

Bullying as a mediator of relationships between adiposity status and weapon carrying

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Abstract

Objectives Although evidence links increased adiposity status with bullying involvement, it is unknown whether this leads to behaviors such as weapon carrying. The purpose of this study was to: (1) analyze relationships between adiposity status and risks for weapon carrying among Canadian school children, and (2) whether this relationship was mediated by reports of bullying.

Methods We conducted a cross-sectional analysis of the health experiences of 7,877 Canadian children. Relationships between adiposity status and weapon carrying were evaluated. Evidence of mediation by bullying involvement was assessed.

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 odds of weapon carrying relative to normal weight males. There was partial mediation of this relationship by physical and relational bullying, both as a perpetrator or a victim. No evidence of a relationship 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 partially by bullying involvement. However, other factors may play a role as mediators in these etiological relationships.

Keywords Obesity · Adolescence · Delinquency · Interpersonal violence · Bullying

Introduction

Overweight and obesity are important pediatric health issues (Flegal and Troiano 2000; Tremblay et al. 2002). While chronic health conditions associated with obesity may not develop for several years, social consequences of obesity are observed in the childhood years (Emond et al. 2007; Griffiths et al. 2006). Obese individuals may suffer from social pressures from their peers (Griffiths et al. 2006; Janssen et al. 2004; Pearce et al. 2002; Robinson 2006), family members (Puhl and Brownell 2006), and even clinicians (Puhl and Brownell 2006). For children, these occur despite the fact that childhood obesity is caused by several factors that are beyond a young persons' control, such as genetics (Reilly et al. 2005), living environments (Papas et al. 2007) and not merely a lack of personal willpower. Negative attitudes toward obese youth by others may manifest in antisocial interpersonal behavior (Carr and Friedman 2005).

Bullying is one negative interpersonal problem that may emerge from these social tendencies and can take several forms, including physical, relational, cyber and verbal bullying. Bullying may lead to adverse health outcomes, including depression, anxiety and headaches (Fekkes et al. 2005). Youth may be targeted for bullying for a number of

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reasons, ranging from physical appearance, race, religion or socio-economic status (Frisén et al. 2008). Of interest to this manuscript is how obese youth experience higher risks of victimization compared to their normal weight peers. Males are likely to suffer from physical victimization, while females are more likely to be involved in relational victimization, which includes social exclusion and spreading lies about an individual (Griffiths et al. 2006; Janssen et al. 2004; Pearce et al. 2002; Robinson 2006). Resultant health effects can include decreased self-esteem (Strauss 2000), and bullying involvement may be hidden from teachers and parents, as victims may suffer in silence (Fekkes et al. 2005).

In order to cope with bullying, youth may carry a weapon to protect themselves (Nansel et al. 2003). This strategy is concerning. Youth caught carrying weapons on school property risk suspension (Ministry of Education. Ontario Education Act 1990), and weapon carrying during adolescence is strongly associated with physical fighting and injury (Lowry et al. 1998; Pickett et al. 2005). If obese youth are resorting to weapon carrying as a result of bullying involvement, then this is a behavior that needs to be understood and prevented.

We analyzed data from the 2006 Canadian *Health Behaviour in School-Aged Children* (HBSC) to examine the mediating role of bullying on the relationship between adiposity and weapon carrying behavior. HBSC is a national survey of the health experiences of young people from across Canada (Boyce 2008). Specific objectives were to determine whether overweight and obesity are 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 (Lowry et al. 1998).

Methods

Subjects and survey instrument

Health Behaviour in School-Aged Children (HBSC) is an international cross-sectional survey conducted in affiliation with the World Health Organization every 4 years (*Health Behaviour in School-Aged Children: A World Health Organization Study* 2007). The 5th cycle of the Canadian survey was administered in 2006, and involved reports from 9,672 students aged 11–15 years, from 186 public schools (74% of the total number of students sampled) (Boyce 2008). From the original sample, 1,685 students

were excluded from this analysis based on missing heights or weights ($n = 1,544$), missing date of birth information ($n = 141$). The final sample available for analysis was 7,987 students. Of these youth, 7,877 responded to all the questions of interest and formed the sample used in the main analyses. 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.

