OBESITY PREVALENCE AND ITS INFLUENCE ON WEIGHT RELATED BEHAVIORS THROUGH MEDIATION BY WEIGHT PERCEPTION

By

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Abstract

Background. Obesity is a top public health priority in the 21st century. The prevalence of obesity has grown considerably over the past quarter century. Exposure to communities of higher obesity prevalence may be shifting the public's perception of ideal weight to heavier weights. The divide between weight perception and objective weight measures may ultimately change weight related behaviors.

Purpose. Our study investigates the relationship between obesity prevalence and weight related behaviors, and weight perception as a potential mediator for this pathway.

Methods. We conducted a cross-sectional study using the Youth Risk Behavior Survey 2011. A total of 11,972 adolescents were included for analysis. All variables were self-reported. Data were stratified by sex and analyzed using multivariate logistic regression models adjusted for confounders and accounting for sampling weights. BMI was included as an interaction term in all models.

Results. High obesity prevalence was associated with a lower likelihood of perceived overweight for overweight adolescents (OR (95%CI): 0.62 (0.39-1.01) for girls; 0.58 (0.36-0.94) for boys). Perceived overweight was associated with a lower likelihood of meeting physical activity (OR (95% CI): 0.71 (0.59-0.85) for girls; 0.40 (0.28-0.58,) for boys) and a higher likelihood of engaging in extreme dieting (OR (95% CI): 2.83 (2.42-3.32) for girls; 2.61 (1.82-3.75) for boys. High obesity prevalence was associated with a higher likelihood of engaging in extreme dieting among boys and girls with normal BMI

(OR (95% CI): 1.34 (1.10-1.65) for girls; 1.56 (1.03-2.36) for boys), but was not associated with meeting physical activity recommendations. Weight perception was not an independent mediator for the relationship between obesity prevalence and weight related behaviors.

Conclusion. High obesity prevalence may contribute to an underestimation of perceived weight among overweight adolescents and to extreme dieting among normal weight adolescents. Overweight perception may promote extreme dieting behaviors and act as a barrier to physical activity. By focusing on system level changes at the community level, public health efforts may effectively combat the current obesity epidemic and avoid any stigmatizing messages by targeting individuals.

Chapter 1 – Introduction

Obesity – Public Health Implications

Obesity has emerged a top public health concern of the 21st century owing to rapid prevalence increases and significant healthcare costs.[1] Worldwide, the United States has the highest rates of obesity; other countries trail in prevalence estimates by a few years according to projected growth trends.[2] Associated complications resulting from excess weight are well documented and include: type 2 diabetes, cardiovascular disease, non-alcoholic fatty liver disease, obstructive apnea, orthopedic complications, cancer, increased disability, and all-cause mortality.[2,3] Moreover, diseases previously attributed to adulthood obesity are now evident in children and adolescents.[4] Finally, negative social and psychological consequences have also surfaced. Harmful stigmas directed towards those classified as overweight or obese are widely documented, and have been associated with matters of social injustice, self-esteem, and quality of life.[5]

The prevalence of obesity has exhibited a substantial upward trend in the past few decades both in the United States and on a global scale. In the United States alone, the estimated prevalence of being overweight or obese in the early 1960s was 45% and has grown to approximately 70%.[2,6] Recent estimates indicate that over 78 million (35.7%) adults and 12.5 million (16.9%) children were obese in 2010 and the prevalence for both is expected to rise even further.[2] Based on projected trends, 80% of all Americans are expected to be either overweight or obese in just 15 years.[7] Due to dramatic prevalence

increases across multiple industrialized nations, obesity is now characterized as a global health crisis.[8]

Resulting from the increases in obesity prevalence are parallel trends of subsequent costs related to morbidity and mortality. Direct medical costs attributed to overweight and obesity are approximately $147 billion per year in 2008, but these costs are projected to increase to approximately $956 billion by 2030, approximately 17.6% of total healthcare costs.[7,9] For individual spending across all payers, obese individuals had an average medical expenditure $1,429 (42.0%) greater than the medical spending of someone with normal weight on a per year basis. According to the Director of Public Health Economics Eric Finkelstein, "there is undeniable link between rising rates of obesity and rising medical spending."[10]

Secular changes in food sources and processing, dietary behavior, and physical activity are all important considerations in addressing public health matters of the current obesity epidemic. Recent research, however, explores inter-relationships among individual-level psychological states and community-level characteristics as potential factors underlying weight related behaviors.

Weight Perception

The Health Belief Model (HBM) suggests that individuals with excess weight must first perceive and acknowledge their weight as a potential risk factor for disease prior to any successful and sustained weight change. As described by the HBM, the perception of

susceptibility (beliefs about the chances of getting a condition) is a critical construct that underlies behavior change.[11,12] An individual's perception of what entails a healthy weight may therefore be more important than actual weight measures for initiating and tailoring sustained weight control interventions.

Early studies illustrated that (i) perception of overweight is a better predictor than actual weight for dieting and exercising in high school students, (ii) perception of overweight is associated with attempted weight loss independent of actual BMI classifications and (iii) dieters are most clearly distinguished between non-dieters by their perception of being overweight.[13,14,15] More recent studies also demonstrate an association between accurate weight perception among overweight with healthy weight-related behaviors and attitudes, and normal weight misperception among those overweight with non healthy behavior.[16–19] While there is promise in accurate perceived weight status as an effective target for healthy weight adoption, research also suggests that perceived overweight may also be linked with detrimental weight-related behaviors.

