Do weight status and weight perception predict academic achievement in adolescents?

A longitudinal analysis of the COMPASS study.

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Abstract

Background: Recent evidence suggests perceptions of overweight account for the psychosocial consequences typically associated with obesity. Previous research indicates the presence of an obesity achievement gap, yet limited research has explored weight perception in association with academic achievement. Previous studies have focused on grades and degree attainment, without consideration of student aspirations and perceived support and ability to achieve higher levels of education. This thesis examined how Body Mass Index (BMI) classification and weight perception relate to academic performance and postsecondary aspirations and expectations in a large cohort of Canadian adolescents. Additionally, the interaction between BMI status and perceptions of weight was examined in relation to academic achievement outcomes.

Methods: Two-year survey data from 25,673 grade 9-12 students attending the 122 Canadian schools that participated in Year 6 (2017/2018) and Year 7 (2018/2019) of the COMPASS study were used. Generalized estimating equation models were used to examine associations between students' BMI classification and weight perception and their math and English/French course grades and post-secondary academic aspirations and expectations. All models were stratified by gender and adjusted for sociodemographic variables and school clustering.

Results: Boys and girls with BMI of obesity and missing BMI classification reported lower grades and post-secondary aspirations and expectations when compared to those with Normal BMI. Similarly, boys and girls with overweight BMI reported lower math and language grades than those with Normal-weight BMIs. Relative to their peers with normal-weight BMI and "about

right" perceptions, those with overweight perceptions and BMI of overweight/obesity reported lower academic grades and post-secondary aspirations and expectations. There was evidence of an additive effect for girls and boys with overweight perceptions and BMI of overweight/obesity on academic outcomes. About right perceptions of weight were protective against lower math grades for boys and girls with overweight/obesity BMI. Results varied by gender and across academic outcomes.

Conclusions: Overall, this thesis demonstrates that an obesity achievement gap remains when controlling for students' perceptions of their weight. Perceptions of overweight had a detrimental effect on academic performance and aspirations/expectations for students with BMI classifications of overweight and obesity, as well as grade outcomes for those with BMI of normal-weight. Results suggest that barriers to academic success exist for students with larger bodies. Future studies should explore the role of internalized and externalized weight bias.

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SECTION 1: Introduction and Research Questions

1.1 Introduction

About 35% of children and adolescents are at risk of having overweight or obesity in Canada [1]. Numerous studies have shown that childhood obesity is associated with various physical health concerns, including orthopedic, gastroenterological, neurological, pulmonary, cardiovascular and endocrine conditions [2]. Additionally, larger bodied adolescents are at increased risk of adverse psychosocial outcomes [3]. Strauss and Pollack report that children and adolescents face many challenges but "few problems in childhood have as significant an impact on emotional development as being overweight" (p.747) [4]. In fact, children with overweight or obesity reported lower quality of life scores than children diagnosed with cancer and undergoing chemotherapy [5]. Previous research also indicates the presence of an obesity achievement gap for children and adolescents [6,7]. More specifically, some evidence suggests students with obesity have poorer academic achievement, more absenteeism, higher dropout rates [6,8], and are less likely to pursue and attain post-secondary education [9,10]. A recent systematic review found support for the presence of a weak negative association between Body Mass Index (BMI) and grades in elementary and secondary school students [11]; however, the authors identified a need for both longitudinal studies to test causality and research on mechanisms [12,13].

What accounts for the potential disparities in academic achievement by weight status remains largely unexplored. Some theories point to cognitive functioning or social factors such as socioeconomic status (SES) [12,13]. However, the limited extant literature is often restricted to small sample sizes, cross-sectional designs, and has yet to test underlying mechanisms.

Literature reviews by Martin et al. and Santana et al. concluded that there is insufficient evidence for an association between weight status and academic performance [14,15]. The meta-analysis by He et al. included 60 studies of weight status and academic performance and found a pooled correlation (r=-.111) between higher BMI and lower grades [11]. The researchers concluded that the relationship was moderated by geographical region, with lower academic achievement more likely to be associated with high BMI in North American samples than other cultures, possibly due to differing weight norms.

While the influence of psychosocial factors such as sociocultural ideals and self-perceptions related to weight status on potential obesity achievement gaps have often been suggested, negligible research has explored their role. Research indicates obesity is linked to poor mental health and lower self-concept [9,16], which are also associated with poor academic achievement [17]. Furthermore, emerging evidence suggests weight perception accounts for many of the psychosocial consequences of commonly associated with obesity [18,19]. That is, the perception of being overweight, rather than weight itself, may be what increases the risk of lower self-concept and poor mental health. In fact, one study found that perceptions of being overweight were more strongly linked to lower grades than BMI [17]. However, our previous cross-sectional paper found overweight BMI and "overweight" perception were both associated with lower academic performance [20]. Besides these two studies, the potential role of weight perception in the obesity achievement gap has been largely overlooked. Moreover, most research focused on academic performance, as indicated by grades or degree attainment. No study to date has considered how weight and perceptions relate to postsecondary aspirations and expectations.

Mixed findings have been reported with respect to gender and the obesity achievement gap. Some studies report significant results only in girls [21–23], in boys [24], or no gender differences [6,25]. During adolescence boys and girls become increasingly aware of body differences, media influences and body ideals [26]. Girls aspire to the thinness ideal and are more likely to report weight loss attempts, while boys have reported weight gain attempts to attain muscularity ideals [27]. Given the inconsistent findings, differing sociocultural weight norms and body ideals by gender, analysis will be stratified by gender to explore potential differences in academic outcomes.

Students with missing BMI and missing weight perceptions will be included in the analysis to capture this important group. Findings from this group warrant attention given the high proportion of adolescents with missing BMI values and the likelihood that missing weight values are not missing at random [28] . Research suggests that missing weight reports are linked to body dissatisfaction, negative body image and greater investment in appearance [29,30]. Missing weight values gives insight into what adolescents are willing to share and are meaningful on their own [31]. Findings from this thesis may support the importance of including participants with missing weight values in research, since their exclusion risks losing those participants that researchers may be most interested in.

The purpose of this thesis is to explore the prospective association between weight status, weight perceptions, and academic outcomes in youth. Further longitudinal research is needed to examine whether an academic achievement gap exists by both weight status and weight perception among youth. Results will have implications for more than 2 million Canadian adolescents, with over 35% of youth at risk of having overweight or obesity in Canada

(1). Academic achievement sets a lifelong trajectory of health and wellbeing. Lower academic achievement is linked to increased rates of unemployment, poverty, criminality and negative future health outcomes [6,7,32,33]. In fact, lower academic achievement has been suggested as an early pathway contributing to the SES disparities found by weight status later in life [34]. Results will help to form a better understanding of the daily experiences and/or potential challenges for adolescents with obesity.

1.2 Research Questions

Using 2-year linked student data from years 6 (2017-2018) and 7 (2018-2019) of the COMPASS study, the following research questions will be addressed:

RQ1: Do weight status as classified by BMI predict academic outcomes, including performance, aspirations, and expectations?

RQ2: Does weight perception account for associations between weight status and academic outcomes?

RQ3: Do the interactions of weight status and weight perceptions predict academic outcomes prospectively?

1.3 Hypothesis

Research Question 1:

I hypothesized that BMI classifications of overweight and obesity will be associated with lower academic performance and lower post-secondary academic aspirations and expectations.

Research Question 2:

I hypothesized that overweight perceptions will be associated with lower academic performance and lower post-secondary aspirations and expectations, and the addition of weight perception to the models will attenuate associations between weight status and academic outcomes.

Research Question 3:

I hypothesized that the effect of obesity weight status on academic performance, aspirations and expectations will vary by weight perception and vice-versa, in which “about the right weight” perceptions will provide a protective effect among those with BMIs classified as overweight or obesity, and overweight perceptions an additive effect to the adverse effect of obesity/overweight BMI on academic outcomes. Also, overweight perceptions in youth with normal weight BMIs will predict lower academic outcomes compared to their peers with “about right” perceptions.

SECTION 2: Literature Review

2.1 Weight Status and Academic Achievement

A review of the literature on childhood and adolescent obesity, weight perception and academic achievement was conducted on the Medline, Web of Science and PsycInfo databases. Several primary research articles were found. Further searching of the literature yielded four systematic reviews and one meta-analysis on the topic of childhood/adolescent weight status and academic performance. The most exhaustive meta-analysis was conducted by He et al. [11] in 2019 and included 60 studies; Caird et al. [35] included 29 studies, and Martin et al. [36] and Santana et al. [15] included 29 and 34 studies, respectively, in their systematic reviews. For the purposes of this thesis findings from primary studies as well as the reviews will be included.

The nature and magnitude of the relationship between overweight or obesity and academic achievement remains unclear. Of the four reviews located: Burkhalter and Hillman [14] and Caird et al. [35] concluded that obesity can be associated with poor academic performance, while Martin et al. [36] and Santana et al. [15] concluded there was not strong evidence of an association between weight status and academic outcomes. Most studies that found a negative correlation between weight status and academic outcomes reported weak to moderate effect sizes. Effect sizes ranged from -.560 [37] to .280 [38] making it difficult to draw conclusions on the strength of the relationship between variables. He et al. reported a weak pooled negative association between BMI and academics (r=-.111) from their meta-analysis [11]. Results were often inconsistent when the covariates accounted for differed across studies.

The association between weight status and grades was attenuated in some studies when accounting for social and behavioral covariates. For instance in a few studies [12,13,39] the association between weight status and academics diminished when models controlled for SES

and maternal education. Similarly, Caird et al. [35] reported that almost half of the 29 studies included in their systematic review found factors such as SES explained the association between BMI and academic performance.

Geographical region may moderate the relationship between BMI and academic performance. He et al. reported that studies conducted with North American and European samples reported larger effect sizes than studies conducted with Asian samples [11]. For instance, one study compared American and Japanese students, and reported that BMI had a significant negative association with grade point average in US college students but no association among college students in Japan [40]. He et al. hypothesized that the differences across regions may be due to differing social ideals of body sizes and societal messages, and recommends future research investigate why the academic performance of students in Western countries may be influenced by their weight status [11].

The impact of grade level on the association between BMI and grades is not consistent across literature. Several studies reported that a negative association between BMI and academics only exists for students in middle grades (grade 7 to 9), and not when considering younger (grades 3 to 6) and older cohorts (grades 11 and 12). For instance, in a study conducted by Mo-suwan et al. among children and adolescents in Thailand, an association between BMI and academic grades was found in adolescents (grades 6 to 9), but not younger students in grades 3 to 6 [41]. The authors hypothesized the difference may be due to younger children being less concerned about their weight status. Similarly, based on a meta-analysis, studies conducted with elementary school samples had the smallest pooled effect (r=-.075),

followed by middle school samples (r=-.128), and then by high school students with the largest pooled effect size (r=-.184) [11].

The effect of gender also differs across studies of BMI and academic achievement. Some studies report significant results only in girls [21–23], in boys [24], or no gender differences [6,25]. In a longitudinal study including 5966 adolescents (11 years old) from the UK Avon Longitudinal Study of Parents and Children, higher BMI was linked to poor academic performance 5 years later in girls but not in boys [23]. No significant differences were found in the meta-analysis by He et al., although the pooled estimate was slightly higher for females than males [11]. While Martin et al. concluded from their systematic review of 31 studies that the association between weight status and academic achievement is inconclusive [36], they followed up with focus groups and reported that girls reported more experiences of psychosocial distress at school than boys, especially in physical education classes [36]. Additionally, adolescent girls with obesity did not perceive obesity to be directly linked to academic performance, but reported their attitude toward school affected grades [36]. These findings highlight the continued need for studies examining the relationship between weight status and academic performance among youth and differences by gender and other sociodemographic factors.

The majority of studies in previous literature used self-reported grades as the outcome variable in BMI and academic achievement studies. Many studies use math and English/reading grades as the dependent variable [6,13,25,42] , some use grade point average and few utilize standardized test scores [43,44]. Interestingly, He et al. grouped studies using standardized test scores versus those using self-reported grades and found no significant difference [11]. This result

is line with a review of 37 independent samples found strong response validity of self-reported grades in high school students [45].

Several mechanisms have been suggested for how obesity could be linked to academic performance. Some researchers have suggested that children with higher BMIs have lower cognitive abilities [12,24,46] in terms of executive functioning and visuospatial performance. However, in a review of studies linking cognitive abilities to weight status, Smith et al. concluded that findings are inconclusive and further research is needed to establish an association [47]. Similarly, a systematic review of 30 studies by Liang et al. reported support for the link between higher weight status and Attention-deficit/ hyperactivity disorder (ADHD) and visuospatial performance, but concluded the existing literature is mixed on the effect of obesity on academic achievement, memory, learning and language [48]. Both reviews call for longitudinal studies to determine the directionality of the relationship between weight status and cognitive performance.

A study of US students in kindergarten and first grade concluded that differences in test scores of children with and without overweight became insignificant when social and behavioral variables, such as SES, screen time and physical activity, and parental time spent with the child were considered [13]. The authors concluded that overweight or obesity are markers but not causes of lower academic performance, and that a mother's level of education and/or ethnicity have stronger associations with academic performance. They cautioned that weight status is a more obvious marker than sociodemographic characteristics, which may contribute to the stigma and stereotypes attached to being overweight.

It is unclear from the literature whether obesity precedes poor academic performance. The majority of the literature is comprised of cross-sectional studies. Theoretically, poor grades could lead to obesity through mediating variables [39], or both may result from shared causal factors. For instance, studies have linked both obesity and poor academic performance to low self-esteem and higher rates of depression, anxiety, and other psychopathology such as ADHD [48,49]. Relatedly, stigmatization by peers and teachers and isolation may mediate the link between adolescent obesity and academic outcomes. Adolescents with obesity report higher feelings of isolation and psychosocial distress within the school setting compared to their average weight peers [49]. It is postulated that the experience of weight-based teasing and resulting feelings of isolation impact academic performance for students with obesity [49,50]. In support, one study found the association between weight status and grades became insignificant when weight-based teasing was entered into the model [49]. Further, stigmatization by teachers may also contribute to the relationship between weight and grades, yet the existing evidence is inconclusive. While one study found no relationship between a child's waist circumference and the teacher's judgment of their ability [51], another study reported that children who were overweight received lower grades by their teachers, despite having similar scores on standardized tests to average weight students [44]. The role of weight bias has not been explored for academic subjects in the school setting but evidence from physical education teachers has been reported [52,53]. Further research is needed to determine the potential role of external and internalized weight stigma on academic outcomes for children and adolescents with obesity.

