.06 – 2.19)) compared to their normal weight peers. Overweight females were more likely to be relationally victimized (OR: 1.41 (1.07 – 1.86)) compared to their normal weight peers (Table 2).

Path B: Bullying leading to weapon carrying

Bullying involvement in any form resulted in elevated and significant ($p<0.01$) odds for weapon carrying among both males and females (Table 2). Males who were relational and physical victims of bullying behavior reported 1.70-fold (1.19 – 2.44) and 2.12-fold (1.42 – 3.15) increases in relative odds of weapon carrying, respectively. This extended to perpetration as well; with male relational perpetrators reporting 3.55-fold (2.36 - 5.35) increases in relative odds of weapon carrying, while male physical perpetrators reported 3.67-fold (2.48 – 5.43) increases in relative odds of weapon carrying (Table 2).

Females also displayed increased odds of weapon carrying upon bullying involvement. Females who were victimized relationally reported 2.64-fold (1.35 – 5.18) increases in relative odds of weapon carrying compared to their normal weight peers, while victims of physical bullying reported 6.21-fold (2.84-13.6) increases in relative odds of weapon carrying (Table 2). Female perpetrators of bullying behavior also reported increased odds of weapon carrying. Perpetrators of relational bullying behavior reported 5.71-fold (2.65 – 12.3) increases in relative odds of weapon carrying, while physical perpetrators reported 5.49-fold (2.04 – 14.7) increases in relative odds of weapon carrying.

Path C: Adiposity status leading to weapon carrying

Overweight and obese males reported 1.45 (1.04-2.02) and 2.19 (1.43-3.35)-fold increases in relative odds of carrying a weapon to school, respectively. No statistically significant associations were identified among overweight or obese females (Table 2).

Assessment of mediation

Among overweight males, no evidence of mediation of the focal relationship between adiposity and weapon carrying was found (Table 2). Among obese males, evidence of mediation of the relationship between adiposity and weapon carrying was found for: relational victimization, physical victimization and physical perpetration (Table 2). Moderate changes in effect estimates were found upon inclusion of the suspected mediator. Obese males were found to have 2.19 (1.43 – 3.35)-fold increases in odds of weapon carrying, but after controlling for relational victimization, these odds decreased to 2.12 (1.38-3.24), a decrease of 6.4%. Similar effects were observed for physical victimization and perpetration, with 5.9% and 7.8% decreases in the magnitude of the odds ratios being observed respectively (Table 3).

For females, no evidence of mediation was found due to the lack of associations between adiposity status and weapon carrying for both overweight and obese females (OR's of 1.13 (0.49 – 2.63) and 0.54 (0.07 – 4.07) respectively).

Discussion

Through this analysis we demonstrated the existence of strong and significant associations between adiposity status and weapon carrying among adolescent males. Bullying involvement partially, but not completely, mediated these relationships among obese males only, indicating that bullying is a component cause of weapon carrying. Bullying involvement may be one indicator of antisocial behavior, but other factors, such as physical fighting or gang involvement may also influence the relationship between adiposity and weapon carrying. In contrast to males, adiposity status was not associated with weapon carrying among females.

The gender differences observed in this study are of interest. Our findings were congruent with previous studies that have identified relationships between victimization by bullying and increased weapon carrying [37,38]. While these studies combined males and females in their analyses, we found that both genders reported significant increases in the relative odds of weapon carrying and that this relationship was not unique to one gender. Weapon carrying may be a coping strategy used by victims of both physical and relational bullying, who are carrying weapons for self-defense [15]. In addition, perpetrators of physical and relational bullying were also found to be more likely to carry weapons, possibly to intimidate others. Direct involvement in bullying at the individual level may explain adiposity-weapon carrying relationships among males.

In contrast, there was no evidence of a relationship between adiposity status and weapon carrying behavior among girls. Thus, the adiposity-weapon carrying relationship was not mediated by bullying behaviors. Large increases in the odds of weapon carrying were found among females involved in any form of bullying (OR > 2.5 in all cases) (Table 2).

We suggest two reasons for the lack of observed relationships between adiposity class and weapon carrying in girls: 1) female involvement in relational bullying is more prevalent than physical bullying, and 2) fear of physical victimization may be driving this relationship rather than actual involvement. First, a weapon confers no advantage to the carrier when relational bullying is considered. Second, while adiposity status may not be a determinant of weapon carrying among females, fear of being victimized provides an impetus for weapon carrying [37]. Higher-order factors, such as perceptions of school safety, which may be influenced by overall bullying prevalence, may affect the prevalence of weapon carrying at school among females [37]. While we did control for the quality of school environments, we could not measure whether individuals were fearful of victimization or felt unsafe at school. It is suspected that this fear may be responsible for the observed relationship, rather than adiposity status, among females.