Linkages between perceived overweight and unhealthy or risky weight-control behaviors may result from processes involving self-esteem, social adjustment, and anxiety.[20] A behavioral theory that may explain detrimental behavior is the Social Cognitive Theory (SCT). The foundation of SCT is a dynamic and continuous interplay among three primary components: characteristics of the individual, behavior of the individual, and the environment.[12,21] In the context of obesity, three important constructs from SCT may be negatively affected by perceived overweight: expectations (no anticipated outcomes of a

healthy behavior), self-efficacy (lowered confidence in performing a behavior), or coping responses (deleterious strategies used to deal with emotional stimuli, e.g. discounting or cognitive distortion), which may lead to detrimental weight related behaviors.

Studies demonstrate a relationship between perceived overweight and negative outcomes. A recent cross sectional study reports that overweight perception may serve as a barrier to physical activity participation among those with overweight or obese BMI classifications.[22,23] Several studies also demonstrate that overweight perception particularly in normal weight adolescents and adults is linked to extreme dieting, though the evidence for overweight individuals is still limited.[24,25] Perceived overweight may therefore involve barriers to healthy weight-related behaviors.

Environmental Exposure of Obesity Prevalence

Social pressures may influence the dynamic between weight perception and true measures of weight. Dramatic increases in obesity prevalence over the past quarter century by definition have changed the ratio of normal weight individuals to those overweight or obese. A potential consequence of increasing obesity prevalence is individual-level changes in overweight perception.

Social comparison theory, proposed by Leon Festinger, hypothesizes that when objective means are not available, people evaluate their opinions and abilities by comparison with the opinions and abilities of others.[26] Two comparison types exist within this theory.

First, upward comparisons relate to comparisons made with those who are "better"; for example, comparison of overweight individuals to normal weight peers may lead to a decrease in subjective wellbeing. Second, downward comparisons relate to comparisons made with those who are "worse"; for example, comparison of overweight individuals to obese peers may lead to an increase in subjective wellbeing.[27] In the context of environments with higher obesity prevalence, it is possible that more downward comparisons and less upward comparisons are made, enhancing subjective wellbeing among those with a heavier weight profile. Thus, with substantial increases in obesity prevalence, the perception of what constitutes a normal weight may have shifted towards heavier weights, creating and widening the divide between actual weight and perception of weight.

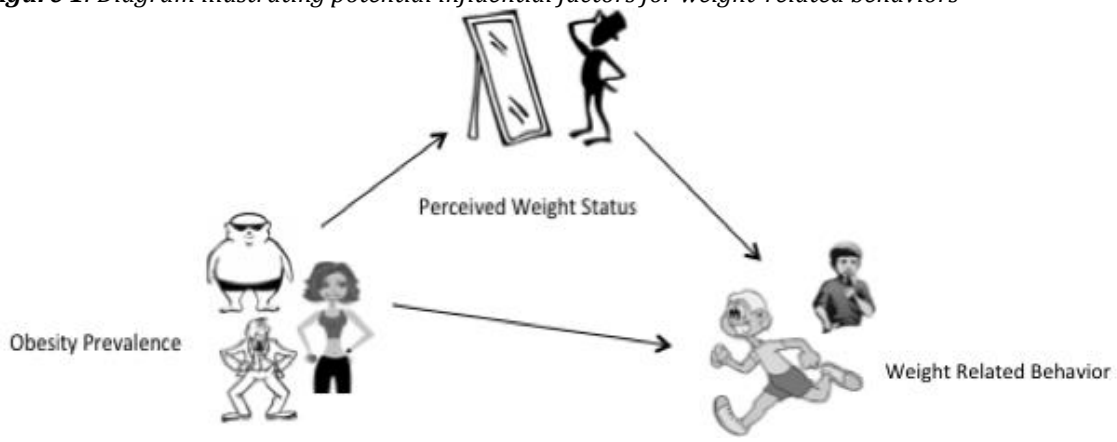
Panel studies in the United States and United Kingdom already illustrate secular changes in weight perception. Using National Health and Nutrition Examination Survey data, Burke et al. (2010) found that overweight men were less likely to perceive themselves as overweight in a recent time period than an earlier time period.[28] Another study illustrates similar findings among men in the United Kingdom despite increasing obesity prevalence.[29] These studies document increasing trends of weight misperception and provide initial evidence of the evolving nature of weight perception in relation to increasing obesity prevalence over time. A limitation of contrasting different periods in time, however, is the inability to account for additional secular changes that may influence weight perception.

Possible effects of obesity prevalence as an environmental exposure have also been studied. In one study, larger women living in neighborhoods comprised of thinner women were more likelihood to report feeling dissatisfied with their own bodies in contrast to women who lived in "larger" comprised neighborhoods.[30] In another study, children living with overweight or obese parents or going to school with overweight or obese classmates were more likely to develop inaccurate perceptions of what constitutes appropriate weight status.[31] Finally, a Christakis et al. (2007) shows that a person's likelihood of becoming obese is 57% greater if he or she has friends who became obese compared to those with non-obese friends. They also found that if one spouse became obese, the likelihood that the other would become obese is 37% greater. Investigators of the study conclude that obesity may likely spread through social ties.[32]

Mediation of Weight Related Behaviors by Weight Perception

The collective evidence suggests that in addition to the dramatic changes in the nature of food, dietary consumption, and physical activity demands are environmental pressures of obesity prevalence, which may also significantly contribute to the growing obesity epidemic. From the described evidence, obesity prevalence may influence individuals by altering the dynamic between perceived weight status and actual weight. Through changes in weight perception, subsequent weight related behaviors may then be responsive to environmental forces. Increasing obesity prevalence may therefore drive perceived weight underestimation and influence weight behaviors.