2.2 Weight Perception and Academic Achievement

Weight perception (WP) refers to how an individual evaluates or 'sees' their weight status. Weight perception can be influenced by cultural norms, mass media and body ideals. Weight misperception happens when there is a discrepancy between an individuals' subjective perception of their weight and their objective weight status [54]. Several studies found that perceptions of 'about the right weight', regardless of actual weight status, were protective against disordered eating practices and avoidance of physical activity [54,55]. One of the potential factors linking obesity and the perception of overweight to adverse outcomes is the experience of stigma and bias. An individual may need to perceive themselves as overweight, in order to internalize bias associated with overweight/obesity. To date, the potential role of self-perceptions in the obesity achievement gap has been largely overlooked.

Emerging evidence suggests weight perception accounts for many of the psychosocial consequences commonly associated with obesity [18]. A study of 1826 Dutch youth found that weight perceptions of 'overweight' or 'underweight' were linked to problem behaviours such as withdrawnness, attention, social and thinking problems [56]. Additionally, those with BMIs classified as overweight or obese but perceptions of being at about the right weight, had similar scores to adolescents in the normal weight BMI category [56]. Another study found that weight perception was associated with mental health indicators such as depression and anxiety in 12 to 13 year old adolescents, but weight status by BMI was not [57]. In fact, our research in adolescents participating in the COMPASS study found associations between obesity by BMI classification and mental health outcomes were no longer significant when accounting for perception of overweight [19]. The perception of being overweight, rather than weight itself, may be what increases the risk of lower self-concept and poor mental health [19,58]. Therefore, weight

perceptions, in addition to actual weight status may be important in understanding the obesity achievement gap. Only two studies have been published that included both BMI and weight perception (WP) as predictors of academic outcomes [17,20]. In the study by Florin et al. weight perception of 'overweight' was more strongly associated with poor academic outcomes than BMI [17]. In our cross-sectional analysis of adolescents from the COMPASS study, we found that both BMI and weight perceptions were associated with lower academic grades [20]

2.3 Longitudinal Modelling

In cross-sectional designs, differences between individuals at one time can be studied (between subjects), but change in variables over time in individuals is not measured (within subjects), and therefore, causality or temporality of a relationship cannot be established [59]. Longitudinal models are possible when multiple measures taken over time are available on a subject [60]. For this thesis, longitudinal mixed effect models were used to assess the prospective effect of BMI and weight perception at baseline on academic achievement one year later, controlling for baseline academic achievement. Data from the 9 year longitudinal COMPASS study made this analysis possible. COMPASS is a prospective cohort study using a rolling replenishment model. Each year, graduating students leave the cohort and new grade 9 students enter into the cohort, providing up to four years of linked data on individual students as they progress from grades 9 through 12. In the proposed thesis, academic achievement outcomes are expected to be lower at follow up among students with obesity and overweight perceptions. The theory for this hypothesis is that the experiences associated with being overweight or obesity within the school setting will augment psychosocial distress and self-

confidence and negatively impact grades and levels of perceived competence and motivation, which will in turn, impact academic aspirations and expectation.

For this thesis, measures are available on math grades, English/French grades, and academic aspirations and expectations at two time points separated by one year and will serve as the dependent variables. More complex repeated measure designs include between-subject repeated measures in addition to within-subject repeated measures [60]. Measures of weight and height to determine BMI classification for weight status and weight perception will serve as the independent variables in the models. For the mixed effects level models in this thesis, between subject measures include ethnicity, gender and grade level. Two cycles of data that included the mental health module were used for analysis in this thesis. Future analysis should include more waves of data to establish temporality between weight status, weight perception and academic achievement.

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SECTION 3: Manuscript

Are Weight Status and Weight Perceptions Linked to Academic Grades and Post-Secondary Aspirations and Expectations? A Prospective Analysis among adolescents in the COMPASS study

3.1 Introduction

It is estimated that one third of Canadian children and adolescents have a BMI that falls within the overweight or obesity categories [1]. Numerous studies have linked obesity to various detrimental physical health outcomes [2]. Additionally, larger bodied adolescents are at increased risk of adverse psychosocial outcomes [3] such as low self-esteem, anxiety, depression and poor social functioning [5,57,61]. Some research also indicates the presence of an obesity achievement gap for children and adolescents [6,7]. More specifically, some evidence suggests students with obesity have poorer academic achievement, more absenteeism, higher dropout rates [6,8], and are less likely to pursue and attain post-secondary education[9,10]. However, the limited extant literature is often inconsistent, and restricted to small sample sizes and cross-sectional designs. Evidence from existing longitudinal studies is mixed and what factors account for potential disparities remain largely unexplored.

A recent systematic review found support for the presence of a weak negative association between BMI and grades in elementary and secondary school students [11]; however, the authors identified a need for longitudinal studies to test temporality. The researchers concluded that the relationship between weight status and academic performance was moderated by geographical region, with lower grades more likely to be associated with high BMI in North America than other cultures possibly due to differing weight norms. In addition to this meta-analysis, two literature reviews concluded that obesity is associated with lower

academic achievement in cross-sectional studies [14,35], while the reviews by Martin et al [36] and Santana et al. [15] concluded there was not strong evidence of an association between weight status and academics. Of the limited longitudinal research, two studies found evidence of a negative association between weight status and grades [23,42], and one found a significant association only in females [43].

Weight perception (WP) refers to how an individual evaluates or 'sees' their weight status. Weight perception can be influenced by cultural norms, mass media, and body ideals. Weight misperception happens when there is a discrepancy between an individuals' subjective perception of their weight and their objective weight status [54]. Emerging evidence suggests weight perception accounts for many of the psychosocial and physical consequences commonly associated with obesity [18]. That is, the perception of being overweight, rather than weight itself, may be what increases the risk of lower self-concept and poor mental and physical health. For instance, Mikkila et al. reported that health behaviour, including food choice and physical activity, had stronger associations with weight perceptions than actual weight [62]. Likewise, several researchers have found that overweight perceptions are stronger predictors of psychosocial distress, low self-esteem, behavioural problems, and poor mental health than actual weight status [18,56,57,63].

Mixed findings have been reported with respect to gender and the obesity achievement gap. Some studies report significant results only in girls [21–23], in boys [24], or no gender differences [6,25]. During adolescence boys and girls become increasingly aware of body differences, media influences and body ideals [26]. Girls aspire to thinness ideals and weight loss attempts while boys have reported weight gain attempts to attain muscularity ideals [27]. Given the inconsistent

findings and differing sociocultural weight norms and body ideals by gender, analysis will be stratified by gender to explore potential differences in academic outcomes.

One of the proposed factors linking obesity and the perception of overweight to adverse outcomes is the experience of weight stigma and bias. Despite the high prevalence of obesity, weight stigma continues to be problematic. Biased stereotypes that individuals living with obesity are lazy, unintelligent, lack willpower, and are generally unmotivated often manifest in different ways leading to prejudice and discrimination [64]. Research indicates that bias toward individuals with overweight and obesity persists in healthcare, employment, and home settings [9]. Education, however, has received less research attention, particularly at the secondary school level. Existing literature reveals elevated weight bias among physical health and education staff and coaches [52,53]. Internalized bias or self-stigma reflects attitudes that an individual directs toward themselves [16], which in turn, contribute to feelings of low self-esteem and psychological distress. An individual may need to perceive themselves as overweight in order to internalize the bias associated with overweight/obesity. In fact, one study found that perceptions of being overweight were more strongly linked to lower grades than BMI [17]. However, our previous cross-sectional paper found overweight BMI and “overweight” perception were both associated with lower academic performance [20]. Besides these two studies, the potential role of weight perception in the obesity achievement gap has been largely overlooked and has yet to be examined prospectively. Moreover, most research focused on academic performance, as indicated by grades or degree attainment no study to date has considered how weight and perceptions relate to postsecondary aspirations and expectations. Post-secondary aspirations

and expectations may tap into the motivation, or potentially an adolescent's confidence and perceived supports, not simply their ability to succeed academically.

Academic achievement continues to hold significant value for parents, policy makers and schools [65]. Deterrents to academic achievement in adolescence have critical implications for future career opportunities and successful transitions to adulthood, with school failure and dropout increasing the risk of later unemployment, poverty, lower quality life, criminality, violence, and various health risk behaviors [6,7,33]. A better understanding of the link between academic achievement and weight status can inform policies and intervention strategies in the school setting to foster a learning environment that allows all youth to thrive. The current study seeks to determine whether weight status is associated with academic grades and post-secondary aspirations and expectations over time. To date, no study has included post-secondary aspirations and expectations as outcome variables in the weight status and academic achievement literature. The purpose of this paper is to address the following research questions:

1. Does weight status predict academic grades in a large sample of youth prospectively?

2. Does weight perception account for associations between weight status and post-secondary aspirations and expectations in a large sample of youth?

3. Do the interactions of weight status and weight perception predict academic outcomes prospectively?

3.2 Methods

3.2.1 Design and Participants

COMPASS is an ongoing prospective study in a large convenience sample of schools in British Columbia (BC), Alberta (AB), Ontario (ON), and Quebec (QC) designed to collect hierarchal data on a variety of risk factors and outcomes once annually from a rolling cohort of ~65,000+ students in grades 9 through 12 (Secondary I-V in QC) and the secondary schools they attend [66]. Further details available at https://uwaterloo.ca/compass-system/. Schools and school boards were purposely selected based on whether they permitted active-information passive-consent protocols, which are critical for collecting robust data among youth [67]. The COMPASS student questionnaire (Cq), a self-report paper-and-pencil survey, is completed once annually by full school samples during one classroom period. The Cq collects student-level data on various health behaviours, correlates and outcomes such as, sedentary behaviours, physical activity, eating habits, substance use, mental health, bullying, academic outcomes, school connectedness, sociodemographic variables, and height and weight to calculate BMI [66]. The cover page of the Cq questionnaire contains questions that allow for a unique self-generated code for each student to be created. This code ensures anonymity for the survey participants while allowing COMPASS researchers to link each student's data over multiple years. A full description of recruitment methods [68] linkage methods [69] and the COMPASS study are available in print [66] and online (www.compass.uwaterloo.ca). The COMPASS study received ethics approval from the University of Waterloo (#30118) and Brock University Human Research Ethics Committee (#18-099) and all participating school boards.

Data from students successfully linked for Year 6 (2017-2018) and Year 7 (2018-2019) of the COMPASS study were used. All grade 9 through 12 students attending participating schools

were eligible to participate and could withdraw at any time. A total of 28,567 students attending 122 participating schools in Ontario (N=61), Quebec (N=37), British Columbia (N=18) and Alberta (N=8) were successfully linked across the two years. The response rate was 81.8% and 84.2% in year 6 and year 7 respectively. Student non-participation primarily resulted from absences or scheduled study-periods during data collection. Participants missing covariate data (n=137) and outcome data (n=2757) were removed leaving a final sample of 25,673 adolescents.

3.2.2 Measures

Weight status. Weight status was defined by Body Mass Index (BMI; kg/m^2) classification determined based on student-reported height and weight, and the World Health Organization [70]age-and sex-adjusted cut points (underweight, normal weight, overweight, obesity). A previous study found the weight status measure to be reliable, valid, and valuable for use when objective methods are not feasible [71]. Given the prevalence of missing BMI data, and as self-reported weight data may not be missing at random [28], a separate category was created for missing BMI. Additionally, GEE analysis is more likely to result in errors for longitudinal data with missing datapoints hence missing BMI and weight perception categories were included in the analysis.

***Weight perception*.** Subjective perception of weight status was determined using the question, "How do you describe your weight?" Response options included: "very underweight", "slightly underweight", "about the right weight", "slightly overweight" and "very overweight". Responses were collapsed into three categories: underweight, about right, and overweight. As

for BMI, missing weight perception responses were included as a fourth category, given the potential for nonresponse to be meaningful and not missing completely at random.

Academic performance. Academic performance was assessed using self-reported grades on the Cq survey. Participants reported their approximate overall mark in their current or most recent math and English/French courses. Response options were: 90-100%; 80-89%; 70-79%; 60-69%; 55-59%; 50-54%; Less than 50%. Self-report grades demonstrated strong response validity in a review of 37 independent samples of high school students [45]. Grade outcomes were dichotomized at 80% since math and English/French grade distributions revealed that half the sample fell below 80% while the remaining half reported grades above 80 as can be seen in Table 2.

Academic aspirations. Academic aspirations were assessed using answers to the following question on the student Cq survey: "What is the highest level of education you would *like* to get?" Response options included: some high school or less; High school diploma or graduation equivalency; College/trade/vocational certificate; University Bachelor's degree; University Master's/PhD/law school/medical school/teacher's college; I don't know. The first two categories of some high school or less and high school diploma or graduation equivalency were combined while the other four categories remained the same.

Academic expectation. Post-secondary expectations were assessed using answers to the following question on the student Cq survey: "What is the highest level of education you *think* you will get?" Response options were the same as above for aspirations and collapsed into five categories.

Covariates. Participant-reported gender (boy, girl), ethnicity (categorized into white, non-white minority) and grade (9, 10, 11, 12, other [Secondary I-II in Quebec]) were entered into the models as covariates. Also, student weekly spending money (categorized into $0, $1-$20, $21-$100, >$100, don't know) was included as an indicator of part-time employment and/or allowance, as proxy for SES in the absence of parental income or education data. School-area median household income (using data from Statistics Canada 2016 Census on census divisions that corresponded with school postal codes) [72] was included in the models.