Measures

Overweight and obesity (primary exposure)

Heights and weights were provided by self-report and used to calculate body mass index (BMI kg/m^2) (Cole et al. 2000). Participating children were either classified as normal weight, overweight or obese based on international cut-offs (Cole et al. 2000). These BMI cutoff values for children 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 exactly 18.0 years of age (Cole et al. 2000). These criteria have been endorsed by the International Obesity Task Force (Bellizzi and Dietz 1999). Despite slight underestimation of BMI, especially among girls, self-reported BMI is consistently associated with later adverse physical health outcomes (Brenner et al. 2003; Himes et al. 2005; Strauss 2000).

Weapon carrying (primary outcome)

The primary study outcome was any reported weapon carrying behavior in the previous 30 days. Weapons were chosen that were for offensive or defensive purposes: (1) brass knuckles, (2) mace/pepper spray, (3) firearms and (4) sticks/clubs. Knives were (conservatively) excluded as pilot testing of the questionnaire indicated that they were often carried for non-aggressive or utilitarian purposes (e.g., hunting), especially in rural areas. Questions on the HBSC survey pertaining to weapon carrying were developed initially for the *Youth Risk Behaviour Survey* and have demonstrated reliability ($\text{Kappa} = 65.7\%$) (Brenner et al. 2002).

Bullying (potential mediator)

Two specific forms of bullying were investigated; physical and relational bullying. Children were asked questions about both perpetration and victimization of bullying behavior, with response categories ranging from: “never” to “greater than once a week”. As per existing precedents (Solberg and Olweus 2003), bullying involvement was dichotomized (at least 2 or 3 times per month or not). Both

physical and relational bullying were categorized in this manner.

Physical bullying perpetration was assessed through a single item: “*I hit, kicked, pushed, shoved around, or locked another student(s) indoors.*” Two items 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.*” A positive response to either of these two relational bullying items indicated relational bullying perpetration. Analogous questions were used to assess victimization. These bullying items have demonstrated internal consistency, and are appropriate for use across countries and cultures (Kyriakides et al. 2006).

Other covariates

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. Life satisfaction was measured using the Cantril Ladder (Health Behaviour in School-Aged Children: A World Health Organization Study 2007). Life satisfaction is a proxy measure for psychosocial resources (Samdal et al. 1998) that 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 (Currie et al. 2008; Health Behaviour in School-Aged Children: A World Health Organization Study 2007). Physical activity was measured via the number of days in a week with more than 60 min of moderate to vigorous physical activity. While physical activity levels can be over-reported, reports of the number of days with 60 min of more physical activity are generally accurate (Welk et al. 2000). Screen time consisted of the sum of self-reported time spent watching television, playing video games and using a personal computer daily (Schmitz et al. 2004). Home, neighborhood and school environments were characterized using previously validated scales (Health Behaviour in School-Aged Children: A World Health Organization Study 2007). Whether a child resided in an urban or rural neighborhood was considered as a covariate, with urban coded as: urban core, urban fringe, urban area outside census metropolitan areas and census agglomerations and secondary urban core. Rural areas included rural fringe and rural area outside census metropolitan areas, defined using Statistics Canada criteria (Statistics Canada 2007).

Data analysis

All statistical analyses were performed using SAS version 9.1.3 using the PROC GLIMMIX procedure (SAS Institute Inc., Cary, NC). 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. Intra-class correlations were calculated using the empty model. Initial models were stratified by gender and controlled for each of the potential covariates described a priori.