Figure 1*: Diagram illustrating potential influential factors for weight-related behaviors*



Obesity prevalence and perceived weight status as potential factors for weight related behavior

Mediation analysis, commonly utilized in psychological research, investigates pathways underlying the relationships between an exposure and outcome. In the context of our study (Figure 1), an antecedent variable (obesity prevalence) is related to a mediating variable (perceived weight status), which in turn, is related to the outcome variable (weight related behavior). We postulate that increasing obesity prevalence within a defined community may drive weight misperception, consequently altering the practice of weight related behaviors.

Study Objectives

Previous studies have investigated environmental factors related to weight (neighborhood or school level summary weight measurements) in relation to weight perception and self-esteem (e.g. body dissatisfaction).[30,31] Our study investigates the association of an environmental characteristic, obesity prevalence, and individual-level weight related behaviors. We hypothesize that high obesity prevalence may be an important environmental characteristic upstream to weight related behaviors.

Prior research suggests an important role of accurate perception of overweight as a necessary first step towards healthy and sustained weight-loss behavior.[16,33] However, these studies investigate perceived weight status as either an outcome variable or explanatory variable. Our study investigates perceived weight status as a potential mediator of obesity prevalence and weight related behaviors. If perceived weight status is found as an independent mediator between high obesity prevalence and healthy weight-related behaviors, it may serve as a critical breakpoint between environments with high obesity prevalence, and non-healthy or unhealthy weight related behaviors that lead to weight gain.

Accurate overweight perception may be an important component in motivation for healthy behavior change such as physical activity, though, it may concurrently be deleterious by negatively influencing matters of self-esteem leading to counterproductive and extreme and risky weight related practices. Our study investigates two outcome variables in relation to perceived overweight: one healthy behavior (physical activity) and one detrimental behavior (extreme dietary practices).

Even modest weight reductions (as little as 5%) in overweight or obese individuals can significantly decrease risks of obesity related health complications.[34] Identifying the critical and delicate role of perceived weight status may provide further insight on current challenges faced in obesity prevention and interventions. By addressing topics of weight perception sensitively, and incorporating important community-level characteristics, we

may begin to successfully mitigate risks through sustained weight reduction as well as decrease the heavy price tag of obesity related medical costs.

Chapter 2 – Methods

Study materials were submitted to Oregon Health & Science University's Institutional Review Board for review. The study was determined to be non-human subjects research. Our study utilizes existing, de-identified, public use data from The Youth Risk Behavior Surveillance System (YRBSS).

Our cross-sectional study investigates the relationship between obesity prevalence as an environmental exposure on weight related behaviors: physical activity and extreme dieting. Further, our study investigates the role of perceived weight status as a potential mediator of this relationship. After stratifying data by sex, we assess mediation by investigating three primary relationships: (i) the estimated effect of obesity prevalence on perceived weight status; (ii) the estimated effect of perceived weight status on two weight related behaviors, physical activity and extreme dieting, (iii) the estimated effect of obesity prevalence on two weight related behaviors, physical activity and extreme dieting.

Study Population

The study utilizes data collected from the 2011 national Youth Risk Behavior Survey (YRBS) data, administered by YRBSS. YRBS 2011 data are nationally representative with a target population of all public and private school students, grades 9 through 12, in all 50 states and the District of Columbia. YRBS sampling procedures employs a three-

stage cluster sampling design. The first stage consists of large counties or smaller adjacent counties and is reported as the primary sampling unit (PSU). The second stage consists of selecting schools from PSU's. The third stage is the random selection of one or two classes from each school. All students within a class are eligible to participate. YRBS is voluntary and anonymous. All analysis was corrected for complex sampling design.

Post processing procedures were performed by YRBS to ensure quality. Editing protocols identifies out-of-range responses, logical consistency, and missing data. Data are removed if a conflict of information arises for example if a student indicates "he or she never smoked", but answers from a following question, "smoked within the past few days," then both responses are removed. Questionnaires with less than twenty valid responses remaining after editing are removed from the dataset.

2011 YRBS response rates consist of the following: 194 schools were selected; a total of 158 (81.4%) participated; a total of 15,503 students submitted a questionnaire out of 17,672. Of the submitted questionnaire, 15,425 (87.3%) remained after YRBS edits. The overall response rate is equal to school response rate times student response rate or (81.4%) * (87.3%) = 71.0%

Our study excludes all participants with underweight BMI classifications and underweight perception. BMI was calculated by YRBS and was based on the formula: BMI (kg/m^2) = [weight (kg)]/ [Height $(m)^2$]. The "SAS Program for the 2000 CDC

Growth Charts" developed by the CDC was used as a reference population to calculate student percentiles for age and sex adjustment. To increase statistical power, sample sizes for each primary relationship was maximized.