This study has several strengths. First, the statistical analysis accounted for clustering of the data that may occur within schools as students within schools are likely to have more similar experiences with bullying than between schools. Second, both the main exposure and outcome measures are validated constructs [13,20,24-26]. Third, since the HBSC survey has been standardized internationally, this study is highly reproducible in other countries to determine if this finding is culturally unique, or if these findings are generalizable beyond Canadian borders.

This study also has several limitations. First, due to its cross-sectional nature, it was not possible to establish the temporal sequence between adiposity, weapon carrying and bullying involvement which limits causal inferences. Second, physical and relational bullying are not mutually exclusive behaviors. Third, a student's motivation for carrying a weapon could not be assessed from this survey. While it was inferred that weapons are carried for defensive purposes, this conclusion is speculative. Fourth, the inability to test for gang involvement formed a limitation as this was not asked on the HBSC survey. Fifth, response bias may be present as students may not report weapon carrying behavior, despite confidentiality. Finally, selection bias may also be present due to: 1) absenteeism from school if students are bullied excessively [39] and 2) children who are heavily involved in weapon carrying may not be in the public school system due to expulsion or truancy. These youth would not have been captured by the 2006 HBSC survey.

This study adds to the growing literature surrounding youth violence. While several studies have investigated adiposity as a potential determinant of bullying involvement [3,5-7], and others have investigated bullying involvement as a determinant of weapon carrying [15], to our knowledge no studies have linked increased adiposity with increased odds of weapon carrying. Since only partial mediation of the focal relationship by bullying involvement was observed, a cluster of factors may be responsible for the increased likelihood of weapon carrying reported by obese males. Other suspected risk factors for weapon carrying include, but are not limited to: physical fighting [40], fear for personal safety [41] and perceptions of school safety [37]. Further research is required to determine if these factors act independently or collectively as mediating variables.

Conclusion

Bullying is one of several antisocial behaviors that overweight and obese individuals may encounter. In order to reduce the prevalence of these discriminatory behaviors, a societal level approach must be taken. Similar to combating racism and religious discrimination, the onus should be placed on modification of societal attitudes. Promotion of an inclusionary environment at the school level, combined with education of the young, are potential methods of addressing these psychologically damaging behaviors.

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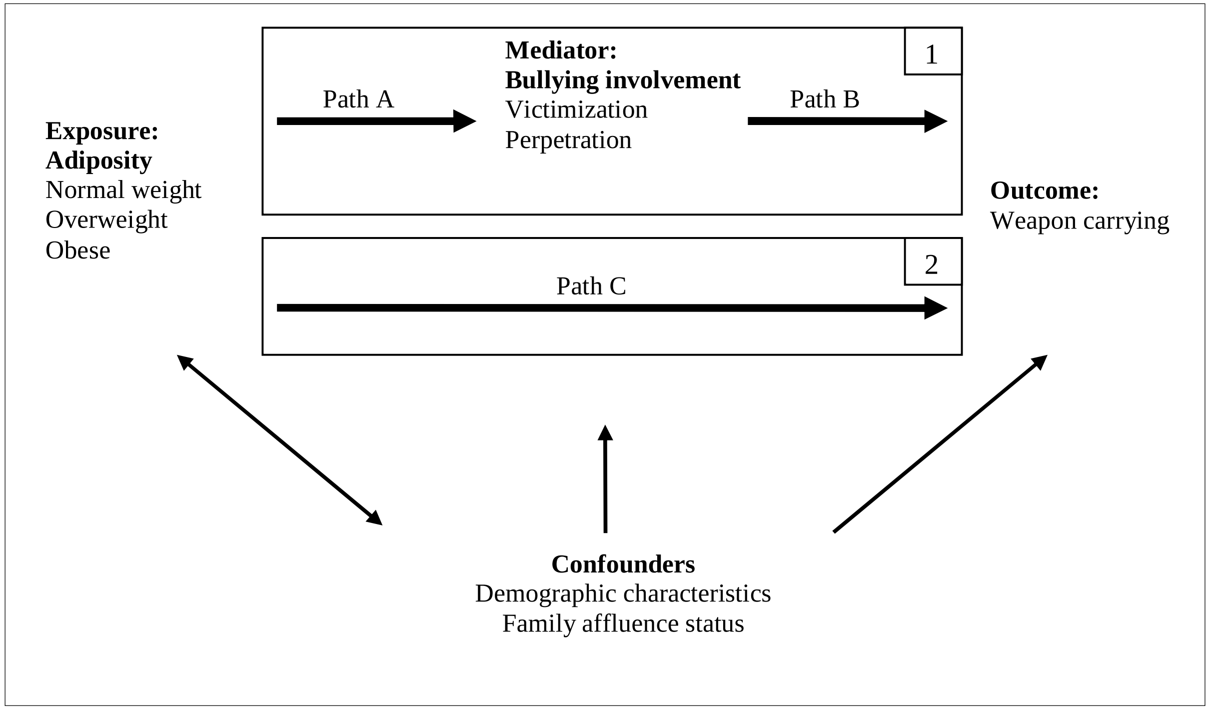