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 (Baron and Kenny 1986, Sobel 1982), evidence of mediation consisted the identification of: (1) socially important increases (OR > 1.5) in the relationship between adiposity class and weapon carrying (Path C; Fig. 1); and (2) statistically significant ($p < 0.05$) relationships observed for Paths B and C; and (3) using a liberal p value ($p < 0.10$), significant findings for Sobel’s test of mediation (Sobel 1982).

Multivariate models were used to investigate the percentage change in main effect estimates (weapon carrying odds related to adiposity class) with and without inclusion of each bullying measure. A multivariate model was built with adiposity class as the primary effect that also controlled for the effects of: age, life satisfaction, socio-economic status, physical activity, “screen time,” and perceived quality of the home, neighborhood and school environments. Then, each of the four forms of bullying was included individually as a covariate in four separate models. 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, as the relationship was eliminated upon the inclusion of the suspected mediator. If this reduction was smaller, partial mediation occurred, and the percentage change in the effect estimate calculated.

Results

Higher percentages of males than females reported weapon carrying (7.2% compared to 1.3%; $p < 0.0001$), and more males than females were found to be overweight (19.1 vs. 12.0%; $p < 0.0001$) or obese (7.3 vs. 3.9%; $p < 0.0001$) (Table 1). Each of the pathways necessary for mediation to occur was evaluated (Fig. 1. Note: these pathways are presented in their conventional order). The intra-class correlation, i.e., variation within schools as a percentage of the total variation, was very small (0.37%).

Fig. 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

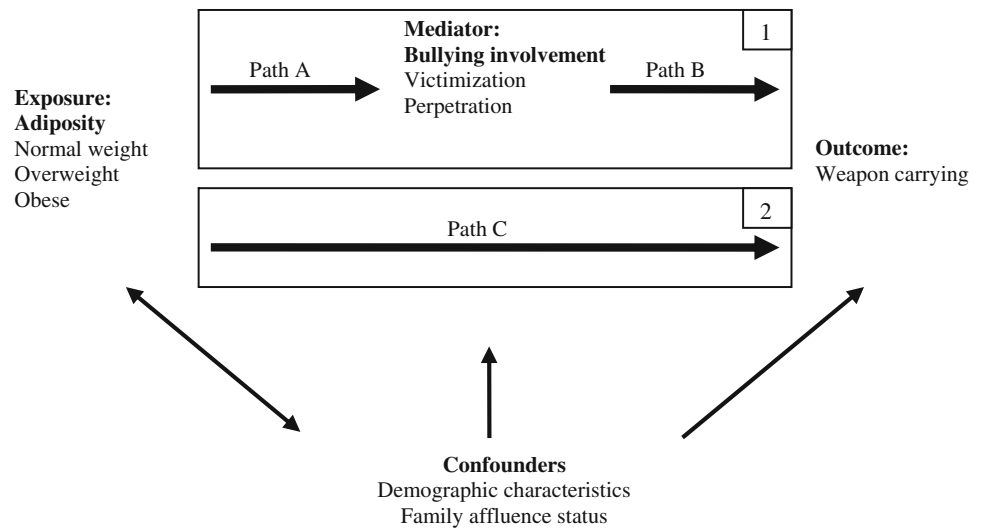


Table 1 Profile of participants in the 2006 Canadian Health Behaviour in School-Aged Children survey

| Variable | <i>n</i> | % |
|-----------------------------------|----------|------|
| Gender (<i>n</i> = 7,987) | | |
| Male | 3,878 | 48.6 |
| Female | 4,109 | 51.7 |
| Grade (<i>n</i> = 7,987) | | |
| Grade 6 | 1,160 | 14.5 |
| Grade 7 | 1,403 | 17.6 |
| Grade 8 | 1,591 | 19.9 |
| Grade 9 | 2,050 | 25.7 |
| Grade 10 | 1,783 | 22.3 |
| Weapon carrying | | |
| Males (<i>n</i> = 3,802) | | |
| Yes | 273 | 7.2 |
| No | 3,529 | 92.8 |
| Females (<i>n</i> = 4,075) | | |
| Yes | 52 | 1.3 |
| No | 4,023 | 98.7 |
| Adiposity status | | |
| Males (<i>n</i> = 3,878) | | |
| Normal weight | 2,853 | 73.6 |
| Overweight | 741 | 19.1 |
| Obese | 284 | 7.3 |
| Females (<i>n</i> = 4,109) | | |
| Normal weight | 3,457 | 84.1 |
| Overweight | 494 | 12.0 |
| Obese | 158 | 3.9 |