Of the total 15,425 students who participated in the 2011 YRBS, 1,140 observations had missing BMI measurements and 383 self-reported underweight BMI's. Upon applying the study exclusion criteria for underweight BMI measurements and missing BMI observations, a total of 13,902 remained. Of the 13,902, there were 202 observations with missing weight perception measurements, and 223 and 1,505 "very underweight" and "slightly underweight" perceived weight status measurements, respectively. Our study sample consisted of n = 11,972 observations after removing those with underweight perception and missing perception measurements. A total of 3,453 (22.4%) observations were excluded from the study population, leaving a maximum total of 6,246 females and 5,726 males for our study (Appendix, Figure 4). Weighted totals are n = 6,151 for females and n = 5,901 for males.

In order to maximize statistical power, missing outcome data were not included in our exclusion criteria. By including all observations with complete data for any given relationship, model-specific samples contained different population totals. In sensitivity analysis, we re-fit our final models using a single subpopulation with complete data on all study variables to identify any significant changes as a result of study population differences. In sensitivity analysis, the study population (n = 11,972) was further restricted to include only individuals who had complete data for all study variables. We

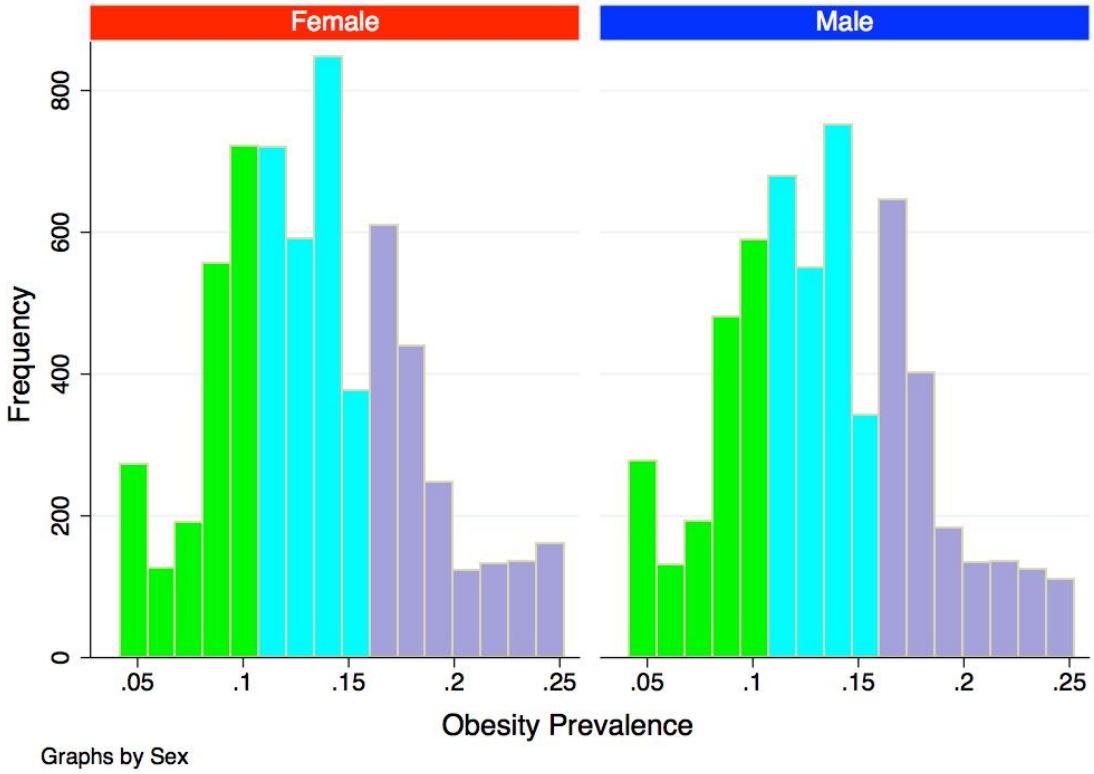
first removed observations with missing behavior outcome variables. A total of n = 163 observations were missing values for either outcome and were removed from the study population (n = 11,809). We then removed records with missing values in any potential confounding variable (smoke status, race/ethnicity, age, and grade level). A total of n = 598 were removed due to incomplete data on confounders. For sensitivity analysis, our final population included 11,211 observations. This includes 94.0% (11,211/11,972) of our study sample and 76.6% (11,211/15,425) of the original YRBS 2011 sample. A total of 5,915 girls and 5,296 males remained for analysis. Each final effects model was reinvestigated; we did not observe any changes in significance for all models or any changes in overall study conclusions.

Obesity Prevalence (Primary Explanatory Variable)

Our primary explanatory variable was obesity prevalence calculated for each PSU. A total of 56 PSU's were included in 2011 YRBS. According to YRBS sampling designs, the obesity prevalence at the PSU level approximates county-level estimates.

Using YRBS's calculated BMI percentiles, we computed obesity prevalence. Students with percentiles at or greater than 95% were used as the numerator; the total population per PSU was used as the population total. All prevalence estimates were calculated correcting for YRBS weighting.

***Figure 2**: Histograms for obesity prevalence stratified by sex: YRBS 2011*



Estimated obesity prevalence was collapsed to tertiles.