Figure 1. Conceptual framework for study of the relationship between adiposity and weapon carrying. The top box (labeled 1) indicates the mediated relationship, while the second box (labeled 2) indicates a direct relationship. Bullying involvement refers to either physical bullying or relational bullying. [35]

Table 1. Profile of the national sample of participants in the Canadian HBSC, 2006

Variable	N	%
Gender (n = 7987)		
Male	3878	48.6
Female	4109	51.7
Grade (n = 7987)		
Grade 6	1160	14.5
Grade 7	1403	17.6
Grade 8	1591	19.9
Grade 9	2050	25.7
Grade 10	1783	22.3
Weapon carrying		
Males (n = 3802)		
Yes	273	7.2
No	3529	92.8
Females (n = 4075)		
Yes	52	1.3
No	4023	98.7
Adiposity status		
Males (n = 3878)		
Normal Weight	2853	73.6
Overweight	741	19.1
Obese	284	7.3
Females (n = 4109)		
Normal Weight	3457	84.1
Overweight	494	12.0
Obese	158	3.9

Table 2. Assessment of possible mediation of the focal relationship between adiposity class and weapon carrying by bullying involvement

Sex / *Weight Class* / Bullying Modality	**Path A** Weight class → Bullying Odds ratio (95% CI)	P-value	**Path B** Bullying → Weapon Carrying Odds ratio (95% CI)	P-value	**Path C** Weight Class → Weapon Carrying Odds ratio (95% CI)	P-value	**Sobel's Test Result** P-value	**Possible Mediation**[b]
Males (n = 3802)								
Overweight								
Relational Victimization	1.02 (0.77 - 1.36)	.87	1.70 (1.19 - 2.44)	.004	1.45 (1.04 - 2.02)	.028	.44	No
Physical Victimization	1.21 (0.87 - 1.69)	.26	2.12 (1.42 - 3.15)	.0002			.15	No
Relational Perpetration	1.06 (0.72 - 1.56)	.75	3.55 (2.36 - 5.35)	<.0001			.38	No
Physical Perpetration	1.17 (0.81 - 1.70)	.41	3.67 (2.48 - 5.43)	<.0001			.21	No
Obese								
Relational Victimization	1.52 (1.06 - 2.19)	.02	1.70 (1.19 - 2.44)	.004	2.19 (1.43 - 3.35)	.0003	.04	Yes
Physical Victimization	1.43 (0.92 - 2.21)	.11	2.12 (1.42 - 3.15)	.0002			.08	Yes
Relational Perpetration	0.92 (0.51 - 1.64)	.77	3.55 (2.36 - 5.35)	<.0001			.62	No
Physical Perpetration	1.59 (0.96 - 2.63)	.07	3.67 (2.48 - 5.43)	<.0001			.04	Yes
Females (n = 4075)								
Overweight								
Relational Victimization	1.41 (1.07 - 1.86)	.01	2.64 (1.35 - 5.18)	.005	1.13 (0.49 - 2.63)	.71	.04	No
Physical Victimization	1.26 (0.78 - 2.05)	.35	6.21 (2.84 - 13.6)	<.0001			.18	No
Relational Perpetration	1.00 (0.61 - 1.66)	.99	5.71 (2.65 - 12.3)	<.0001			.49	No
Physical Perpetration	1.33 (0.67 - 2.65)	.42	5.49 (2.04 - 14.7)	.0007			.22	No
Obese								
Relational Victimization	1.51 (0.97 - 2.35)	.07	2.64 (1.35 - 5.18)	.005	0.54 (0.07 - 4.07)	.55	.07	No
Physical Victimization	1.63 (0.80 - 3.32)	.17	6.21 (2.84 - 13.6)	<.0001			.10	No
Relational Perpetration	1.46 (0.71 - 3.02)	.31	5.71 (2.65 - 12.3)	<.0001			.16	No
Physical Perpetration	0.99 (0.30 - 3.33)	.99	5.49 (2.04 - 14.7)	.0007			.51	No

Pathway in the proposed model[a]

[a]All models control for: age, life satisfaction, socio-economic status, physical activity, "screen time," and perceived quality of the home, neighborhood and school environments.
[b]Evidence of mediation was inferred from the magnitude and significance of Paths A, B and C, and Sobel's test[35,36]

Table 3. Results of multi-level logistic regression analyses examining overweight and obesity as risk factors for weapon carrying among males (n=3802).