3.2.3 Statistical Analysis

First, descriptive analyses were conducted to determine the frequency, distribution, and bi-variate correlations among variables. Chi-square tests were used to examine academic outcomes and correlates by weight status, weight perception and sex. Next, twelve longitudinal Generalized Estimating Equation (GEE) models were conducted. The first model used baseline BMI category as a predictor of math grades at follow up one year later. Model 2 used baseline BMI category and weight perception as predictors of Math grades at follow up. Model 3 used BMI category as a predictor of English/French grades. Model 4 used baseline BMI category and weight perception as predictors of English/French grades. Model 5 used baseline BMI category as a predictor of academic aspirations. Model 6 used BMI category and weight perception as predictors of academic aspirations. Model 7 used baseline BMI category as a predictor of post-secondary expectations and in model 8 weight perception was added. Models 9, 10 and 11 and 12 tested the interaction effect of BMI category and weight perception category as predictors of math grades, English/French grades, and post-secondary academic aspirations and expectations respectively. All models included the covariates and outcome variables at baseline

and were stratified by gender SAS 9.4 software and Proc GEE were used to complete the analysis. The correlation structure was specified as type=exch to acknowledge the school clustering effect.

SECTION 4: Results

4.1 Descriptive Statistics

Descriptive statistics for all students are found in Table 1. In the final sample after excluding missing data, 46.2% of participants identified as boys and 53.8% identified as girls. About three quarters of the sample (78.0%) identified as White while 22.0% identified as Non-White, Mixed or Other race/ethnicity. For weight status, just over half of the sample (54.8%) had a BMI classification of normal, while 12.0% and 5.5% had BMIs classified as overweight and obesity respectively. Only 1.8% of the sample had an underweight BMI. A quarter (25.9%) of the sample were missing BMI data due to missing weight, height and/or age responses. More than half of students (59.7%) reported "about the right weight" perceptions, while 16.1% and 23.1% reported "underweight" and "overweight" perceptions respectively. Only 1.1% of the sample did not report weight perception.

Descriptive statistics for all academic outcomes can be found in Table 2. Half of the sample (52.5%) reported math grades above 80% and the remaining half reported grades of 79 or less. Similarly, 53.0% of the sample reported English/French grades of 80% or above while the remainder of the sample reported grades below 79%. For post-secondary academic *aspirations*, only 5.3% of students aspired for a high school diploma or less. The proportion of students that aspired for a college diploma or Trade certificate (17.6%) was equivalent to those that wanted a university bachelor's degree (17.7) while 39.4% aspired for post-graduate and professional degrees such as medicine and law. The remaining 22.1% reported that they did not know what their post-secondary aspirations were at the time of the survey. For student post-secondary academic *expectations*, about one fifth of the sample expected to receive either a

college diploma or trade certificate (22.1%) or a university bachelor's degree (22.1%). About a quarter (26.8%) of the sample expected to achieve a post-graduate or professional degree, while 22.1% did not know what their post-secondary academic expectations were. Finally, 7.2% of the sample reported expectations of high school graduation or less.

4.2 BMI and Weight Perception Concordance

See Table 3 for weight perception and BMI concordance in girls and 3 b for concordance in boys. For those with an underweight BMI, most girls and boys reported underweight perceptions (66.1%, 67.3%) while some reported about right weight perceptions (3.8%, 4.5%). For those with normal BMIs, boys were more likely to perceive themselves as being underweight than girls (12.7% vs. 28.8%), while more girls than boys in the normal BMI category reported overweight perceptions (14.2% vs 5.4%). For those with overweight BMIs, girls were again more likely to also report overweight perceptions than boys (61.6% vs 42.8%). Most boys and girls with obesity BMI scores also reported overweight perceptions (79.9%, 78.4%). Responses were as follows for girls and boys with missing BMI classifications: the majority reported about right weight perceptions (60.7%, 53.7%) while less girls reported "underweight" perceptions than boys (10.5% vs. 20.8%) and 28.8% of girls and 25.5% of boys had "overweight" perceptions.

4.3 Math Grades

See Table 4 for results of model 1 testing BMI category as a predictor of math grades above 80% one year later and model 2 with weight perception added as predictor. Models were stratified by gender and controlled for school grade level, race/ethnicity, median area household income, weekly spending money and math grades at baseline. Girls and boys with

missing BMI scores were less likely to report math grades above 80% when compared to their peers with normal BMIs. No effect resulted for BMI of overweight for boys and girls when compared to peers with normal BMI. Boys with BMI of obesity were less likely to report math grades above 80% when compared to boys with normal BMI, however no effect was observed for girls with obese BMIs. Boys and girls with math grades of 80% or higher at baseline were more likely to report grades above 80% at follow up than peers who had lower grades at baseline. Students attending school in areas with median household incomes of more than $100,000 were less likely to get math grades above 80% when compared to those attending schools with median household incomes in the range of $50,000-$75,000. Boys and girls that had no weekly spending money were more likely to report math grades above 80% than their peers with $1-20 per week to spend or save. Adding weight perception in model 2, perceptions of underweight or overweight were not significant predictors of math grades for girls or boys, when compared to perceptions of being at "about the right" weight. Boys with missing weight perceptions were less likely to report math grades above 80% when compared to boys who perceived their weight as about right. Girls with underweight BMI were less likely to report math grades above 80% with the addition of weight perception to the model. All other BMI and covariate effects remained unchanged from model 1. The QIC values for model 1 were 15823.43 and 13688.91 for girls and boys respectively. The QIC values for model 2 were 15828.16 and 13686.45 for girls and boys respectively.

4.4 English/French Grades

See Table 5 for model 3 testing BMI classification and covariates predicting English/French grades at follow up. Underweight BMI was not a significant predictor of

English/French grades above 80%. Girls, but not boys, with overweight BMI were less likely to report higher English/French grades relative to girls with normal weight BMI. Girls and boys with obesity and missing BMI classifications were less likely to report English/French grades above 80% when compared to their peers with normal weight BMI. Weekly spending money, ethnicity and school area median household income were not significant predictors of English/French grades. Baseline English/French grades above 80% were a significant predictor of English/French grades above 80% one year later. The addition of weight perception in model 4 slightly attenuated the estimates for BMI. The addition of weight perception in model 4 slightly attenuated BMI estimates. The effect of overweight BMI on English/French grades was no longer significant for girls, however all other results remained unchanged. Weight perception was not a significant predictor of English/French grades for both boys and girls. QIC values for model 3 were 14413.06 and 13047.06 for girls and boys respectively. QIC values for model 4 were 14416.87 and 13051.12 for girls and boys respectively.

4.5 Post-Secondary Academic Aspirations

Table 6 depicts results of models 5 (BMI) and 6 (BMI and weight perception) predicting academic aspirations. Boys with overweight BMI reported lower academic aspirations than boys with normal BMI. Boys and girls with obese BMI reported lower academic aspirations than their peers with normal BMI. Those who identified as Non-White minority reported higher aspirations than their peers who identified as White. Boys and girls who reported having no weekly spending money or “I don’t know” reported higher aspirations than those who had $1-$20 per week. Baseline academic aspirations were a significant predictor of aspirations at follow up. Relative to their grade 9 students (Quebec Secondary III) counterparts, girls in grades

10, 11 and 12 reported lower aspirations, while girls and boys in Quebec Secondary I-II reported higher aspirations. The addition of weight perception in model 6 attenuated the estimates for girls with BMI of obesity and boys with BMI of overweight and obesity no longer had significantly lower aspirations than their peers with normal weight BMI. Boys with perceptions of overweight were less likely to report aspirations past high school than boys who reported perceptions of being at "about the right weight". QIC values for model 5 were 35317.55 and 33333.26 for girls and boys respectively. QIC values for model 6 were 34960.78 and 32926.08 for girls and boys respectively.

4.6 Post-Secondary Academic Expectations

Table 7 presents results of model 7 (BMI only) and model 8 (BMI and weight perception) predicting post-secondary academic expectations. Boys and girls with BMI of obesity and boys with missing BMI data reported lower expectations than their peers with BMI of normal. No effects were observed with BMIs of underweight or overweight on expectations. Girls and boys who identified as Non-White Minority were more likely to report higher academic expectations than those who identified as White. Girls in Quebec Secondary I-II reported higher expectations than their peers in Secondary III, while other grade levels had no effect. Girls from schools with median household incomes in the categories of $25,000-$50,000 and $75,000-$100,000 reported higher academic expectations when compared to those at schools in areas with median household incomes of $50,000-75,000. Girls who reported weekly spending money of $0 or "I don't know" reported higher expectations than those who reported $1-20 of weekly spending money. When weight perceptions were added in model 8, the lower expectations for girls with BMI of obesity was no longer significant. For boys, the addition of weight perceptions

attenuated the estimates for BMIs of obesity or missing. Weight perception was not a significant predictor of expectations for girls. However, perceptions of overweight were a significant predictor of lower expectations for boys when compared to those with “about right” perceptions. QIC values for model 7 were 38680.32 and 33601.35 for girls and boys respectively. QIC values for model 8 were 38676.69 and 33600.33 for girls and boys respectively.

4.7 Interaction of BMI and Weight Perception

Tables 8-11 and Figures 1,2,3 and 4 present results of models testing an interaction effect between BMI category and weight perception predicting academic outcomes. Students with weight perceptions of missing or underweight and those with a BMI of underweight were removed from the interaction models due to lower frequencies in those categories leaving a final sample of 21,089 students. For math, girls with normal, overweight, or missing BMI and overweight perceptions were more likely to have lower math grades one year later than their peers with normal-weight BMIs and “about right” perceptions. Boys with an overweight or missing BMI and “about right” perceptions had lower math grades than those with normal-weight BMI and “about right” perceptions. Similarly, for English/French, boys with BMIs classified as normal, overweight or missing and overweight perceptions had lower English/French grades than their peers with normal-weight BMIs and “about right” perceptions. For girls, having a BMI classified as normal and “overweight” perceptions did not predict English/French grades, yet all other interaction categories were predictive of lower English/French grades relative to normal BMIs and “about right” perceptions. BMIs of overweight and “about right” perceptions predicted lower post-secondary academic aspirations

for both girls and boys relative to their peers with normal BMIs and “about right” perceptions. Results of other interactions between BMI and weight were not significant for girls for academic aspirations. For boys, BMIs of overweight or missing and overweight perceptions predicted lower aspirations than BMIs of normal and “about right” perceptions. The interaction of all BMI classifications with perceptions of overweight predicted lower post-secondary expectations for girls relative to “about right” perceptions. BMIs of overweight or missing with “overweight” perceptions predicted lower expectations for boys than normal BMIs and “about right” perceptions. BMIs of overweight and “about right “perceptions also predicted lower expectations for boys than normal BMIs and “about right” perceptions. QIC values for model 8 (Math grade) were 13802.76 and 10425.37 for girls and boys respectively. QIC values for model 9 (English/French grade) were 12427.34 and 9830.66 for girls and boys respectively. QIC values for model 10 (aspirations) were 30547.58 and 25316.18 for girls and boys respectively. QIC values for model 11 (expectations) were 33447.06 and 25569.20 for girls and boys respectively.

SECTION 5: Discussion

In a large sample of Canadian secondary school students, this study sought to determine if weight status by BMI classification and weight perception prospectively predicted academic grades and post-secondary aspirations and expectations one year later, stratifying by gender and controlling for academic outcomes and sociodemographic variables at baseline. Overall, results suggest both obesity BMI and overweight perceptions may independently predict poorer academic achievement in boys and girls, albeit their significance and interaction effects varied across gender and academic outcomes.

Obesity BMI predicted poorer academic achievement, when not controlling for weight perceptions. Boys with BMIs in the obesity range were less likely to report high math and English/French grades, while girls with obesity BMIs were only less likely to report high English/French grades. Both boys and girls with obesity BMIs were less likely to report higher post-secondary academic aspirations and expectations than their peers with normal-weight BMIs. Adolescents with missing BMI data were also less likely to report math and English/French grades over 80% than those with normal-weigh BMIs. The effect of BMI classification on grades remained largely unchanged with the addition of weight perception to the models, with the exception that obesity BMI was no longer significantly associated with post-secondary aspirations for boys and post-secondary expectations for girls.

The interaction effects between BMI status and weight perception suggest that overweight perceptions adversely affect academic outcomes for students with normal-weight, overweight/obesity, and missing BMIs, while about right perceptions may provide a protective effect. For academic performance, overweight perceptions predicted lower math grades in girls

and lower English/French grades in boys, whether they had normal-weight or overweight/obesity BMIs, compared to those with "about right" perceptions and normal-weight BMIs. Overweight/obesity BMIs were associated with lower English/French grades in girls with either overweight or about right weight perceptions, compared to girls with normal-weight BMIs and "about right" perceptions. In terms of the educational level students would like to and expect to achieve, overweight/obesity BMI was associated with lower aspirations for both girls and boys, and for lower expectations in boys only, across weight perceptions. Overweight perceptions were associated with lower expectations in girls across BMI categories. Overall, these findings suggest that both a youth's weight and how they perceive their weight are important contributors of academic performance as well as aspirations and expectations for tertiary education.

The inclusion of weight perception is an important addition to the literature exploring weight status and school performance since weight perception can account for many of the adverse physical and psychosocial outcomes associated with obesity [18,56,73]. The perception of being overweight, rather than weight itself, may be what increases the risk of lower self-concept and poor mental health [19,58]. Only two other studies have explored weight perception as a predictor of academic grades to the author's knowledge. Florin et al.'s 2011 study found weight perception to be a stronger predictor of academic grades than weight status [17]. Florin et al. (2011) reported that adolescents with overweight and obesity BMI had lower odds of higher grades than their average weight counterparts, in concordance with this study. In addition to the cross-sectional design and smaller sample, Florin et al. conducted separate models for adolescents with overweight BMIs and those with obesity BMIs. In our previous cross-sectional

study we found that both perceptions of overweight and overweight/obesity BMI status had independent associations with lower grades relative to "about right" perceptions and normal weight BMI, respectively [20]. Our current findings show the interaction effects between weight status by BMI and weight perceptions on academic outcomes. Overweight/obesity BMIs and overweight perceptions predicted lower English/French grades, aspirations and expectations for boys and lower math and language grades and expectations for girls, than normal-weight BMI and "about right" perceptions. Results of the interaction models varied by outcome and gender, with "overweight" perceptions having either an additive effect or "about right" perceptions a protective effect.