***Table 1**: Estimated means for obesity prevalence by tertile stratified by sex: YRBS 2011 [mean(count)]*

	Girls	**Boys**
Obesity Prevalence	13.2 (6,151)	13.0 (5,900)
Obesity Prevalence by Tertile		
Low Prevalence	8.1 (2,057)	8.0 (2,110)
Medium Prevalence	12.8 (1,992)	12.8 (1,741)
High Prevalence	18.6 (2,102)	18.5 (2,049)

Weighted calculations adjust for three-stage cluster sample design. Obesity prevalence represents approximate county-level geographic area.

Perceived Weight Status (Mediating Variable)

Perceived weight status was determined by the question, "How do you describe your weight?" Participants were provided response options of, "very underweight, slightly underweight, about the right weight, slightly overweight, and very overweight." After

excluding both "very underweight" and "slight underweight" observations, we dichotomized the variable into either perceived normal weight if participants reported "about the right weight," or, perceived overweight if participants reported "slightly overweight" or "very overweight." Those categorized as perceived normal weight served as the referent group for all regression analysis.

Weight Related Behaviors (Primary Outcome Variables)

Our study used two weight related behaviors as our primary outcomes: (i) physical activity and (ii) extreme dieting. We interpreted physical activity as a healthy weight-related behavior; extreme dieting was interpreted as a non-healthy or negative behavior.

Physical activity was generated using the survey question, "During the past 7 days, on how many days were you physically active for a total of at least 60 minutes per day?" Response options ranged from "0 days" to "7 days." The U.S. Department of Health and Human Services' Physical Activity Guidelines Advisory Committee Report of 2008, the recommendations for reduction in overall adiposity and visceral adiposity was regular moderate-to-vigorous physical activity 3 to 5 days per week for 30 to 60 minutes. Our study dichotomized physical activity to "meeting daily physical activity recommendations" if respondents reported 5 or more days of physical activity for at least 60 minutes. Reporting less than 5 days was classified as "not meeting daily physical activity recommendations."

We performed sensitivity analysis by investigated an additional cut point for physical activity. A cut point of 7 days of physical activity for at least 60 minutes was used for "meeting daily physical activity recommendations." We found no substantial changes to study findings in terms of significance or overall study conclusions.

Extreme dieting behaviors combined three survey questions: (i) "During the past 30 days, did you go without eating for 24 hours or more (also called fasting) to lose weight or to keep from gaining weight?" (ii) "During the past 30 days, did you take any diet pills, powders, or liquids without a doctor's advice to lose weight or to keep from gaining weight?" (iii) "During the past 30 days, did you vomit or take laxatives to lose weight or to keep from gaining weight?" Our study dichotomized these behaviors to "engagement in extreme dieting" if respondent reported engaging in any of the behaviors listed above or "no engagement in extreme dieting" if there was no report of any behavior.

Covariates

Other variables used for subgroup analyses and for the assessment of potential confounding included: sex (female, male), age (14 years old, 15 years old, 16 years old, 17 years old, or 18 years old or older), grade (9th grade, 10th grade, 11th grade, 12th grade), a combined race/ethnicity collapsed into a 4 category variable (white non-Hispanic, Hispanic any race, Black non-Hispanic, and Other), smoking status (no smoking in the past 30 days, smoking in the past 30 days), and BMI weight classifications (normal weight, overweight, and obese).

Statistical Analyses

Univariate Preliminary Data Analysis

Based on prior studies, factors predicting perceived weight status and weight related behaviors vary dramatically between girls and boys. [17,18,31] As a result, all data were stratified by sex to account for gender differences prior to performing any statistical testing. All analysis used appropriate survey functions to adjust for YRBS complex sampling design using STATA statistical software (version 11.2; Stata Corp, College Station, Texas). Statistical significance was set at $\alpha = 0.05$. For interaction effects, we set statistical significance at $\alpha = 0.10$. A higher threshold for significance was used for interaction to detect any potentially weaker, but real differences in point estimates across BMI classification.

We began statistical analysis by performing descriptive analysis to characterize the study population and assess for data completeness. We first performed one-way tabulations for each study variable to identify the number and percentage of missing observations. Tabulations included both weighted and unweighted assessments.

Bivariate Preliminary Data Analysis

Sex-stratified χ^2 analyses were utilized to test crude associations among categorical variables. We performed bivariate analyses between our primary explanatory variable

(obesity prevalence) with all other study variables; our mediator (perceived weight status) with all other variables; and our outcome variable (physical activity and extreme dieting) with all other variables. Both weighted and unweighted measurements were performed to determine percentages and raw cell counts, respectively.

To identify potential effect modification by BMI and identify potential low frequencies for future interaction effects in our models, we also examined each bivariate relationship - (i) obesity prevalence and perceived weight status, (ii) perceived weight status and weight related behavior, and (iii) obesity prevalence and weight related behavior stratified by BMI classification, for boys and girls separately.

Multivariate Analysis

Sex-stratified, multivariate logistic regression models were then generated to estimate all primary relationships, controlling for confounders and accounting for sample weights. Prior to model building, we tested the assumption of linearity in the logit function for our continuous variable, obesity prevalence. The evidence suggested non-linearity for some models. To maintain variable consistency across all study models, we collapsed obesity prevalence into tertiles, producing a categorical variable of three levels: low, medium, and high obesity prevalence.