Weight Class	**Adjusted model***	**Adjusted model[a], also controlling for indicated bullying form**							
		Relational victimization		Physical victimization		Relational perpetration		Physical perpetration	
	Odds ratio (95% CI)	Odds ratio (95% CI)	% change[b]	Odds ratio (95% CI)	% change[b]	Odds ratio (95% CI)	% change[b]	Odds ratio (95% CI)	% change[b]
Normal weight	1.00	1.00		1.00		1.00		1.00	
Overweight	1.45 (1.04 - 2.02)	1.45 (1.04 - 2.02)	-0.9	1.41 (1.00 - 1.97)	-10.1	1.47 (1.05 - 2.06)	3.5	1.44 (1.03 - 2.01)	-3.0
Obese	2.19 (1.43 - 3.35)	2.12 (1.38 - 3.24)	-6.4	2.12 (1.38 - 3.26)	-5.9	2.26 (1.47 - 3.48)	5.8	2.10 (1.36 - 3.24)	-7.8

[a]All models control for: age, life satisfaction, socio-economic status, physical activity, "screen time," and perceived quality of the home, neighborhood and school environments.
[b]% change: percentage change in the effect estimates upon including that form of bullying ($OR_{adjusted} - OR_{adjusted + bullying} / OR_{adjusted} - 1$)

Chapter 6
General Discussion

6.1 Summary of Key Findings

The purpose of this thesis was to investigate social consequences associated with excess adiposity among Canadian youth. The first manuscript examined youth in grades 9 and 10 at baseline, then followed these children after one year. Obese and overweight males reported 2-fold increases in both physical and relational victimization, while obese females reported 3-fold increases in perpetration of relational bullying. Adiposity class was shown to precede bullying involvement in a sub-analysis of those free of the outcome at baseline. These findings are congruent with previous cross-sectional research (1-3) and confirmed that important social consequences may be experienced by obese youths.

The second manuscript was based on a Canadian sample of youth from grades 6 through 10. Results suggest that overweight and obese males report increased odds of weapon carrying compared to their normal weight peers. Among obese males, partial mediation of this relationship was observed by acts of: physical victimization, relational victimization and physical perpetration. Bullying involvement may be one indicator of antisocial behaviour, but other factors, including physical fighting (4) or fear for personal safety (5) may also be mediating the focal relationship. No such relationships were observed among female students.

The manuscripts reported slightly different associations between adiposity class and bullying involvement. For example, in Manuscript 1 obese males reported 2.07 (0.85 - 5.02)-fold increases in relative odds of physical victimization (Manuscript 1, Table 3), while in Manuscript 2 obese males reported that they had 1.43 (0.92 - 2.21)-fold increases in the relative odds of physical victimization (Manuscript 2, Table 2). This may be due to differences between the study populations on the dimensions of age and geographical location. The first manuscript sampled youths from grades 9 to 11, while the second manuscript sampled youths in grades 6 through 10.

In addition, the first manuscript only included youths from Ontario, while the second manuscript included youths across Canada.

6.2 Limitations of the Thesis

Both manuscripts were subject to similar limitations. First, the HBSC survey was completed via self-report. While students are assured of the confidentiality of their answers, some may still falsify responses to specific questions. However, the measures have been tested for reliability and have been found to be reliable measures of their respective constructs (6-10). Second, both manuscripts are suspect to response bias. Those youths who are heavily involved in bullying or weapon carrying may underreport their involvement. Third, cultural variations may exist in bullying involvement and these could not be controlled for using available measures (6,11-13).

The first manuscript suffered from some specific limitations. The small number of incident cases of bullying prevented us from conducting a conventional prospective cohort study. Second, the short period of follow-up may not have been sufficient for bullying behaviours to manifest.

The second manuscript also had some unique limitations. Since this manuscript was cross-sectional in nature, temporality could not be assessed as part of this analysis. Second, the motives behind weapon carrying could not be evaluated. Whether this relationship was due to bullying involvement or other factors remains unknown.

6.3 Strengths of the Thesis

Both manuscripts had common strengths. The use of multi-level modelling is a primary strength, with several advantages. This approach does not assume that the observations are independent. Since the students are selected by school (the HBSC sampling frame), it stands to reason that those students within a school will be more similar than those between schools. As a result, an assumption that each student experienced behaviours independent of others would erroneously decrease the standard error associated with the final measures of association. This thesis used a large sample of the Ontario youth population for the first manuscript, and the representative national youth population for the second manuscript. Finally, the survey instrument itself has been extensively validated and is an accurate measure of the constructs it measures (6-10).