Path C: associations between adiposity status and weapon carrying

Overweight and obese males reported 1.45 (95% CI: 1.04–2.02) and 2.19 (95% CI: 1.43–3.35)-fold increases in

relative odds of carrying a weapon to school, respectively. No statistically significant increases in odds were identified among overweight or obese females (Table 2). No variations were found between urban and rural youth and hence all subjects were pooled for all further analyses. A sensitivity analysis was also performed with carrying of knives included as part of the weapon carrying outcome. Overweight and obese males reported 1.32 (95% CI: 1.05–1.66) and 1.52 (95% CI: 1.09–2.12)-fold increases in the relative odds of carrying a weapon to school. Females did not report statistically significant changes in odds of weapon carrying.

Path A: associations between adiposity status and 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, 95% CI: 1.06–2.19) compared to their normal weight peers. Overweight females were also more likely to be relationally victimized (OR: 1.41, 95% CI: 1.07–1.86) compared to their normal weight peers (Table 2). No statistically important associations were observed among obese females.

Path B: associations between bullying and weapon carrying

Bullying involvement in any form resulted in significantly elevated ($p < 0.01$) odds for weapon carrying among both males and females (Table 2). Male victims of relational and physical bullying reported 1.70-fold (95% CI: 1.19–2.44) increases and 2.12-fold (95% CI: 1.42–3.15) increases in the odds of weapon carrying, respectively. This extended to perpetration as well; with male relational perpetrators

Table 2 Assessment of possible mediation of the focal relationship between adiposity class and weapon carrying by bullying involvement in the 2006 Canadian Health Behaviour in School-Aged Children survey