We began with a preliminary, full model containing the primary predictor and all potential confounders. To assess confounding, we performed the following procedure: (1)

identify the strength of confounding by each variable: each variable was removed from the full model, independently, to determine the percent change of the primary predictor's beta coefficient. Percent change was calculating by comparing the beta coefficient of the primary predictor in the full model with the beta coefficient of the primary predictor in the partial model. Ranks were assigned to each potential confounder depending on the magnitude of the percent change; (2) remove variables from the full model beginning with the weakest confounder: the weakest potential confounder was removed from the full model first. If the percentage change from the full model compared to the partial was less than 10.0%, it was removed. The next weakest potential confounder was then removed and compared to the initial full model. If the percentage change was less than 10.0% it was removed. This procedure was repeated for each variable until all potential confounders were assessed. The final effects model included the primary predictor, identified confounding variable, and BMI as an interaction term with the primary predictor.

BMI as an interaction variable was included in all models to further assess each primary relationship across BMI classification. This was required to identify the direction of weight misperception (e.g. normal weight individual with overweight perception is a perceived weight overestimation; an obese individual with a normal weight perception is a perceived weight underestimation). Further, psychological responses to external stimuli may be different between those with normal BMI classifications and those weight overweight or obese classifications, requiring the need to assess BMI specific point estimates.

A sensitivity analysis was performed to assess the accuracy of our model building procedure. Our models were reassessed with our preliminary, full model as the crude model containing only our primary predictor and BMI as an interaction term. Each potential confounder was inserted into crude model independently to assess for potential confounding. Any established confounder was included in the final effects model. This approach led to consistent results from the above procedure, as we found no changes in significance or overall study conclusions.

Perceived weight status mediation was investigated by using criteria for mediation described by Mackinnon et al. (2007): (i) a significant relationship between the primary independent variable (obesity prevalence) and outcome variable (weight related behavior); (ii) a significant relationship between primary independent variable (obesity prevalence) and potential mediator (perceived weight status); (iii) the mediator (perceived weight status) must be significantly related to the outcome behavior (weight related behavior) even after adjustment for the independent variable (obesity prevalence); and (iv) the beta coefficient of the obesity prevalence in the crude model (obesity prevalence only regressed on weight related behavior) must be larger in magnitude then the beta coefficient of obesity prevalence in the model adjusted for mediator (obesity prevalence and perceived weight status regressed on weight related behavior).[36]

We performed model diagnostics using SAS statistical software (Version 9.3; SAS Institute Inc., Cary, NC, USA). Similar model diagnostics procedures were attempted for

each model. Procedures included an assessment of goodness-of-fit and model discriminatory capacity by generating Receiver Operating Characteristic curves. The procedures utilized the command, "svylogitgof," which performs an F-adjusted mean residual test of a design based logistic regression model. Further diagnostic testing included: the calculation of 'change in pearson', 'change in deviance', and 'cook's' approaches. Predicted values were graphed with respect to predicted and leverage value probabilities, however due to the use of only categorical data, the number of covariate patterns was small, limiting the usage of these graphs. Results are presented in Table 8 in the appendix section.

Chapter 3 – Results

Population Characteristics

Sex stratified, population characteristics are presented in Table 2. A larger percentage of girls perceived themselves as overweight (38.7%) compared to boys (28.8%) despite a higher proportion of girls with normal BMI classification (72.2%) than boys (62.8%). Gender differences were also found for study outcome variables - approximately 61.7% of boys reported meeting recommended physical activity levels compared to 39.9% of girls; in contrast, more girls reported engaging in extreme dieting (22.1%) compared to boys (9.9%).

The majority of boys and girls (58.3%) were White non-Hispanic. Most students reported no smoking within the past 30 days prior to completing the survey (83.4% of girls and 80.3% of boys). The distribution of students per grade level was roughly even for both genders. Age category was nearly similar in terms of gender; the youngest reported age was 14 years for both girls and boys and a small percentage reported being 18 years or older: 12.2% for girls and 14.5% for boys.

***Table 2**: Study population characteristics, stratified by sex: Youth Risk Behavior Survey 2011 [count (%)]*

	Girls	**Boys**
Total	6151	5901
Age Category		
14 Years Old	774 (12.6)	635 (10.8)
15 Years Old	1531 (24.9)	1502 (25.5)
16 Years Old	1594 (25.9)	1518 (25.7)
17 Years Old	1504 (24.5)	1393 (23.6)
18 Years Old or Older	749 (12.2)	853 (14.5)
Grade		
9th Grade	1663 (27.1)	1622 (27.6)
10th Grade	1569 (25.5)	1506 (25.7)
11th Grade	1485 (24.2)	1413 (24.1)
12th Grade	1425 (23.2)	1332 (22.7)
Race/Ethnicity		
White Non-Hispanic	3542 (58.3)	3393 (58.3)
Hispanic Any Race	1155 (19.0)	1185 (20.4)
Black Non-Hispanic	847 (13.9)	773 (13.3)
Other	537 (8.8)	471 (8.1)
BMI Classification		
Normal Weight	4443 (72.2)	3707 (62.8)
Overweight	1042 (17.0)	1057 (17.9)
Obese	666 (10.8)	1136 (19.3)
Smoke Status		
Non Smoker	4999 (83.4)	4565 (80.3)
Smoker	995 (16.6)	1119 (19.7)
Weight Perception		
Perceived Normal Weight	3769 (61.3)	4199 (71.2)
Perceived Overweight	2382 (38.7)	1702 (28.8)
Obesity Prevalence Classification		
Low	2057 (33.5)	2110 (35.8)
Medium	1992 (32.4)	1741 (29.5)
High	2102 (34.2)	2049 (34.7)
Physical Activity		
Meets Recommendation	2402 (39.3)	3601 (61.7)
Does not Meet Recommendation	3706 (60.7)	2240 (38.4)
Extreme Dieting		
Engages in Extreme Dieting	1357 (22.1)	580 (9.9)
Does Not Engage in Extreme Dieting	4789 (77.9)	5302 (90.1)

Weighted calculations adjust for three-stage cluster sample design. Totals may not sum to final sample size due to missing variables; percentages may not sum to 100 due to rounding.