The first manuscript is one of two studies that have investigated bullying involvement longitudinally among youth. The previous study followed youths from 7.5 to 8.5 years of age, and results from these two school contexts are consistent. This suggests that obese youths may be involved in bullying through the life course. The second manuscript is the first to evaluate the relationship between weapon carrying and adiposity class. This study shows that adiposity can be associated with direct social outcomes of a very serious nature.

6.4 Statistical Power

Power in this study refers to the ability to correctly conclude that the risks of obese children being victims or perpetrators of bullying differ significantly from normal weight children, assuming they actually do differ. Power was estimated based on classical power calculations, adjusting for the HBSC design effect of 1.4. Since multi-level modelling is a relatively new technique, there is no standard way to approach power calculations in this context. The design effect takes into account the clustered nature of the data when calculating the sample size, as the clustering will erroneously reduce the standard error. This would result in a higher likelihood of incorrectly rejecting the null hypothesis if not accounted for (Type 1 error).

Power calculations were performed and are available in Appendix C. We were sufficiently powered to detect all four forms of bullying among males, with statistical power above 80% if odds ratios above 2.5 existed. However, there are insufficiencies in power for small odds ratio estimates, and only 18%-25% power was available for odds ratios of the order of 1.5. This was due to the small sample size available.

6.5 Future Research Directions

Future research should continue to explore the social consequences of excess adiposity in youth. A prospective cohort study, following students through all four years of high school, would be ideal to track the development of these behaviours and to establish temporality between the variables of interest, although it may be suspect to methodological challenges. Research surrounding the coping mechanisms employed by youth to address victimization is lacking. Such research would allow policymakers to create more effective interventions.

The results of Manuscript 2 revealed that bullying involvement partially mediates the relationship between adiposity status and weapon carrying. However, due to only partial mediation being observed, other factors may be responsible for this behaviour. This is an area that requires further study to determine the motives for weapon carrying among youth. Weapon carrying is a marker of later violent behaviour and may lead to other serious health issues to both the carrier and their peers. Once the motives behind weapon carrying at school are understood, interventions can be developed to address these concerns, and hopefully reduce weapon carrying at school.

6.6 Public Health and Policy Implications

Although the results seen in Manuscript 1 are limited, a distinct relationship is observed between adiposity class and later odds of bullying involvement. Results of the second manuscript show that obese males are likely to turn to weapons as a potential coping mechanism. These behaviours need to be understood so that school level interventions can be employed that encourage youths to appreciate their peers regardless of their appearance.

In both of the studies in this thesis, distinct gender differences were found. Bullies will target that which is important to their peers, and thus males may be physically bullied, while females may be relationally bullied (14). School-based anti-bullying interventions have been shown to be effective overall, with recent studies showing estimated reductions of 13% to 37% (15, 17, 18). In these studies, gender differences were found in receptiveness. Our results support these observations. As a result, interventions should be gender-specific in order to maximize their effectiveness.

Targeting those at particularly high risk for specific forms of bullying involvement may increase the effectiveness of interventions, as well as decreasing negative psychosocial consequences of bullying involvement. However, while designing these interventions, care must be taken to avoid blaming the victims of these behaviours and further ostracizing them from their peers. Current interventions have focused on increasing awareness surrounding bullying behaviours, empowering bystanders and providing support for victims (16-18). These interventions should also consider that extreme bullying may lead to weapon carrying and other behaviours. Particular focus should be paid to school level interventions, using techniques similar to those combating racism and gender discrimination, to reduce the prevalence of weight-based teasing. Promoting an environment where all body types are accepted is one avenue by which this psychologically damaging behavior can be reduced and hopefully eliminated.