| Pathway in the proposed model ^a | | | | | | | | | | | |
|--|--------------|-------------------------|---------|----------------------------|---------|--------------------------------|---------|--|---------|---------------------|---------------------------------|
| Sex | Path A | | | Path B | | | Path C | | | Sobel's test result | Possible mediation ^b |
| | Weight class | Weight class → bullying | | Bullying → weapon carrying | | Weight class → weapon carrying | | | | | |
| Bullying modality | | Odds ratio (95% CI) | P value | Odds ratio (95% CI) | P value | Odds ratio (95% CI) | P value | | P value | P value | |
| Males (n = 3,802) | | | | | | | | | | | |
| Overweight | | | | | | | | | | | |
| Relational victimization | | 1.02 (0.77–1.36) | 0.87 | 1.70 (1.19–2.44) | 0.004 | 1.45 (1.04–2.02) | 0.028 | | 0.44 | No | |
| Physical victimization | | 1.21 (0.87–1.69) | 0.26 | 2.12 (1.42–3.15) | 0.0002 | | | | 0.15 | No | |
| Relational perpetration | | 1.06 (0.72–1.56) | 0.75 | 3.55 (2.36–5.35) | <0.0001 | | | | 0.38 | No | |
| Physical perpetration | | 1.17 (0.81–1.70) | 0.41 | 3.67 (2.48–5.43) | <0.0001 | | | | 0.21 | No | |
| Obese | | | | | | | | | | | |
| Relational victimization | | 1.52 (1.06–2.19) | 0.02 | 1.70 (1.19–2.44) | 0.004 | 2.19 (1.43–3.35) | 0.0003 | | 0.04 | Yes | |
| Physical victimization | | 1.43 (0.92–2.21) | 0.11 | 2.12 (1.42–3.15) | 0.0002 | | | | 0.08 | Yes | |
| Relational perpetration | | 0.92 (0.51–1.64) | 0.77 | 3.55 (2.36–5.35) | <0.0001 | | | | 0.62 | No | |
| Physical perpetration | | 1.59 (0.96–2.63) | 0.07 | 3.67 (2.48–5.43) | <0.0001 | | | | 0.04 | Yes | |
| Females (n = 4,075) | | | | | | | | | | | |
| Overweight | | | | | | | | | | | |
| Relational victimization | | 1.41 (1.07–1.86) | 0.01 | 2.64 (1.35–5.18) | 0.005 | 1.13 (0.49–2.63) | 0.71 | | 0.04 | No | |
| Physical victimization | | 1.26 (0.78–2.05) | 0.35 | 6.21 (2.84–13.6) | <0.0001 | | | | 0.18 | No | |
| Relational perpetration | | 1.00 (0.61–1.66) | 0.99 | 5.71 (2.65–12.3) | <0.0001 | | | | 0.49 | No | |
| Physical perpetration | | 1.33 (0.67–2.65) | 0.42 | 5.49 (2.04–14.7) | 0.0007 | | | | 0.22 | No | |
| Obese | | | | | | | | | | | |
| Relational victimization | | 1.51 (0.97–2.35) | 0.07 | 2.64 (1.35–5.18) | 0.005 | 0.54 (0.07–4.07) | 0.55 | | 0.07 | No | |
| Physical victimization | | 1.63 (0.80–3.32) | 0.17 | 6.21 (2.84–13.6) | <0.0001 | | | | 0.10 | No | |
| Relational perpetration | | 1.46 (0.71–3.02) | 0.31 | 5.71 (2.65–12.3) | <0.0001 | | | | 0.16 | No | |
| Physical perpetration | | 0.99 (0.30–3.33) | 0.99 | 5.49 (2.04–14.7) | 0.0007 | | | | 0.51 | No | |

^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

reporting 3.55-fold (95% CI: 2.36–5.35) increases in the odds of weapon carrying, while physical perpetrators reported 3.67-fold (95% CI: 2.48–5.43) increases (Table 2).

Females who were victimized relationally reported 2.64-fold (95% CI: 1.35–5.18) increases in the odds of weapon carrying compared to those who were not victimized, while victims of physical bullying reported 6.21-fold (95% CI: 2.84–13.6) increases (Table 2). Female perpetrators of bullying behavior (both types) each reported 5-fold increases in odds of weapon carrying.

Assessment of mediation

Among overweight males, no evidence of mediation of the relationship between adiposity and weapon carrying by bullying status was found (Table 2). Among obese males, evidence of partial mediation was identified for: relational victimization, physical victimization and physical perpetration. Moderate changes in effect estimates, i.e., <10%, were found upon inclusion of each suspected mediator (Table 3). While bullying appears to be involved in this relationship, it did not completely explain the relationship between adiposity class and weapon carrying among young males, interpreted as partial mediation.

Among 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 (95% CI: 0.49–2.63) and 0.54 (95% CI: 0.07–4.07), respectively].

Discussion

This analysis showed the existence of strong and significant associations between adiposity status and weapon carrying among adolescent males. Bullying involvement partially

mediated these relationships among obese males only, although the change in the overall effect estimate upon the inclusion of bullying was small (<10%). Bullying may represent one component cause of weapon carrying, but other factors, such as physical fighting or gang involvement may also be involved in the relationship between adiposity and weapon carrying (Forrest et al. 2000). These relationships appear to apply to young men only.

Gender differences that were observed in this study are of interest. Our findings were consistent with previous studies that have identified relationships between victimization by bullying and increased weapon carrying (Khoury-Kassabri et al. 2007; Ybarra et al. 2007) and we observed this finding in both genders. Weapon carrying may be a coping strategy used by victims of both physical and relational bullying, who are carrying weapons for self-defense (Nansel et al. 2003). 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 partially explains adiposity–weapon carrying relationships among males, through the process of mediation. 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 as was the case in males.