Crude Associations Among Study Variables

Perceived Overweight

Results from sex stratified bivariate analysis are reported in Table 3. For girls, perceived overweight was most common for older students and higher school grade. This growing pattern with older age and grade however, was not observed in boys. Perceived overweight was most common among those with minority race/ethnicity for both sexes, but was significant only in boys. Perceived overweight was more common among smokers for both sexes, but was significant only in girls.

Girls and boys exposed to low obesity prevalence reported perceived overweight less frequently compared to those living in areas of either medium or high obesity prevalence. Further, girls and boys reported perceived overweight more frequently with greater BMI (from normal to overweight to obese).

Meeting Physical Activity Recommendations

Meeting physical activity recommendations was most common among younger and lower school grade for girls. For boys, lower grades had higher frequencies for meeting physical activity; the distribution for age was similar across age categories. White non-Hispanics tended to have highest frequencies of meeting physical activity recommendations for either sex, but were only significant among girls. Non-smokers

more frequently meet physical activity recommendations, but was significant only in girls.

Girls and boys more frequently met physical activity recommendations if exposed to areas with low obesity prevalence (not significant for either sex), or had perceived normal weight (significant for either sex). Meeting physical activity was most common for normal weight girls and boys (significant for both sexes).

Extreme Dieting

Extreme dieting was most common 15 year old girls and least common among 14 year old girls. The distribution for grade was nearly similar across grade levels. For boys, higher frequencies were found among older ages and higher-grade levels. Extreme dieting was most common among Hispanic any race for both sexes. Smokers tended to engage in more extreme dieting than non-smokers among boys and girls.

Extreme dieting was most frequent in boys and girls in areas of high obesity prevalence, in those with perceived overweight, and those with obese BMI classification. All associations were significant for boys and girls.

***Table 3**: Crude associations among obesity prevalence (primary exposure) and confounders with weight perception (potential mediator) and weight related behaviors (primary outcome): YRBS 2011 [count (%)][a]*

	Girls (n = 6,151)			**Boys (n = 5,901)**		
	Perceived Overweight [b]	**Meets PA Recommendations [c]**	**Engages in Extreme Dieting[d]**	**Perceived Overweight [b]**	**Meets PA Recommendations [c]**	**Engages in Extreme Dieting[d]**
Total	2,382 (38.7)	2,402 (39.3)	1,357 (22.1)	1,702 (28.8)	3,601 (61.7)	580 (9.9)
Age Category						
14 Years Old[f]	284 (36.7)	368 (48.1)	142 (18.3)	187 (29.5)	388 (62.8)	31 (4.9)
15 Years Old	572 (37.4)	688 (45.3)	367 (24.0)*	464 (30.9)	941 (63.2)	174 (8.4)*
16 Years Old	619 (38.8)	582 (36.9)*	347 (21.8)	410 (27.1)	944 (62.5)	174 (11.5)*
17 Years Old	604 (40.2)	543 (36.3)*	336 (22.4)	392 (28.1)	821 (59.4)	143 (10.3)*
18 Years Old or Older	304 (40.5)	221 (29.5)*	165 (22.0)	249 (29.2)	507 (60.3)	106 (12.5)*
P-Value[e]	0.482	**< 0.001**	0.269	0.377	0.591	**< 0.001**
Grade						
9th Grade[f]	617 (37.1)	748 (45.4)	381 (22.9)	457 (28.2)	1,017 (63.8)	126 (7.8)
10th Grade	596 (38.0)	646 (41.4)	336 (21.5)	426 (28.3)	954 (63.7)	144 (9.6)
11th Grade	585 (39.4)	536 (36.5)*	333 (22.5)	399 (28.3)	840 (59.7)	166 (11.8)*
12th Grade	580 (40.7)	467 (32.9)*	304 (21.3)	406 (30.5)	776 (59.0)	138 (10.4)*
P-Value[e]	0.363	**< 0.001**	0.731	0.643	0.144	**0.013**
Race/Ethnicity						
White Non-Hispanic[f]	1,321 (37.3)	1,535 (43.5)	805 (22.7)	985 (29.0)	2,130 (63.2)	317 (9.4)
Hispanic Any Race	470 (40.7)	378 (33.1)*	290 (25.2)	378 (31.9)	695 (59.4)*	130 (11.0)
Black Non-Hispanic	333 (39.3)	269 (32.3)*	142 (16.8)*	161 (20.8)*	462 (61.2)	71 (9.3)
Other	231 (43.1)	202 (37.8)	99 (18.5)	159 (33.6)*	268 (57.4)	51 (10.8)
P-Value[e]	0.126	**< 0.001**	**0.009**	**< 0.001**	0.136	0.475