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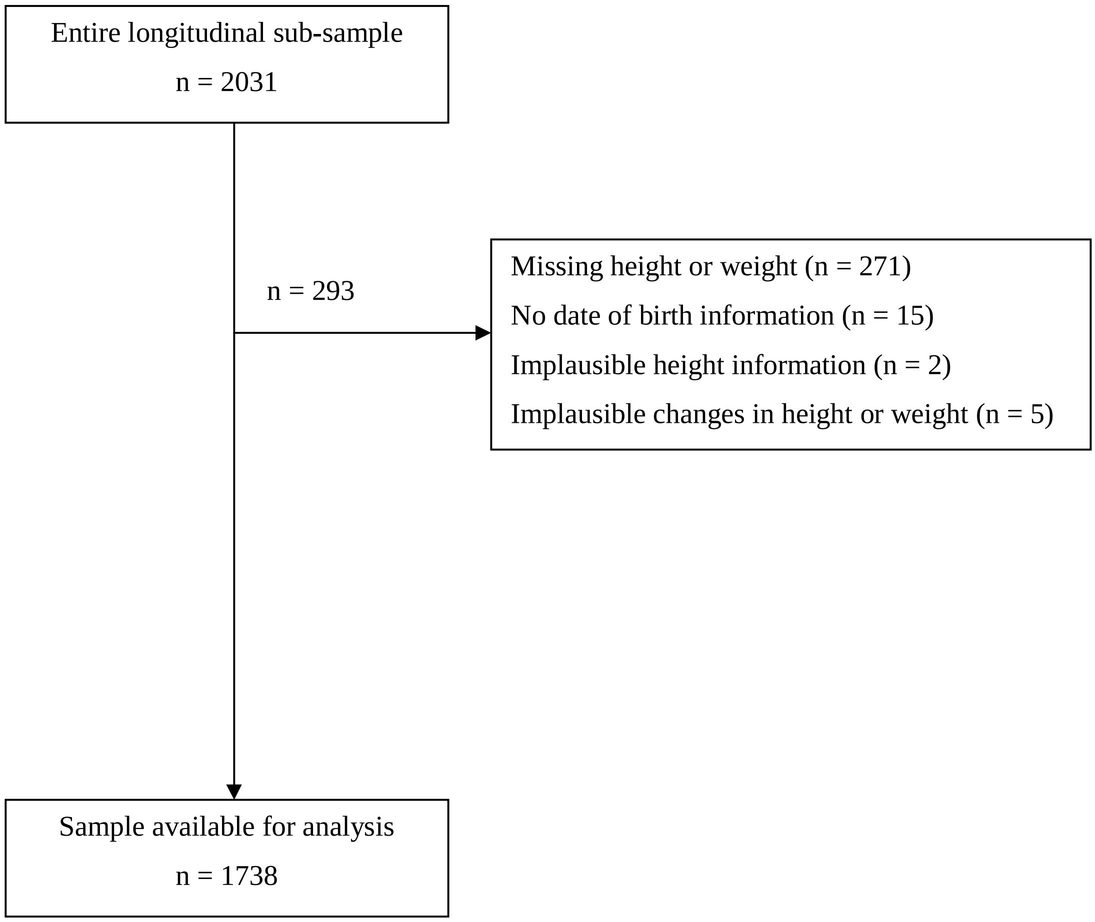
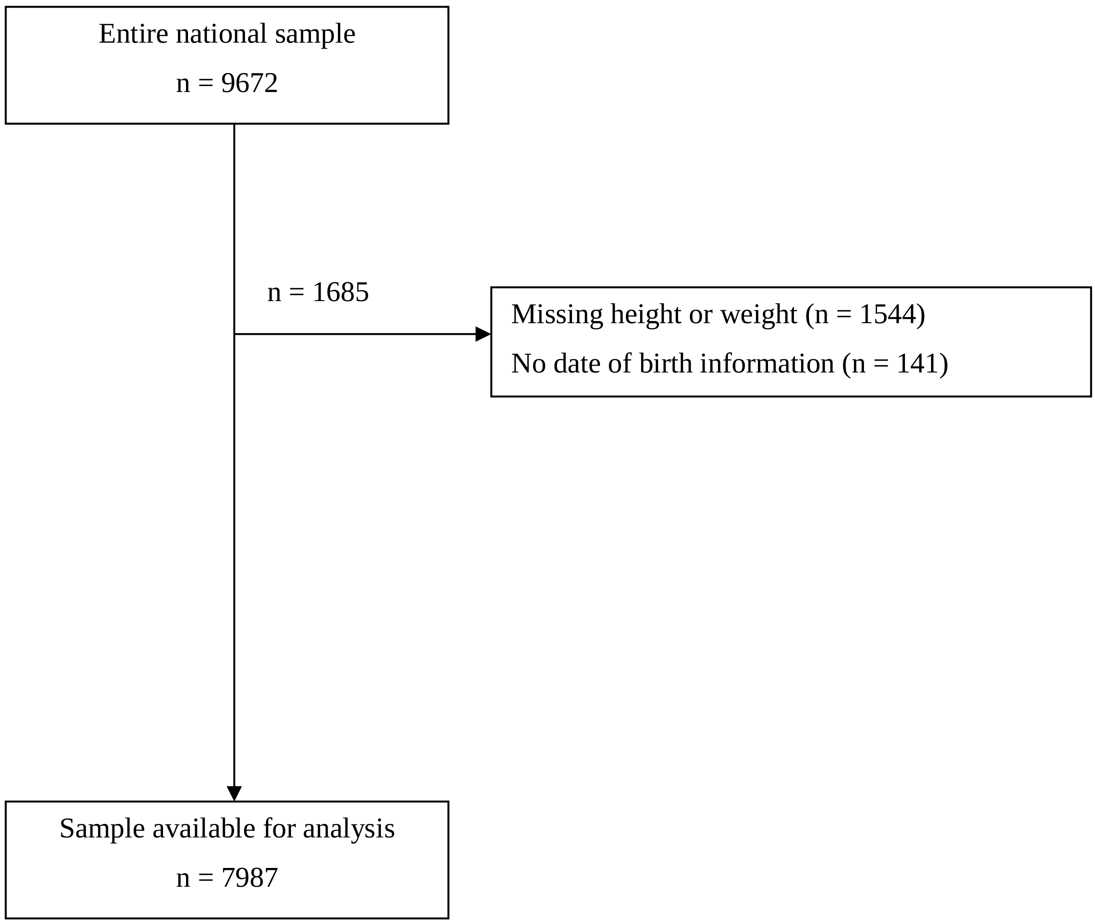
Appendix A