Results of this study contribute to the body of work exploring the obesity achievement gap. Mixed findings exist in the literature with several recent literature reviews suggesting the presence of this gap [14,74], while others [15,36] reporting no significant findings in the studies reviewed. It is plausible that factors, such as sociodemographic factors and mental health, may account for differences in academic outcomes by weight status. Theories of selection state that children with lower BMIs tend to have families with higher socioeconomic status, which contribute to better test scores, higher grades and greater odds for attaining post-secondary degrees [75,76] However, socioeconomic variables only explain about half of the association between higher BMI and education attainment [76,77]. More than half of the studies included in Caird et al.'s review found that factors such as parental education, physical activity and parental involvement explained the relationship between lower academic achievement in children and adolescents with overweight [35]. As indicators of parental education were not available in the present sample, lower socioeconomic (SES) was controlled for by indicators of school area

median household income and weekly spending money. Unexpectedly, youth attending schools in areas with lower median household incomes and those with less spending money than their peers were more likely to report higher grades. Further research is needed to explore the role of SES in the obesity achievement gap. Future studies should explore mental health as a mechanism in the association between weight status, weight perceptions and grades. Recent studies have linked poor mental health with worse academic performance [58], "over-weight" perceptions and higher BMI status [19]

The current study expands the literature exploring the obesity achievement gap through the inclusion of post-secondary academic aspirations and expectations. Unlike previous studies that measured educational attainment, this study examined adolescents' hopes and expectations to pursue higher degrees while still in secondary school. Relative to their peers with "normal-weight" BMIs, students with obesity BMI were less likely to report higher academic aspirations, as well as expectations to achieve such post-secondary degrees. These results coincide with existing evidence of links between obesity and lower education attainment [7,77–79]. For instance, Benson et al. (2018) found that having overweight or obesity at 18 years old predicted lower odds of attaining education past high school for women [7]. von Hippel and Lynch (2014) found that overweight BMI in adolescence predicted lower post-secondary attainment in adulthood [77]. The longitudinal study by French et al. (2018) found that girls with obesity in adolescence were less likely to have achieved a bachelor's degree when followed up in adulthood [78]. A systematic review of 289 articles by Cohen et al. (2013) concluded that most studies found a consistent relationship between higher body weight and lower education attainment despite using different measures of obesity and education [79]. Our

results may suggest that discrepancies in educational attainment by weight status may start early, as reflected in lower aspirations and expectations. Other factors, such as lower beliefs about their personal ability or financial capability to pursue higher education, may be responsible for lower educational aspirations, expectations and attainment among individuals with larger bodies.

A possible explanation for lower achievement and education attainment among youth with larger bodies is related to obesity stigma. Weight bias has been documented in physical education teachers [9,16,53,64] as well as healthcare, employment and home settings [9,16]. Negative perceptions about children and adolescents with higher BMIs may result in unfair grade distribution, impair academic performance in schools, and the ability to aspire to and reach post-secondary education goals. Kenney et al. (2015) studied 3362 children participating in the Early Childhood Longitudinal Study-Kindergarten Cohort from fifth to eighth grade and found that teachers perceived girls with larger bodies to have worse reading abilities and boys with higher weight to have worse math abilities [80]. Children who had high BMI scores in fifth grade and increased in BMI scores by eighth grade were faced with worse perceptions of math and reading abilities by their teachers than students higher BMIs in eighth grade only. This is despite the fact that the authors found no association between weight status and standardized test scores [80]. Studies that have used objective grading measures have found no association between weight and academic achievement [43,44,81–83]. In a grading validity study, 133 teachers in New York State were provided with essays and accompanying pictures of students to mark. Researchers found that teachers assigned students with overweight/obesity lower grades than students with average body size despite similar work quality [84]. In our sample of Canadian

youth, those with obesity BMI reported lower grades as well as lower higher education goals. Future studies should consider the potential role of weight bias on academic achievement.

One of the most consistent results across models was the detrimental associations of missing BMI data in both boys and girls. Students with missing BMI data and overweight perceptions were less likely to report higher academic grades and post-secondary academic aspirations and expectations than their peers with normal-weight BMIs and "about right" perceptions. About one-quarter of students had missing BMI data. Given the high proportion of adolescents represented and likelihood that missing values are not missing at random, findings from this group warrant attention. Research suggests that missing weight reports are linked to body dissatisfaction, negative body image and greater investment in appearance [29,30]. It is plausible that those who are self-conscious about their weight lack confidence in their academic abilities. It is also possible that missing BMI status is an indicator of internalized weight stigma, where individuals apply negative stereotypes about larger bodies to themselves. Internalized weight stigma has been linked to poor mental health, disordered eating and lower self-esteem [16,64]. Missing weight values gives insight into what adolescents are willing to share and are meaningful on their own [31]. Findings from this study and others point to the importance of including participants with missing weight values in research, since their exclusion risks losing those participants that researchers may be most interested in.

5.1 Implications and Future Research

Future research should include more waves of data to establish temporality and explore the underlying mechanisms between weight and academic outcomes in addition to developing and testing potential interventions. These findings have implications for over 2 million Canadian

youth with one in two and one in three children/adolescents having overweight or obesity respectively [1], not to mention the many more with perceptions of overweight, regardless of weight status. Interventions at the school level may alter negative trajectories. Bias and diversity training for educational staff as well as upstream public health measures that alter dominant narratives surrounding weight and abilities can work hand in hand to provide better education environments, more fair grading and assessment, and equal opportunity to all students regardless of body size. Future research should explore potential underlying mechanisms linking weight status and poorer academic outcomes. It is plausible lower grades contribute to the reduced likelihood of aspiring and expecting higher educational attainment. Future research including BMI data should consider inclusion of participants with unreported weight to ensure capturing those participants of interest. Given the prevalence of studies that account for grade differences by weight status based on teacher assessment, future studies should also utilize standardized test scores to decipher the separate effects of weight status on grades, and teacher perceptions or subjective marking effects on grades for students with larger bodies.

5.2 Limitations

Several limitations require consideration. As the COMPASS study was not designed to be representative, results may not be generalizable to the entire population. However, the large sample size, full school samples, and high response rates, help support generalizability. There is risk of recall and social desirability bias with self-reported data. Lower achieving students may have reported higher marks than they achieved. However, a review of 37 independent samples reported strong validity of self-reported grades [45]. Also the COMPASS study employs active-

information, passive-consent data collection protocols, and does not require student names, to reduce response bias and support perceptions of anonymity [67]. Another limitation worth noting is the large number of participants with missing weight data, and the odds that it is not missing at random. Hence participants with missing BMI data were included in the analysis as their own category to help mitigate this potential bias. Inclusion of more sociodemographic variables such as parental education and time parents spend with child could further add to the validity of findings. Similarly weight stigma, a documented issue in multiple setting [9,16] may play a role in how students with larger bodies are assessed and should be included in research exploring the obesity achievement gap. It is also unclear whether respondents were comparing their weight to their ideal body, their peers or a medical standard when responding to the weight perception question. Grades on subjects other than math and English/French were not available and standardized test scores were also not available for students. Additionally, it is unclear if participants fell their grades are an accurate reflection of their efforts. Moreover, the compass study does not collect data from teachers on their grading policies and perception of student abilities. Finally, despite the prospective design, causality in the relationship between weight status and academic performance cannot be established. Future research should consider recruiting participants earlier in childhood and following them through childhood, adolescence and early adulthood.

5.3 Conclusion

This study is the first prospective analysis of weight status and academic outcomes to consider the role of weight perceptions and to examine post-secondary aspirations and expectations. Results support the existence of an obesity achievement gap. Our results show

that both academic performance and post-secondary aspirations and expectations differ by body weight. Findings of this study add to existing evidence of lower education attainment associated with obesity. Results warrant attention and further exploration, as these trajectories may start early, with discrepancies in aspirations, expectations, and performance already present in adolescence. Lower academic performance sets long-term trajectories of social and developmental health.

Declarations

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Competing interests: The authors declare that they have no competing interests/conflicts of interests.

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boards approved all procedures. All students attending participating schools were invited to participate using active-information passive-consent parental permission protocols. Students could withdraw from the study at any time.

Tables and Figures

Table 1. Demographic characteristics of students linked for participation in Year 6 (2017/18) and 7 (2018/19) of the COMPASS Study in Canada. Results presented for Year 6 (N = 26,537).

Variable	Total N (%)	Boys N (%)	Girls N (%)	Chi Square p-value
Gender				
Boy	12268 (46.2%)	-	-	
Girl	14269 (53.8%)	-	-	
Grade				<.001
9	8537 (32.2%)	3978 (32.4%)	4559 (32.0%)	
10	8263 (31.1%)	3779(30.9%)	4484 (31.0%)	
11	5021 (18.9%)	2359 (19.2%)	2662 (18.7%)	
12	272(1.0%)	180 (1.5%)	92 (0.6%)	
Other*	4444(16.8%)	1972 (16.0%)	2472 (17.3%)	
Ethnicity				.04
White	20726 (78.0%)	9513 (77.5%)	11213 (78.6%)	
Other	5811(22.0%)	2755 (22.5%)	3056 (21.4%)	
Spending money				<.0001
$0	4859 (18.3%)	2533 (20.7%)	2326 (16.3%)	
$1-20	7772 (29.3%)	3536 (28.8%)	4236 (29.8%)	
$21-100	5791 (21.8%)	2559 (20.9%)	3232 (22.7%)	
>$100	3442 (13%)	1704 (13.9%)	1738 (12.1%)	
I don’t know	4673 (17.6%)	1936 (15.8%)	2737 (19.1%)	
BMI classification				<.001
Underweight	487 (1.8%)	241 (2.0%)	246 (1.7%)	
Normal	14526 (54.8%)	6325 (51.6%)	8201 (57.5%)	
Overweight	3184 (12.0%)	1665 (13.6%)	1519 (10.6%)	
Obese	1457 (5.5%)	900 (7.3%)	557 (3.9%)	
Missing	6883 (25.9%)	3137 (25.5%)	3746 (26.3%)	
Weight Perception				<.0001
Underweight	4282 (16.1%)	2667 (21.7%)	1615 (11.3%)	
About right	15837 (59.7%)	6925 (56.5%)	8912 (62.5%)	
Overweight	3582 (23.1%)	2539 (20.7%)	13,374 (25.1%)	
Missing	297 (1.1%)	137 (1.1%)	160 (1.1%)	

* Secondary I-II in Quebec schools equivalent to Grades 7 and 8

Table 2. *Academic achievement characteristics of students linked for participation in Year 6 (2017/18) and 7 (2018/19) of the COMPASS Study in Canada. Results presented for Year 6 (N = 26,537).*

Variable	Total N (%)	Boys N (%)	Girls N (%)	Chi Square p-value
Math Grade				<.0001
90-100%	6366 (24.0%)	2718 (22.2%)	3648 (25.5%)	
80-89%	7553 (28.5%)	3403 (27.8%)	4250 (29.8%)	
70-79%	6027 (22.8%)	2920 (23.8%)	3097 (21.8%)	
60-69%	3539 (13.5%)	1735 (14.1%)	1804 (12.6%)	
50-59%	2167 (8.2%)	1096 (8.9%)	1071 (7.5%)	
Below 50%	795 (3.0%)	396 (3.2%)	399 (2.8%)	
English/French Grade				<.0001
90-100%	4325 (16.3%)	1266 (10.3%)	3059 (21.4%)	
80-89%	9740 (36.7%)	3883 (31.7%)	5857 (41.0%)	
70-79%	7433 (28.0%)	3907 (31.8%)	3526 (24.7%)	
60-69%	3427 (12.9%)	2129 (17.4%)	1298 (9.1%)	
50-59%	1333 (5.0%)	897 (7.3%)	436 (3.1%)	
Below 50%	279 (1.1%)	186 (1.5%)	93 (0.7%)	
Academic Aspirations				<.0001
High school or less	1413 (5.3%)	900 (7.3%)	513 (3.6%)	
College/Trade	4683 (17.6%)	2737 (22.3%)	1946 (13.6%)	
Bachelor's Degree	4691 (17.7%)	2281 (18.6%)	2410 (16.9%)	
Master's/PhD/law school /MD	10,455 (39.4%)	3711 (30.3%)	6744 (47.3%)	
I don't know	5295 (20.0%)	2639 (21.5%)	2656 (18.6%)	
Academic Expectations				<.0001
High school or less	1919 (7.2%)	1111 (9.1%)	804 (5.6%)	
College/Trade	5773 (21.8%)	3233 (26.3%)	2540 (17.8%)	
Bachelor's Degree	5852 (22.1%)	2697 (22.0%)	3155 (22.1%)	
Master's/PhD/law school/MD	7108 (26.8%)	2542 (20.7%)	4566 (32.0%)	
I don't know	5889 (22.1%)	2685 (21.9%)	3204 (22.5%)	

Table 3. Weight perception by BMI classification among girls (a) and boys (b) linked for participation in Year 6 (2017/18) and 7 (2018/19) of the COMPASS Study in Canada. Results for Year 6 (N = 26,537).