We suggest two reasons for the lack of observed relationships between adiposity status 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 a mechanism responsible for this relationship rather than actual involvement. 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

Table 3 Results of multi-level logistic regression analyses examining overweight and obesity as risk factors for weapon carrying among males ($n = 3,802$) in the 2006 Canadian Health Behaviour in School-Aged Children survey

| 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) | % Change | Odds ratio (95% CI) | % Change | Odds ratio (95% CI) | % Change | 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 ($OR_{\text{adjusted}} - OR_{\text{adjusted} + \text{bullying}} / OR_{\text{adjusted}} - 1$)

(Khoury-Kassabri et al. 2007). 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 (Khoury-Kassabri et al. 2007). 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. This fear may be responsible for the observed relationship, rather than adiposity status, among females.

Strengths of this investigation warrant comment. Our 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, the items used to measure our primary constructs were all validated and have been used repeatedly (Boyce 2008; Brener et al. 2002; 2003; Himes et al. 2005; Strauss 2000). Third, since the HBSC survey has been standardized internationally, this study is 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 limitations. 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, alternative forms of bullying may also be affecting this relationship, such as verbal or cyber bullying. With the increasing awareness of social media, cyber bullying in particular is becoming of interest to schools and researchers alike, although this was less common in 2006 than today. These were not investigated in the current study. Fourth, students' individual motivations for carrying a weapon were not assessed in this survey. While it was inferred that weapons are carried for defensive purposes, this conclusion is speculative. Carrying a weapon may have developed as a response to external stimuli other than bullying, such as gang involvement. In addition, while these behaviors appear to be stable (Brener et al. 2002), it is unknown how much weapon carrying behaviors change over time. Fifth, race and ethnicity were not asked in the 2006 Canadian HBSC, and so could not be investigated in this analysis. Sixth, response bias may be present as students may not report weapon carrying behavior, despite confidentiality. Seventh, selection bias may also be present due to: (1) absenteeism from school if students are bullied excessively and (2) children who are heavily involved in weapon carrying may be absent due to expulsion or truancy. These youth would not have been captured by the 2006 HBSC survey. Finally, all data were obtained via self report. While the measures that were used have been subject to validation, some misclassification is likely and would impact the strength of the observed relationships.

This study adds to the literature on youth violence. While several studies have investigated adiposity as a potential determinant of bullying involvement (Griffiths et al. 2006; Janssen et al. 2004; Pearce et al. 2002; Robinson 2006), and others have investigated bullying involvement as a determinant of weapon carrying (Nansel et al. 2003), to our knowledge no studies have linked increased adiposity with increased odds of weapon carrying. Our results indicate the presence of strong and significant associations between weight class and weapon carrying behavior among males. However, 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. This is supported by the observation that inclusion of bullying as a covariate in the adiposity status–weapon carrying relationship results in small changes in the effect estimates (<10%), which also suggests other factors may be involved in weapon carrying. Other suspected risk factors for weapon carrying include, but are not limited to: physical fighting (Muula et al. 2008), and perceptions of school safety (Khoury-Kassabri et al. 2007). We have yet to determine if these factors act independently or collectively as mediating variables.

Bullying is one of several socially stigmatizing behaviors that overweight and obese individuals may encounter. In order to reduce the prevalence of these 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, is a potential method of addressing these psychologically damaging behaviors. Interventions designed at the school level have incorporated a combination of bystander empowerment, as well as educating youth on alternative methods of conflict resolution, although the evidence in this area is mixed (Bauer et al. 2007; Merrell et al. 2008). While our results suggest that bullying involvement may partially mediate the relationship between adiposity status and weapon carrying, the overall impact of bullying is relatively small. Researchers in the school system need to determine the reasons for weapon carrying, especially among the obese population, in order to reduce the prevalence of these potentially dangerous behaviors.

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Conflict of interest The authors declare that they have no conflict of interest.

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