Manuscript 1 Exclusion Flow Chart



Appendix B

Manuscript 2 Exclusion Flow Chart



Appendix C
Power Calculations

		Power to detect OR = 1.50	Power to detect OR = 2.00	Power to detect OR = 2.50
Males				
Physical	Victimization	18%	53%	85%
	Perpetration	20%	60%	90%
Relational	Victimization	25%	69%	95%
	Perpetration	20%	58%	89%
Females				
Physical	Victimization	11%	31%	59%
	Perpetration	10%	26%	50%
Relational	Victimization	33%	83%	99%
	Perpetration	20%	58%	89%

$N_{exposed}$ The number of students exposed (i.e. the number expected to be obese or overweight)
r The ratio of unexposed to exposed
p The proportion of students who have the outcome (i.e. are bullied)
p_o The prevalence of bullying involvement in the *unexposed*
p_1 The prevalence of bullying involvement in the *exposed*
d The difference between p_1 and p_o
$z_{\alpha/2}$ The level of significance (using $\alpha = 0.05$, $z_{\alpha/2} = 1.96$)

Power $= \Phi\ Z_{(1-\beta)} = \Phi\ \{d\ [(nr)/p(1-p)(1+r)]^{1/2} - Z_{\alpha/2}\}$

Appendix D
Additional Tables

These tables indicate the association between the covariates and the outcomes of interest in both Manuscript 1 and Manuscript 2. All analyses were bivariate in nature, considering each covariate as an independent predictor of the outcome of interest.

Table 1: Associations between covariates and outcomes of interest (bullying involvement) for Manuscript 1 among males

		Physical Perpetration	Physical Victimization	Relational Perpetration	Relational Perpetration
Weight Class	Normal Weight	1.00	1.00	1.00	1.00
	Overweight	0.90 (0.41 - 2.01)	1.60 (0.71 - 3.56)	1.05 (0.51 - 2.17)	1.28 (0.65 - 2.53)
	Obese	0.84 (0.19 - 3.66)	2.83 (0.92 - 8.69)	0.78 (0.18 - 3.37)	1.66 (0.56 - 4.95)
Family Affluence Status	Low			1.0	0.00 (0.00 - 0.00)
	Medium	0.33 (0.10 - 1.16)	1.32 (0.49 - 3.55)	0.60 (0.25 - 1.44)	0.87 (0.38 - 1.98)
	High	1.14 (0.58 - 2.26)	1.42 (0.62 - 3.23)	0.76 (0.40 - 1.47)	0.94 (0.49 - 1.81)
School Activity	Low	1.00	1.00	1.00	1.00
	Medium	2.17 (0.97 - 4.85)	0.61 (0.25 - 1.50)	1.10 (0.51 - 2.35)	0.91 (0.46 - 1.82)
	High	1.78 (0.81 - 3.93)	0.68 (0.31 - 1.52)	1.29 (0.65 - 2.56)	0.63 (0.32 - 1.28)
Outside School Activity	Low	1.00	1.00	1.00	1.00
	Medium	1.33 (0.65 - 2.73)	1.02 (0.47 - 2.22)	0.90 (0.43 - 1.86)	1.03 (0.52 - 2.05)
	High	0.86 (0.37 - 1.98)	0.32 (0.10 - 1.11)	0.87 (0.41 - 1.86)	0.93 (0.45 - 1.93)
Self Esteem	Quartile 1	1.00	1.00	1.00	1.00
	Quartile 2	1.04 (0.30 - 3.66)	0.66 (0.26 - 1.68)	0.34 (0.14 - 0.85)	0.30 (0.14 - 0.65)
	Quartile 3	2.54 (0.86 - 7.52)	0.58 (0.24 - 1.39)	0.44 (0.20 - 0.96)	0.22 (0.10 - 0.46)
	Quartile 4	1.19 (0.34 - 4.19)	0.14 (0.03 - 0.67)	0.54 (0.23 - 1.26)	0.24 (0.10 - 0.56)