3 a)

	BMI Classification Girls				
Weight Perception	Underweight	Normal	Overweight	Obesity	Missing
Underweight	66.1%	12.7%	0.8%	3.2%	10.5%
About Right	29.4%	73.1%	37.6%	16.9%	60.7%
Overweight	4.5%	14.2%	61.6%	79.9%	28.8%

3 b)

	BMI Classification Boys				
Weight Perception	Underweight	Normal	Overweight	Obesity	Missing
Underweight	67.3%	28.8%	1.7%	3.7%	20.8%
About Right	28.9%	65.8%	55.5%	17.9%	53.7%
Overweight	3.8%	5.4%	42.8%	78.4%	25.5%

Table 4 *Estimates for BMI and weight perception predicting math grades over 80% one year later using generalized equation estimation models.*

	Girls N=13,919		Boys N=11,754	
Variable	Model 1 b (95% CI)	Model 2 b (95% CI)	Model 1 b (95% CI)	Model 2 b (95% CI)
Intercept	3.09 (2.92, 3.26)***	3.10 (2.93, 3.27)***	2.65 (2.44, 2.84)***	2.64 (2.44, 2.84)***
BMI				
Underweight	-0.06 (-0.73, -0.19)	-0.44 (-0.72, -0.17)**	-0.19 (-0.33, 0.29)	-0.02 (-0.32, 0.29)
Normal *(ref.)*	-	-	-	-
Overweight	-0.12 (-0.25, 0.01)	-0.10 (-0.24, 0.45)	-0.08 (-0.20, 0.04)	-0.11 (-0.24, 0.02)
Obese	-0.15 (-0.38, 0.06)	-0.12 (-0.99, 0.33)	-0.22 (-0.38, -0.05)**	-0.28 (-0.47, -0.10)**
Missing	-0.28 (-0.37, -0.19)***	-0.27*** (-0.37, -0.17)	-0.15 (-0.27, -0.04)*	-0.16 (-0.28, -0.05)***
Ethnicity				
Non-white minority	0.10 (-0.01, 0.22)	0.10 (-0.01, 0.22)	0.07 (-0.06, 0.18)	0.06 (-0.06, 0.18)
White *(ref.)*	-	-	-	-
Median Income				
$25,000-50,000	0.04 (-0.14, 0.22)	0.04 (-0.15, 0.23)	0.18 (-0.04, 0.40)	0.18 (-0.05, 0.40)
$50,001-75,000 *(ref.)*	-	-	-	-
$75,001-100,000	-0.01 (-0.17, 0.16)	-0.01-0.17, 0.16)	-0.09 (-0.26, 0.08)	-0.10 (-0.27, 0.07)
>$100,000	-0.50 (-0.64, -0.36)***	-0.50 (-0.64, -0.36)***	-0.53 (-0.74, -0.33)***	-0.53 (-0.74, -0.32)***
Math Grade (baseline)	2.05 (-2.12, -1.96)***	2.05 (2.14, 1.93)***	1.93 (1.84, 2.02)***	1.93 (1.83, 2.02)***
Grade				
9 *(ref.)*	-	-	-	-
10	0.02 (-0.12, 0.15)	0.02 (-0.12, 0.15)	-0.06 (-0.20, 0.08)	-0.06 (-0.20, 0.08)
11	0.12 (0.07, -0.02)	0.12 (-0.01, 0.26)	0.15 (0.01, 0.29)*	0.15 (0.01, 0.29)
12	0.11 (-0.50, 0.72)	0.11 (-0.50, 0.72)	0.31 (-0.10, 0.71)	0.30 (-0.11, 0.71)
QC I-II	0.26 (0.13, 0.38)***	0.23 (0.13, 0.38)***	0.20 (-0.03, 0.42)	0.20 (-0.03, 0.43)
Spending money				
$0	0.16 (0.05, 0.27)**	0.16 (0.05, 0.27)**	0.19 (0.08, 0.29)***	0.19 (0.08, 0.29)**
$1-20 *(ref.)*	-	-	-	-
$21-100	-0.02 (-0.10, 0.07)	-0.02 (-0.10, 0.07)	0.08 (-0.05, 0.20)	0.08 (-0.04, 0.20)
>$100	0.05 (-0.09, 0.18)	0.05 (-0.09, 0.18)	-0.54 (-0.74, -0.33)***	0.15 (-0.01,0.31)
I don't know	0.12 (0.02, 0.22)*	0.12 (0.02, 0.22)*	0.16 (0.04, 0.29)*	0.17 (0.04, 0.29)*
Weight Perception				
Underweight		-0.04 (-0.15, 0.07)		0.01 (-0.10, 0.11)
About Right *(ref.)*		-	-	-
Overweight		-0.07 (-0.17, 0.04)		0.09 (-0.24, 0.20)
Missing		-0.17 (-0.62, 0.28)		-0.47 (-0.88, -0.05)*

Notes: All models account for school clustering. * = p <.05, ** = p <.01, ***p <.001.

Table 5. Estimates for BMI and weight perception predicting English/French grades over 80% one year later using generalized equation estimation models.

	Girls N=13,919		Boys N=11,754	
Variable	Model 3 b (95% CI)	Model 4 b (95% CI)	Model 3 b (95% CI)	Model 4 b (95% CI)
Intercept	3.87 (3.64, 4.09)***	3.88 (3.66, 4.11)***	2.76 (2.53, 2.98) ***	2.74 (2.51, 2.97)***
BMI				
Underweight	-0.06 (-0.26, 0.38)	0.10 (-0.22, 0.43)	-0.09 (-0.33, 0.15)	-0.12 (-0.36, 0.13)
Normal *(ref.)*	-	-	-	-
Overweight	-0.17 (-0.30, -0.03)*	-0.14 (-0.29, 0.01)	-0.04 (-0.17, 0.09)	-0.01 (-0.15, 0.14)
Obese	-0.31 (-0.48, -0.13)***	-0.27 (-0.47, -0.07)**	-0.29 (-0.43, -0.14)***	-0.23 (-0.39, -0.06)**
Missing	-0.40 (-0.39, -0.40)***	-0.39 (-0.48, -0.29)***	-0.26 (-0.35, -0.16)***	-0.24 (-0.36, -0.14)***
Ethnicity				
Non-white minority	-0.10 (-0.22, 0.01)	-0.10 (-0.22, 0.01)	-0.07 (-0.18, 0.03)	-0.07 (-0.18, 0.04)
White *(ref.)*	-	-	-	-
Median Income				
$25,000-50,000	-0.05 (-0.40, 0.30)	-0.05 (-0.40, 0.30)	0.04 (-0.29, 0.36)	0.04 (-0.29, 0.37)
$50,001-75,000 *(ref.)*	-	-	-	-
$75,001-100,000	-0.01 (-0.23, 0.20)	-0.01 (-0.23, 0.21)	-0.17 (-0.42, 0.07)	-0.18 (-0.43, 0.06)
>$100,000	-0.13 (-0.60, 0.35)	-0.13 (-0.61, 0.34)	-0.10 (-0.69, 0.48)	-0.11 (-0.69, 0.48)
English/French Grade (baseline)	2.25 (2.14, 2.37)***	2.25 (2.14, 2.37)	1.99 (1.89, 2.11)***	1.99 (1.88, 2.11)***
Grade				
9 *(ref.)*	-	-	-	-
10	0.08 (-0.21, 0.05)	-0.08 (-0.21, 0.05)	0.01 (-0.13, 0.13)	0.01 (-0.13, 0.14)
11	0.07 (-0.10, 0.24)	0.07 (-0.10, 0.24)	0.17 (0.00, 0.33)	0.17 (0.01, 0.33)*
12	0.16 (-0.62, 0.93)	0.16 (-0.62, 0.94)	0.10 (-0.35, 0.54)	0.10 (-0.35, 0.54)
QC I-II	-0.12 (-0.28, 0.04)***	-0.11 (-0.28, 0.04)	0.14 (-0.05, 0.33)	0.14 (-0.05, 0.33)
Spending money				
$0	0.10 (-0.02, 0.23)	0.10 (-0.02, 0.23)	0.01 (-0.10, 0.13)	0.01 (-0.10, 0.13)
$1-20 *(ref.)*	-	-	-	-
$21-100	-0.03 (-0.13, 0.08)	-0.02 (-0.13, 0.08)	0.02 (-0.09, 0.15)	0.03 (-0.10, 0.15)
>$100	-0.13 (-0.27, 0.05)	-0.13 (-0.27, 0.02)	-0.02 (-0.15, -.12)	-0.01 (-0.15, 0.13)
I don't know	0.03 (-0.08, 0.13)	0.02 (-0.08, 0.12)	0.04 (-0.08, 0.15)	0.04 (-0.08, 0.16)
Weight Perception				
Underweight		-0.09 (-0.20, 0.02)		0.06 (-0.04, 0.16)
About Right *(ref.)*		-	-	-
Overweight		-0.07 (-0.17, 0.03)		-0.06 (-0.17, 0.05)
Missing		-0.10 (-0.57, 0.36)		-0.29 (-0.67, 0.09)

Notes: All models account for school clustering. * = p <.05, ** = p <.01, ***p <.001

Table 6 Estimates for BMI and weight perception predicting Academic Aspirations one year later using generalized equation estimation models.

	Girls N=13,919		Boys N=11,754	
Variable	Model 5 b (95% CI)	Model 6 b (95% CI)	Model 5 b (95% CI)	Model 6 b (95% CI)
Intercept	-5.76 (-6.09, -5.43)***	-4.48 (-4.75, -4.20)***	-4.84 (-5.05, -4.62)***	-4.05 (-4.27, -3.82)***
Intercept	-3.29 (-3.55, -2.04)***	-2.02 (-2.26, -1.76)***	-3.28 (-3.47, -3.09)***	-2.50 (-2.73, -2.27)***
Intercept	-1.98 (-2.21, -1.74)***	-0.62 (-0.88, -0.36)***	-2.16 (-2.34, -1.98)***	-1.31 (-1.55, -1.07)***
Intercept	0.25 (0.04, 0.47)*	1.64 (1.36, 1.92)***	0.11 (-0.07, 0.29)	1.05 (0.78, 1.32)***
BMI				
Underweight	-0.01 (-0.25, 0.22)	0.03 (-0.21, 0.26)	-0.12 (-0.13, 0.36)	0.14 (-0.11, 0.39)
Normal *(ref.)*	-	-	-	-
Overweight	-0.08 (-0.17, 0.01)	-0.05 (-0.14, 0.04)	-0.10 (-0.20, -0.01)*	-0.06 (-0.16, 0.04)
Obese	-0.22 (-0.38, -0.07)**	-0.18 (-0.34, -0.02)*	-0.16 (-0.28, -0.04)**	-0.04 (-0.18, 0.10)
Missing	-0.03 (-0.11, -0.06)	0.05 (-0.04, 0.14)	-0.06 (-0.15, 0.04)	0.05 (-0.04, 0.15)
Ethnicity				
Non-white minority	0.20 (0.13, 0.28)***	0.15 (0.08, 0.23)***	0.28 (0.19, 0.38)***	0.21 (0.13, 0.30)***
White *(ref.)*	-	-	-	-
Median Income				
$25,000-50,000	0.12 (-0.06, 0.31)	0.09 (-0.08, 0.26)	0.18 (0.01, 0.34)*	0.13 (-0.01, 0.26)
$50,001-75,000 *(ref.)*	-	-	-	-
$75,001-100,000	0.09 (0.00, 0.18)	0.08 (-0.01, 0.17)	0.02 (-0.11, 0.16)	0.03 (-0.09, 0.15)
>$100,000	0.04 (-0.19, 0.26)	0.02 (-0.19, 0.23)	-0.13 (-0.40, 0.15)	-0.17 (-0.42, 0.09)
Aspirations (baseline)	0.78 (0.73, 0.84)***	0.78 (0.72, 0.84)***	0.68 (0.64, 0.71)***	0.68 (0.63, 0.72)***
Grade				
9 *(ref.)*	-	-	-	-
10	-0.15 (-0.23, -0.07)***	-0.16 (-0.24, -0.08)***	0.03 (-0.11, 0.05)	-0.05 (-0.13, 0.03)
11	-0.26 (-0.36, -0.15)***	-0.28 (-0.38, -0.17)***	-0.09 (-0.18, 0.01)	-0.13 (-0.22, -0.04)**
12	-0.47 (-0.90, -0.03)*	-0.33 (-0.78, 0.11)	-0.10 (-0.37, 0.17)	-0.12 (-0.39, 0.16)
QC I-II	0.28 (0.16, 0.40)***	0.32 (0.20, 0.44)***	0.16 (0.03, 0.28)*	0.16 (0.04, 0.28)**
Spending money				
$0	0.17 (0.07, 0.27)***	0.20 (0.10, 0.30)***	0.13 (0.04, 0.23)**	0.17 (0.07, 0.26)***
$1-20 *(ref.)*	-	-	-	-
$21-100	0.04 (-0.05, 0.12)	0.02 (-0.06, 0.10)	-0.03 (-0.11, 0.06)	-0.04 (-0.12, 0.05)
>$100	0.02 (-0.10, 0.13)	0.02 (-0.10, 0.13)	-0.11 (-0.23, -0.01)*	-0.12 (-0.23, -0.02)*
I don't know	0.14 (0.05, 0.24)**	0.17 (0.08, 0.27)***	0.08 (-0.02, 0.18)	0.11 (0.01, 0.21)*
Weight Perception				
Underweight		0.01 (-0.09, 0.11)		-0.04 (-0.12, 0.03)

About Right *(ref.)*	-	-	-
Overweight	0.01 (-0.08, 0.08)		-0.10 (-0.20, -0.01)*
Missing	0.05 (-0.23, 0.38)		-0.12 (-0.43, 0.19)

Notes: All models account for school clustering. * = p <.05, ** = p <.01, ***p <.0

Table 7. Estimates for BMI and weight perception predicting Academic Expectations one year later using generalized equation estimation models.