Table 2: Associations between covariates and outcomes of interest (bullying involvement) for Manuscript 1 among females

		Physical Perpetration	Physical Victimization	Relational Perpetration	Relational Perpetration
Weight Class	Normal Weight	1.00	1.00	1.00	1.00
	Overweight	*	*	0.45 (0.11 - 1.89)	0.47 (0.19 - 1.19)
	Obese	*	*	4.75 (1.69 - 13.39)	1.55 (0.52 - 4.59)
Family Affluence Status	Low	1.00	1.00	1.00	1.00
	Medium	0.52 (0.10 - 2.63)	0.39 (0.08 - 1.86)	0.55 (0.21 - 1.41)	0.42 (0.22 - 0.80)
	High	1.00 (0.32 - 3.15)	0.87 (0.31 - 2.43)	0.94 (0.47 - 1.91)	0.52 (0.31 - 0.87)
School Activity	Low	1.00	1.00	1.00	1.00
	Medium	0.16 (0.02 - 1.23)	0.97 (0.32 - 2.92)	0.51 (0.23 - 1.14)	0.47 (0.26 - 0.84)
	High	0.52 (0.11 - 2.37)	0.96 (0.26 - 3.59)	0.52 (0.19 - 1.36)	0.70 (0.38 - 1.31)
Outside School Activity	Low	1.00	1.00	1.00	1.00
	Medium	0.27 (0.04 - 2.14)	0.23 (0.03 - 1.78)	0.56 (0.23 - 1.37)	0.93 (0.53 - 1.61)
	High	1.03 (0.23 - 4.74)	1.29 (0.36 - 4.62)	0.33 (0.08 - 1.39)	0.73 (0.34 - 1.59)
Self Esteem	Quartile 1	1.00	1.00	1.00	1.00
	Quartile 2	1.70 (0.40 - 7.20)	0.33 (0.09 - 1.23)	0.69 (0.29 - 1.65)	0.37 (0.21 - 0.67)
	Quartile 3	1.03 (0.23 - 4.64)	0.33 (0.10 - 1.09)	0.70 (0.31 - 1.56)	0.29 (0.16 - 0.51)
	Quartile 4	0.83 (0.14 - 5.05)	0.13 (0.02 - 1.06)	0.55 (0.20 - 1.49)	0.12 (0.05 - 0.31)

***** indicates unstable effect estimates due to small sample sizes

Table 3: Associations between covariates and outcome of interest (weapon carrying) for Manuscript 2

Variable	Level	Males	Females
Weight Class	Normal Weight	1.00	1.00
	Overweight	1.40 (1.04 - 1.90)	1.30 (0.61 - 2.78)
	Obese	2.06 (1.40 - 3.05)	0.50 (0.07 - 3.69)
Family Affluence Status	Low	1.00	1.00
	Medium	0.93 (0.58 - 1.49)	0.51 (0.22 - 1.17)
	High	0.89 (0.56 - 1.41)	0.49 (0.22 - 1.11)
School Activity	Low	1.00	1.00
	Medium	1.38 (1.01 - 1.88)	1.03 (0.56 - 1.89)
	High	1.19 (0.87 - 1.64)	0.69 (0.32 - 1.50)
Outside School Activity	Low	1.00	1.00
	Medium	0.76 (0.55 - 1.07)	0.58 (0.24 - 1.38)
	High	1.21 (0.90 - 1.63)	1.39 (0.69 - 2.84)
Parental Involvement Scale	Low	1.00	1.00
	Medium	0.84 (0.62 - 1.14)	0.42 (0.18 - 1.00)
	High	0.82 (0.59 - 1.16)	0.59 (0.23 - 1.51)
Neighbourhood Scale	Low	1.00	1.00
	Medium	0.59 (0.41 - 0.85)	0.51 (0.24 - 1.11)
	High	0.62 (0.47 - 0.82)	0.41 (0.22 - 0.78)
School Environment Scale	Low	1.00	1.00
	Medium	0.51 (0.38 - 0.69)	0.37 (0.19 - 0.72)
	High	0.32 (0.23 - 0.45)	0.13 (0.05 - 0.33)
Self-Esteem	Low	1.00	1.00
	Medium	0.69 (0.50 - 0.94)	0.48 (0.25 - 0.92)
	High	0.60 (0.44 - 0.82)	0.28 (0.12 - 0.69)