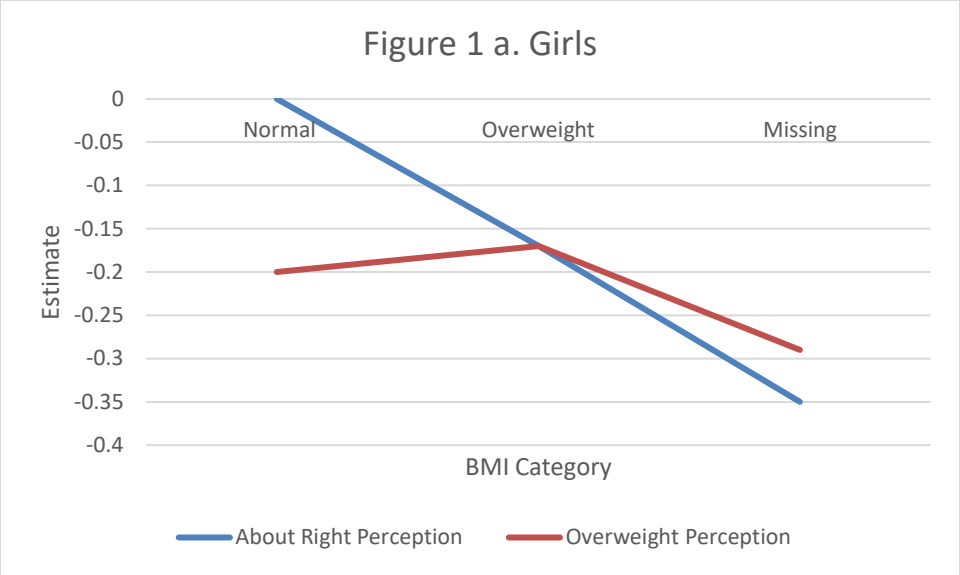
	Girls N=13,919		Boys N=11,754	
Variable	Model 7 b (95% CI)	Model 8 b (95% CI)	Model 7 b (95% CI)	Model 8 b (95% CI)
Intercept	-5.10 (-5.35, -4.86)***	-5.08 (-5.32, -4.84)***	-4.68 (-4.91, -4.46)***	-4.65 (-4.87, -4.43)***
Intercept	-3.37 (-3.55, -3.18)***	-3.34 (-3.53, -3.16)***	-3.48 (-3.67, -3.28)***	-3.45 (-3.65, -3.25)***
Intercept	-1.92 (-2.10, -1.74)***	-1.89 (-2.07, -1.72)***	-2.25 (-2.45, -2.05)***	-2.22 (-2.42, -2.02)***
Intercept	0.14 (-0.04, 0.31)	0.17 (-0.01, 0.34)	-0.01 (-0.21, 0.18)	0.02 (-0.17, 0.21)
BMI				
Underweight	-0.03 (-0.32, 0.25)	-0.01 (-0.30, 0.27)	0.04 (-0.21, 0.28)	0.07 (-0.18, 0.31)
Normal *(ref.)*	-	-	-	-
Overweight	-0.05 (-0.15, 0.05)	-0.01 (-0.11, 0.10)	-0.09 (-0.17, 0.01)	-0.07 (-0.16, 0.03)
Obese	-0.21 (-0.36, -0.05)**	-0.14 (-0.31, 0.03)	-0.24 (-0.35, -0.11)***	-0.17 (-0.32, -0.34)*
Missing	-0.08 (-0.16, 0.01)	-0.06 (-0.14, 0.02)	-0.14 (-0.24, -0.05)**	-0.12 (-0.22, -0.03)*
Ethnicity				
Non-white minority	0.18 (0.10, 0.26)***	0.19 (0.11, 0.27)***	0.27 (0.17, 0.36)***	0.27 (0.17, 0.37)***
White *(ref.)*	-	-	-	-
Median Income				
$25,000-50,000	0.22 (0.04, 0.39)*	0.22 (0.04, 0.39)*	0.22 (0.08, 0.37)**	0.22 (0.08, 0.37)**
$50,001-75,000 *(ref.)*	-	-	-	-
$75,001-100,000	0.11 (0.01, 0.21)*	0.11 (0.01, 0.21)*	0.05 (-0.09, 0.19)	0.05 (-0.09, 0.19)
>$100,000	0.15 (-0.12, 0.42)	0.15 (-0.12, 0.42)	0.07 (-0.23, 0.37)	0.07 (-0.23, 0.38)
Expectation (baseline)	0.70 (0.65, 0.74)***	0.69 (0.65, 0.73)***	0.66 (0.62, 0.69)***	0.66 (0.62, 0.70)***
Grade				
9 *(ref.)*	-	-	-	-
10	-0.06 (-0.15, 0.03)	-0.06 (-0.14, 0.03)	-0.07 (-0.15, 0.02)	-0.07 (-0.15, 0.02)
11	-0.08 (-0.18, 0.02)	-0.08 (-0.17, 0.02)	0.02 (-0.09, 0.13)	0.02 (-0.09, 0.13)
12	-0.30 (-0.66, 0.07)	-0.29 (-0.65, 0.73)	0.02 (-0.28, 0.32)	0.03 (-0.27, 0.33)
QC I-II	0.25 (0.12, 0.38)***	0.25 (0.12, 0.37)	0.13 (-0.01, 0.26)	0.12 (-0.01, 0.25)
Spending money				
$0	0.12 (0.03, 0.21)**	0.12 (0.04, 0.21)**	0.09 (-0.01, 0.19)	0.09 (-0.01, 0.18)
$1-20 *(ref.)*	-	-	-	-
$21-100	0.07 (-0.02, 0.15)	0.07 (-0.02, 0.15)	-0.01 (-0.10, 0.09)	-0.01 (-0.11, 0.09)
>$100	-0.03 (-0.13, 0.08)	-0.02 (-0.13, 0.81)	-0.06 (-0.18, 0.05)	-0.07 (-0.18, 0.05)
I don't know	0.09 (0.01, 0.17)*	0.09 (0.01, 0.17)*	0.09 (-0.01, 0.19)	0.09 (-0.01, 0.19)
Weight Perception				
Underweight		-0.06 (-0.15, 0.03)		-0.07 (-0.15, 0.01)
About Right *(ref.)*	-	-	-	-
Overweight		-0.11 (-0.19, -0.03)		-0.11 (-0.20, -0.01)*
Missing		-0.20 (-0.51, 0.11)		-0.12 (-0.42, 0.18)

Notes: All models account for school clustering. * = p <.05, ** = p <.01, ***p <.001.

Table 8. Estimates for BMI classification and weight perception interaction as predictors of Math Grades over 80% one year later using generalized estimating equations

Variable	Girls (N=12,105) b (95% CI)	Boys (N=8,984) b (95% CI)
Intercept	3.14 (2.95, 3.32)***	2.81 (2.58, 3.05)***
Main Effects (BMI Normal and About Right Perceptions ref)		
BMI		
Overweight	-0.17 (-0.36, 0.03)	-0.18 (-0.34, -0.02)*
Missing	-0.35 (-0.48, -0.22)***	-0.19 (-0.33, -0.05)**
Weight Perception		
Overweight	-0.20 (-0.35, -0.05)***	0.12 (-0.13, 0.38)
Interactions		
Overweight*Overweight	-0.17 (-0.32,-0.01)*	-0.11 (-0.24, 0.03)
Missing*Overweight	-0.29 (-0.43, -0.16)***	-0.14 (-0.33, 0.05)

Notes: all models control for ethnicity, weekly spending money, median household income, math grade at baseline and grade level. * = p <.05, ** = p <.01, ***p <.001.



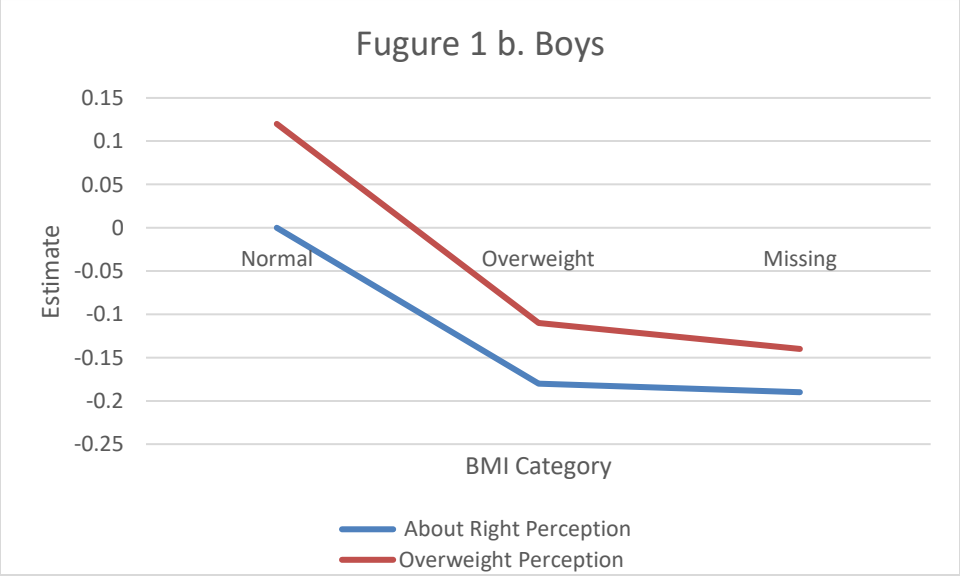
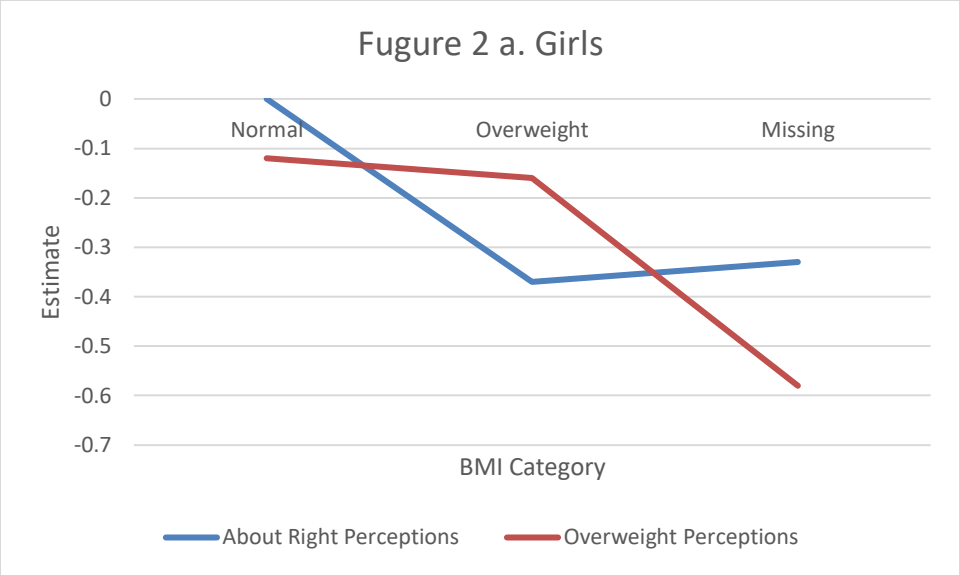


Figure 1. Interaction between BMI classification and weight perception at baseline as predictors of math grades at follow up among girls (a) and boys (b)

Table 9. Estimates for BMI classification and weight perception interaction as predictors of English/French Grades over 80% one year later using generalized estimating equations

Variable	Girls (N=12,105) b (95% CI)	Boys (N=8.984) b (95% CI)
Intercept	-0.68 (-0.85, -0.50)***	-0.21 (-1.45, -0.96)***
Main Effects (BMI Normal and About Right Perceptions ref)		
BMI		
Overweight	-0.37 (-0.61, -0.14)**	-0.10 (-0.28, 0.08)
Missing	-0.33 (-0.47, -0.20)***	-0.30 (-0.49, 0.16)***
Weight Perception		
Overweight	-0.12 (-0.27, 0.04)	-0.35 (-0.60, -0.10)**
Interactions (BMI*Weight Perception)		
Overweight*Overweight	-0.16 (-0.31, -0.01)*	--0.16 (-0.30, -0.02)*
Missing*Overweight	-0.58 (-0.75, -0.41)***	-0.25 (-0.41, -0.09)**

Notes: all models control for ethnicity, weekly spending money, median household income, English/French grade at baseline and grade level. * = p <.05, ** = p <.01, ***p <.001.



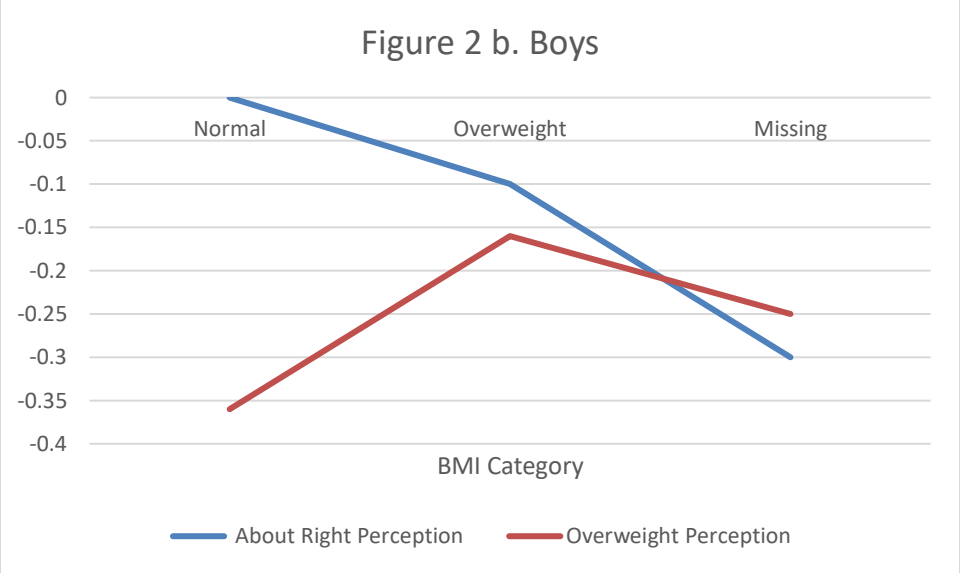
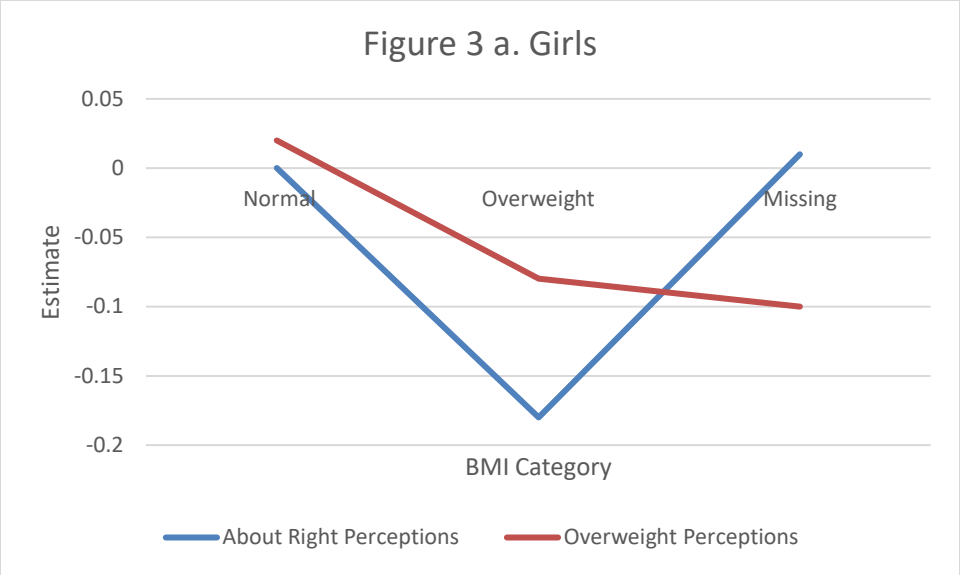


Figure 2. Interaction between BMI classification and weight perception at baseline as predictors of English/French grades at follow up among girls (a) and boys (b)

Table 10.. *Estimates for BMI classification and weight perception interaction as predictors of Academic Aspirations one year later using generalized estimating equations*

Variable	Girls (N=12,105) b (95% CI)	Boys (N=8,984) b (95% CI)
Intercept	-5.84 (-6.19, -5.49)***	-4.93 (-5.19, -4.67)***
Intercept	-3.34 (-3.61, -3.06)***	-3.36 (-3.58, -3.14)***
Intercept	-2.01 (-2.27, -1.75)***	-2.23 (-2.43, -2.02)***
Intercept	0.24 (0.01, 0.48)*	0.10 (-0.09, 0.29)
Main Effects (BMI Normal and About Right ref)		
BMI		
Overweight	-0.18 (-0.32, -0.04)*	-0.19 (-0.31, -0.06)**
Missing	0.01 (-0.11, 0.12)	-0.01 (-0.12, 0.11)
Weight Perception		
Overweight	0.02 (-0.10, 0.14)	-0.10 (-0.27, 0.08)
Interaction (BMI*Weight Perception)		
Overweight*Overweight	-0.08 (-0.19, 0.03)	-0.12 (-0.22, 0.02)*
Missing*Overweight	-0.10 (-0.22, 0.02)	-0.26 (-0.42, -0.10)**

Notes: all models control for ethnicity, weekly spending money, median household income, aspirations at baseline and grade level. * = p <.05, ** = p <.01, ***p <.001.



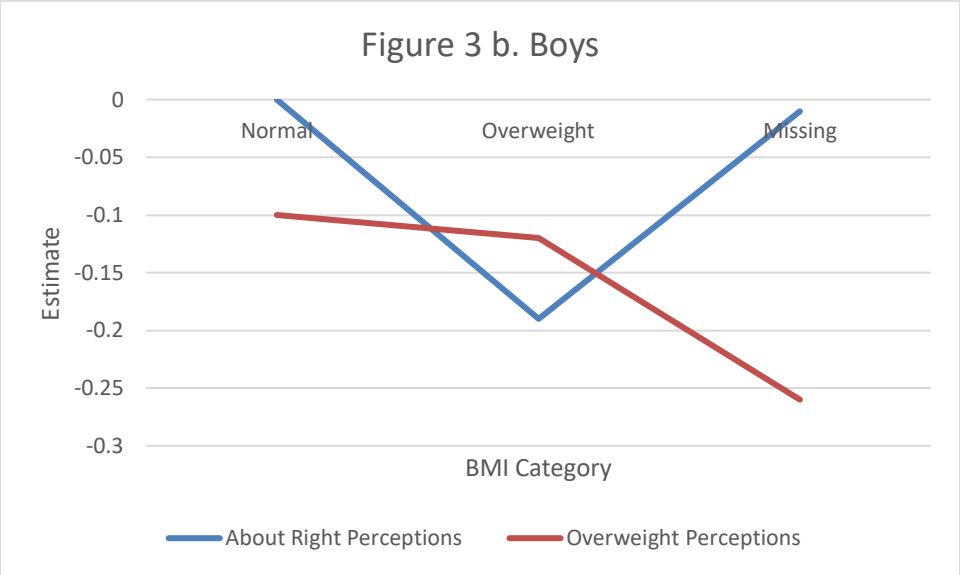
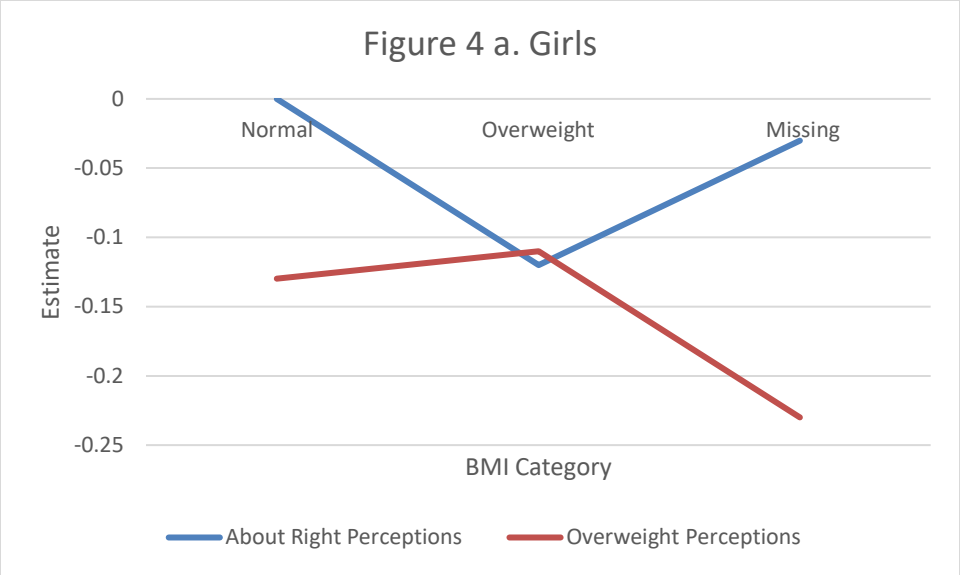


Figure 3. Interaction between BMI classification and weight perception at baseline as predictors of academic aspirations at follow up among girls (a) and boys (b)

Table 11. Estimates for BMI classification and weight perception interaction as predictors of Academic Expectations one year later using generalized estimating equations

Variable	Girls (N=12,105) b (95% CI)	Boys (N=8,984) b (95% CI)
Intercept	-5.14 (-5.39, -4.90)***	-4.74 (-4.96, -4.49)***
Intercept	-3.37 (-3.56, -3.17)***	-3.51 (-3.73, -3.30)***
Intercept	-1.91 (-2.11, -1.72)***	-2.28 (-2.49, -2.06)***
Intercept	0.19 (-0.01, 0.38)*	-0.01 (-0.22, 0.19)
Main Effects (BMI Normal and About Right ref)		
BMI		
Overweight	-0.12 (-0.26, 0.02)	-0.15 (-0.26, -0.04)**
Missing	-0.03 (-0.13, 0.07)	-0.10 (-0.21, 0.02)
Weight Perception		
Overweight	-0.13 (-0.23, -0.03)*	-0.20 (-0.41, 0.01)
Interaction (BMI*Weight Perception)		
Overweight*Overweight	-0.11 (-0.20, -0.01)*	-0.18 (-0.28, -0.07)**
Missing*Overweight	0.23 (-0.36, -0.09)***	-0.31 (-0.45, -0.16)***

Notes: all models control for ethnicity, weekly spending money, median household income, expectations at baseline and grade level. * = p <.05, ** = p <.01, ***p <.001



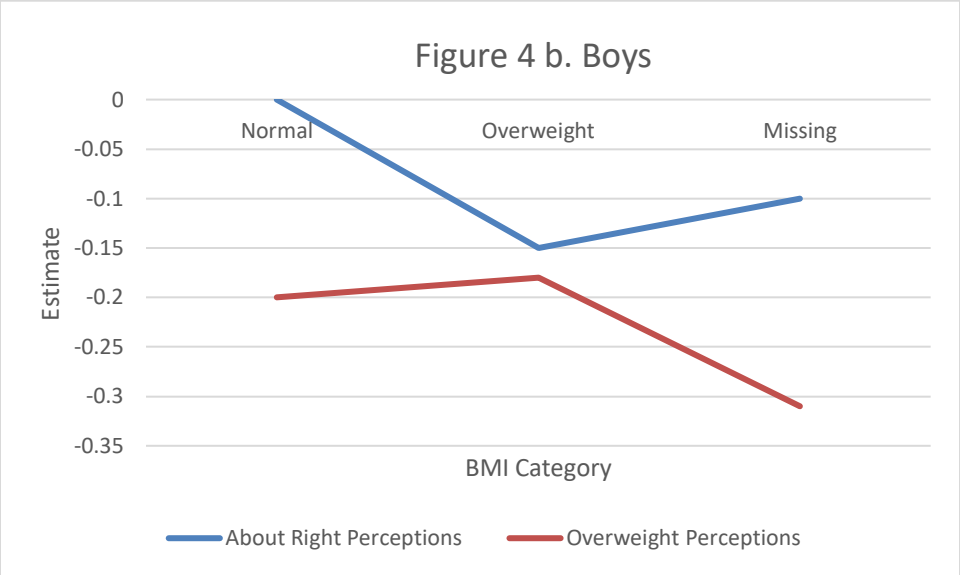


Figure 4. Interaction between BMI classification and weight perception at baseline as predictors of academic expectations at follow up among girls (a) and boys (b)

References

1. Shentow-Bewsh R, Zuberi D. Reducing the prevalence of obesity in Canada: a call to action. *Soc Work Public Health*. 2018;33(6):329-341. doi:10.1080/19371918.2018.1482252

2. Must A, Anderson SE. Effects of obesity on morbidity in children and adolescents. *Nutr Clin Care*. 2003;6(1):4-48.

3. Erickson SJ. Are overweight children unhappy? Body mass index, depressive symptoms, and overweight concerns in elementary school children. *JAMA J Am Med Assoc*. 2000;(21). https://doi.org/10.1001/archpedi.154.9.931

4. Strauss RS, Pollack HA. Social marginalization of overweight children. *JAMA J Am Med Assoc*. 2003;(17):2239.

5. Schwimmer JB, Burwinkle TM, Varni JW, Schwimmer JB, Burwinkle TM, Varni JW. Health-related quality of life of severely obese children and adolescents. *JAMA J Am Med Assoc*. 2003;289(14):1813-1819.

6. Shore SM, Sachs ML, Lidicker JR, Brett SN, Wright AR, Libonati JR. Decreased scholastic achievement in overweight middle school students. *Obes 19307381*. 2008;16(7):1535-1538.

7. Benson R, Von Hippel PT, Lynch JL. Does more education cause lower BMI, or do lower-BMI individuals become more educated? Evidence from the National Longitudinal Survey of Youth 1979. *Soc Sci Med*. Published online 2018. doi:10.1016/j.socscimed.2017.03.042

8. Lanza HI, Huang DYC. Is Obesity associated with school dropout? Key developmental and ethnic differences. *J Sch Health*. 2015;85(10):663-670.

9. Puhl RM, Heuer CA. The stigma of obesity: a review and update. *Obes 19307381*. 2009;17(5):941-964. doi:10.1038/oby.2008.636

10. Larsen JK, Kleinjan M, Engels RCME, Fisher JO, Hermans RCJ. Higher weight, lower education: A longitudinal association between adolescents' body mass index and their subsequent educational achievement level? *J Sch Health*. 2014;84(12):769-776. doi:10.1111/josh.12212

11. He J, Chen X, Fan X, Cai Z, Huang F. Is there a relationship between body mass index and academic achievement? A meta-analysis. *Public Health Elsevier*. 2019;167:111-124. doi:10.1016/j.puhe.2018.11.002

12. Yanfeng Li, Qi Dai, Jackson JC, Jian Zhang. Overweight Is associated with decreased cognitive functioning among school-age children and adolescents. *Obes 19307381*. 2008;16(8):1809-1815.

13. Datar A, Sturm R, Magnabosco JL. Childhood overweight and academic performance: National Study of Kindergartners and First-Graders. *Obes 19307381*. 2004;12(1):58.

14. Burkhalter TM, Hillman CH. A narrative review of physical activity, nutrition, and obesity to cognition and scholastic performance across the human lifespan. *Adv Nutr*. 2011;2(2):201S.

15. Santana CCA, Hill JO, Azevedo LB, Gunnarsdottir T, Prado WL. The association between obesity and academic performance in youth: a systematic review. *Obes Rev*. 2017;(10):1191. doi:10.1111/obr.12582

16. Pont SJ, Puhl R, Cook SR, Slusser W. Stigma experienced by children and adolescents with obesity. *Pediatrics*. 2017;140(6):1-11. doi:10.1542/peds.2017-3034

17. Florin TA, Shults J, Stettler N. Perception of overweight Is associated with poor academic performance in US adolescents. *J Sch Health*. 2011;81(11):663-670. doi:10.1111/j.1746-1561.2011.00642.x

18. Atlantis E, Ball K. Association between weight perception and psychological distress. *Int J Obes*. 2008;32(4):715-721.

19. Patte KA, Livermore M, Qian W, Leatherdale ST. Do weight perception and bullying victimization account for links between weight status and mental health among adolescents? *BMC Public Health*. 21 (1) 1062-1062. https://doi.org/10.1186/s12889-021-11037-8

20. Livermore M, Duncan MJ, Leatherdale ST, Patte KA. Are weight status and weight perception associated with academic performance among youth? *J Eat Disord*. 2020;8(1):52. doi:10.1186/s40337-020-00329-w

21. Morita N, Nakajima T, Okita K, Ishihara T, Sagawa M, Yamatsu K. Relationships among fitness, obesity, screen time and academic achievement in Japanese adolescents. *Physiol Behav*. 2016;163:161-166. doi:10.1016/j.physbeh.2016.04.055

22. Wingfield RJ, Graziano PA, McNamara JPH, Janicke DM. Is there a Relationship between body mass index, fitness, and academic performance? Mixed results from students in a Southeastern United States elementary school. *Curr Issues Educ*. 2011;14(2). Accessed September 19, 2019. https://cie.asu.edu/ojs/index.php/cieatasu/article/view/727

23. Booth JN, Tomporowski PD, Boyle JME, et al. Obesity impairs academic attainment in adolescence: findings from ALSPAC, a UK cohort. *Int J Obes*. 2014;38(10):1335-1342. doi:10.1038/ijo.2014.40

24. Black N, Johnston DW, Peeters A. Childhood obesity and cognitive achievement. *Health Econ*. 2015;24(9):1082-1100. doi:10.1002/hec.3211

25. Du Toit D, Pienaar AE, Trutter L. Relationshio between physical fitness and academic performance in South African children. *South Afr J Res Sport Phys Educ Recreat*. 2011;33(3):23-35.

26. Voelker DK, Reel JJ, Greenleaf C. Weight status and body image perceptions in adolescents: current perspectives. *Adolesc Health Med Ther*. 2015;6(default):149-158. doi:10.2147/AHMT.S68344

27. Neumark-Sztainer D, Wall MM, Larson N, et al. Secular trends in weight status and weight-related attitudes and behaviors in adolescents from 1999 to 2010. *Prev Med*. 2011;54(1):77-81. doi:10.1016/j.ypmed.2011.10.003

28. Aceves-Martins M, Whitehead R, Inchley J, Giralt M, Currie C, Solà R. Self-reported weight and predictors of missing responses in youth. *Nutrition*. 2018;53:54-58. doi:10.1016/j.nut.2018.01.003

29. Fonseca H, Gaspar de Matos M, Guerra A, Gomes-Pedro J. Emotional, behavioural and social correlates of missing values for BMI. *Arch Dis Child*. 2009;94(2):104-109. doi:10.1136/adc.2008.139915

30. Tiggemann M. Nonreporting of body mass index: A research note on the interpretation of missing data. *Int J Eat Disord*. 2006;39(4):346-349. doi:10.1002/eat.20264

31. Tabachnick BG, Fidell LS, Ullman JB. *Using Multivariate Statistics*. Seventh edition. Pearson; 2019.

32. Deighton J, Humphrey N, Belsky J, Boehnke J, Vostanis P, Patalay P. Longitudinal pathways between mental health difficulties and academic performance during middle childhood and early adolescence. *Br J Dev Psychol*. 2018;36(1):110-126.

33. McLaren L. Socioeconomic status and obesity. *Epidemiol Rev*. 2007;29(1):29-48.

34. OECD iLibrary | The heavy burden of obesity: The economics of prevention. Accessed October 18, 2019. https://www.oecd-ilibrary.org/social-issues-migration-health/the-heavy-burden-of-obesity_67450d67-en

35. Caird J, Kavanagh J, O'Mara-Eves A, et al. Does being overweight impede academic attainment? A systematic review. *Health Educ J*. 2014;73(5):497-521.

36. Martin A, Booth J, McGeown S, et al. Longitudinal associations between childhood obesity and academic achievement: Systematic review with focus group data. *Curr Obes Rep*. 2017;6(3):297.

37. Pellicer-Chenoll M, Garcia-Massó X, Morales J, et al. Physical activity, physical fitness and academic achievement in adolescents: a self-organizing maps approach. *Health Educ Res*. 2015;30(3):436-448. doi:10.1093/her/cyv016

38. Ramaswamy R, Mirochna M, Perlmuter LC. The negative association of BMI with classroom effort in elementary school children. *J Child Health Care*. 2010;14(2):161-169. doi:10.1177/1367493509359222

39. Judge S, Jahns L. Association of overweight with academic performance and social and behavioral problems: an update from the early childhood longitudinal study. *J Sch Health*. 2007;(10):672.

40. Kobayashi F. Academic achievement, BMI, and fast food intake of American and Japanese college students. *Nutr Food Sci*. Published online September 11, 2009. doi:10.1108/00346650910992213

41. Mo-suwan L, Lebel L, Puetpaiboon A, Junjana C. School performance and weight status of children and young adolescents in a transitional society in Thailand. *Int J Obes*. 1999;23(3):272-277. doi:10.1038/sj.ijo.0800808

42. Gable S, Krull JL, Chang Y. Boys' and girls' weight status and math performance from kindergarten entry through fifth grade: a mediated analysis. *Child Dev*. 2012;83(5):1822-1839. doi:10.1111/j.1467-8624.2012.01803.x

43. Datar A, Sturm R. Physical education in elementary school and body mass index: Evidence from the Early Childhood Longitudinal Study. *Am J Public Health*. 2004;94(9):1501-1506. doi:10.2105/AJPH.94.9.1501

44. MacCann C, Roberts RD. Just as smart but not as successful: obese students obtain lower school grades but equivalent test scores to nonobese students. *Int J Obes*. 2013;37(1):40-46. doi:10.1038/ijo.2012.47

45. Nathan R. Kuncel, Marcus Credé, Lisa L. Thomas. The validity of self-reported grade point averages, class ranks, and test scores: A meta-analysis and review of the literature. *Rev Educ Res*. 2005;75(1):63.

46. Cook RL, O'Dwyer NJ, Donges CE, et al. Relationship between Obesity and Cognitive Function in Young Women: The Food, Mood and Mind Study. *J Obes*. Published online October 8, 2017:1-11.

47. Smith E, Hay P, Campbell L, Trollor JN. A review of the association between obesity and cognitive function across the lifespan: implications for novel approaches to prevention and treatment. *Obes Rev*. 2011;(9):740.

48. Liang J, Matheson BE, Kaye WH, Boutelle KN. Neurocognitive correlates of obesity and obesity-related behaviors in children and adolescents. *Int J Obes*. 2014;38(4):494-506.

49. Gunnarsdottir T, Njardvik U, Olafsdottir AS, Craighead LW, Bjarnason R. Teasing and social rejection among obese children enrolling in family-based behavioural treatment: effects on psychological adjustment and academic competencies. *Int J Obes*. 2012;36(1):35-44.

50. Krukowski RA, Smith West D, Philyaw Perez A, Bursac Z, Phillips MM, Raczynski JM. Overweight children, weight-based teasing and academic performance. *Int J Pediatr Obes*. 2009;4(4):274-280.

51. Shackleton NL, Campbell T. Are teachers' judgements of pupils' ability influenced by body shape? *Int J Obes*. 2014;38(4):520-524.

52. Greenleaf C cgreenleaf@coe unt edu, Weiller K. Perceptions of youth obesity among physical educators. *Soc Psychol Educ*. 2005;8(4):407-423.

53. Peterson JL, Puhl RM, Luedicke J. An experimental assessment of physical educators' expectations and attitudes: The importance of student weight and gender. *J Sch Health*. 2012;82(9):432-440. doi:10.1111/j.1746-1561.2012.00719.x

54. Patte KA, Laxer RE, Qian W, Leatherdale ST. An analysis of weight perception and physical activity and dietary behaviours among youth in the COMPASS study. *SSM - Popul Health*. 2016;2:841-849.

55. Sonneville KR, Thurston IB, Milliren CE, Gooding HC, Richmond TK. Weight misperception among young adults with overweight/obesity associated with disordered eating behaviors. *Int J Eat Disord*. 2016;49(10):937-946.

56. ter Bogt TFM, van Dorsselaer SAFM, Monshouwer K, Verdurmen JEE, Engels RCME, Vollebergh WAM. Body Mass Index and body weight perception as risk factors for internalizing and externalizing problem behavior among adolescents. *J Adolesc Health*. 2006;39(1):27-34.

57. Jansen W, van de Looij-Jansen PM, de Wilde EJ, Brug J. Feeling fat rather than being fat may be associated with psychological well-being in young Dutch adolescents. *J Adolesc Health*. 2008;42(2):128-136.

58. Duncan MJ, Patte KA, Leatherdale ST. Mental health associations with academic performance and education behaviors in Canadian secondary school students. *Can J Sch Psychol*. Published online 2021:82957352199731. doi:10.1177/0829573521997311

59. Ployhart RE, Vanderberg RJ. Longitudinal Research: The theory, design, and analysis of change - 2010. Accessed September 20, 2019. https://journals.sagepub.com/doi/10.1177/0149206309352110

60. Salkind NJ. *Encyclopedia of Measurement and Statistics. [Electronic Resource]*. SAGE; 2006. http://proxy.library.brocku.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat00778a&AN=bu.b3000278&site=eds-live&scope=site

61. Williams J, Wake M, Hesketh K, Waters E, Maher E. Health-related quality of life of overweight and obese children. *JAMA J Am Med Assoc*. 2005;(1):70.

62. Mikkilä V, Lahti-Koski M, Pietinen P, et al. Associates of obesity and weight dissatisfaction among Finnish adolescents. *Public Health Nutr*. 2003;6(1):49-56.

63. Paxton SJ, Neumark-Sztainer D, Hannan PJ, Eisenberg ME. Body dissatisfaction prospectively predicts depressive mood and low self-esteem in adolescent girls and boys. *J Clin Child Adolesc Psychol*. 2006;35(4):539-549.

64. Pearl RL, Puhl RM. Weight bias internalization and health: a systematic review. *Obes Rev*. 2018;(8):1141. doi:10.1111/obr.12701

65. Clarke J, Fletcher B, Lancashire E, Pallan M, Adab P. The views of stakeholders on the role of the primary school in preventing childhood obesity: a qualitative systematic review. *Obes Rev*. 2013;(12):975.

66. Leatherdale ST, Brown KS, Carson V, et al. The COMPASS study: a longitudinal hierarchical research platform for evaluating natural experiments related to changes in school-level programs, policies and built environment resources. *BMC Public Health*. 2014;14:331. doi:10.1186/1471-2458-14-331

67. Courser MW, Shamblen SR, Lavrakas PJ, Collins D, Ditterline P. The Impact of Active Consent Procedures on Nonresponse and Nonresponse Error in Youth Survey Data: Evidence from a New Experiment. *Eval Rev*. 2009;33(4):370-395.

68. Reel B, Brendin C, Leatherdale S. Compass System. Published 2018. Accessed September 10, 2019. https://uwaterloo.ca/compass-system/publications/compass-year-5-and-6-school-recruitment-and-retention

69. Battista K, Qian W, Bredin C, Leatherdale S. Student data linkage over multiple years | Compass System | University of Waterloo. Published 2019. Accessed October 18, 2019. https://uwaterloo.ca/compass-system/student-data-linkage-over-multiple-years

70. WHO | Growth reference data for 5-19 years. WHO. Accessed August 20, 2019. https://www.who.int/growthref/en/

71. Leatherdale ST, Laxer RE. Reliability and validity of the weight status and dietary intake measures in the COMPASS questionnaire: are the self-reported measures of body mass index (BMI) and Canada's food guide servings robust? *Int J Behav Nutr Phys Act*. 2013;10(1):42. doi:10.1186/1479-5868-10-42

72. Government of Canada SC. Download, Census Profile, 2016 Census. Published February 8, 2017. Accessed April 17, 2021. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/download-telecharger/comp/page_dl-tc.cfm?Lang=E

73. Christoph MJ, Jarrett ES, Gower AL, Borowsky IW. Weight status and weight perception in relation to mental distress and psychosocial protective factors among adolescents. *Acad Pediatr*. 2018;18(1):51-58. doi:10.1016/j.acap.2017.08.007

74. Taras H, Potts-Datema W. Obesity and student performance at school. *J Sch Health*. 2005;75(8):291-295. doi:10.1111/j.1746-1561.2005.00040.x

75. Falkner NH, Neumark-Sztainer D, Story M, Jeffery RW, Beuhring T, Resnick MD. Social, Educational, and Psychological Correlates of Weight Status in Adolescents. *Obes 19307381*. 2001;9(1):32.

76. Crosnoe R. Gender, obesity, and education. *Sociol Educ*. 2007;80(3):241-260.

77. von Hippel PT, Lynch JL. Why are educated adults slim—Causation or selection? *Soc Sci Med 1982*. 2014;105:131-139. doi:10.1016/j.socscimed.2014.01.004

78. French SA, Wall M, Corbeil T, Sherwood NE, Berge JM, Neumark-Sztainer D. Obesity in adolescence predicts lower educational attainment and income in adulthood: The Project EAT Longitudinal Study. *Obes Silver Spring Md*. 2018;26(9):1467-1473. doi:10.1002/oby.22273

79. Cohen AK, Rai M, Rehkopf DH, Abrams B. Educational attainment and obesity: a systematic review: Educational attainment and obesity. *Obes Rev*. 2013;14(12):989-1005. doi:10.1111/obr.12062

80. Kenney EL, Gortmaker SL, Davison KK, Austin SB. The academic penalty for gaining weight: a longitudinal, change-in-change analysis of BMI and perceived academic ability in middle school students. *Int J Obes*. 2015;39(9):1408-1413. doi:10.1038/ijo.2015.88

81. Kaestner R, Grossman M. Effects of weight on children's educational achievement. *Econ Educ Rev*. 2009;28(6):651-661. doi:10.1016/j.econedurev.2009.03.002

82. Veldwijk J, Fries MCE, Bemelmans WJE, et al. Overweight and School Performance Among Primary School Children: The PIAMA Birth Cohort Study. *Obes Silver Spring Md*. 2012;20(3):590-596. doi:10.1038/oby.2011.327

83. Zavodny M. Does weight affect children's test scores and teacher assessments differently? *Econ Educ Rev*. 2013;34:135-145. doi:10.1016/j.econedurev.2013.02.003

84. Finn KE, Seymour CM, Phillips AE. Weight bias and grading among middle and high school teachers. *Br J Educ Psychol*. 2019;n/a(n/a). doi:10.1111/bjep.12322