[a] Adjusted for YRBS three stages cluster sample design. Totals may not sum to final sample size due to missing variables; percentages may not sum to 100 due to rounding.
[b] Weighted counts and percentages of students with perceived overweight versus perceived normal weight.
[c] Weighted counts and percentages of students meeting recommended physical activity levels versus not meeting recommended levels
[d] Weighted counts and percentages of students engaging in extreme dieting practices versus not engaging in extreme dieting practices.
[e] P-values based on $\chi 2$ analysis between exposure and outcome cell proportions.
[f] Referent group for pairwise comparisons for each variable containing more than two categories.
** Indicates statistical significance for pairwise comparison. Significance level set $\alpha=0.05$.*

***Table 3 (continued)**: Crude associations among obesity prevalence (primary exposure) and confounders with weight perception (potential mediator) and weight related behaviors (primary outcome): YRBS 2011 [count (%)][a]*

	Girls (n = 6,151)			Boys (n = 5,901)		
	Perceived Overweight [b]	**Meets PA Recommendations [c]**	**Engages in Extreme Dieting[d]**	**Perceived Overweight [b]**	**Meets PA Recommendations [c]**	**Engages in Extreme Dieting[d]**
Total	2,382 (38.7)	2,402 (39.3)	1,357 (22.1)	1,702 (28.8)	3,601 (61.7)	580 (9.9)
Smoke Status						
Non Smoker	1,875 (37.5)	2,061 (41.5)	899 (18)	1,311 (28.7)	2,830 (62.6)	331 (7.3)
Smoker	444 (44.7)	282 (28.5)	397 (39.9)	328 (29.3)	662 (59.8)	211 (18.9)
P-Value[e]	**0.003**	**< 0.001**	**< 0.001**	0.707	0.217	**< 0.001**
Obesity Prevalence						
Low Prevalence[f]	707 (34.3)	869 (42.6)	388 (18.9)	539 (25.5)	1314 (62.7)	164 (7.8)
Medium Prevalence	804 (40.3)*	795 (40.2)	446 (22.4)*	524 (30.1)*	1062 (61.7)	194 (11.1)*
High Prevalence	872 (41.5)*	738 (35.3)*	523 (24.9)*	639 (31.2)*	1225 (60.5)	223 (10.9)*
P-Value[e]	**< 0.001**	0.097	**0.002**	**0.004**	0.661	**0.005**
Perceived Weight						
Normal Weight	N/A	1,599 (42.8)	592 (15.7)	N/A	2,802 (67.3)	329 (7.9)
Overweight	N/A	803 (33.9)	765 (32.1)	N/A	799 (47.6)	252 (14.9)
P-Value[e]	N/A	**< 0.001**	**< 0.001**	N/A	**< 0.001**	**< 0.001**
BMI						
Normal Weight[f]	1,016 (22.9)	1,818 (41.2)	850 (19.2)	351 (9.5)	2,390 (65.1)	282 (7.6)
Overweight	754 (72.3)*	399 (38.5)	314 (30.1)*	457 (43.2)*	621 (59.3)*	110 (10.5)*
Obese	612 (91.9)*	185 (27.9)*	193 (28.9)*	894 (78.7)*	589 (52.7)*	188 (16.7)*
P-Value[e]	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**

[a] Adjusted for YRBS three stages cluster sample design. Totals may not sum to final sample size due to missing variables; percentages may not sum to 100 due to rounding.
[b] Weighted counts and percentages of students with perceived overweight versus perceived normal weight.
[c] Weighted counts and percentages of students meeting recommended physical activity levels versus not meeting recommended levels
[d] Weighted counts and percentages of students engaging in extreme dieting practices versus not engaging in extreme dieting practices.
[e] P-values based on $\chi 2$ analysis between exposure and outcome cell proportions.
[f] Referent group for pairwise comparisons for each variable containing more than two categories.
** Indicates statistical significance for pairwise comparison. Significance level set $\alpha=0.05$*

Logistic Regression Analysis

Estimated Effect of Obesity Prevalence on Perceived Overweight

After controlling for confounders, overweight boys and girls living in environments with high obesity prevalence were 42% and 38% less likely (OR=0.58 and 0.62), respectively, to perceive themselves as overweight than those living in areas with low obesity prevalence, although this relationship was marginally significant in girls (Table 4). Among girls, we observed stronger estimated effects of obesity prevalence on perceived overweight among those with greater BMI. However, these estimates were imprecise and not statistically significant. This pattern was not observed among boys. These findings suggest that obesity prevalence may primarily be related to weight perception of overweight boys and girls.

***Table 4**. Estimated Effect of Obesity Prevalence on Perceived Overweight stratified by Sex and tested for BMI interaction, United States adolescent high school students, YRBS 2011*[a]

Model[b]	Girls			Boys		
	OR[c]	95% CI	P-Value	OR[c]	95% CI	P-Value
Normal Weight						
Low Obesity Prevalence	1	N/A	N/A	1	N/A	N/A
Medium Obesity Prevalence	1.05	(0.86, 1.29)	0.593	1.05	(0.69, 1.60)	0.816
High Obesity Prevalence	1.05	(0.85, 1.31)	0.630	1.11	(0.78 1.59)	0.536
Overweight						
Low Obesity Prevalence	1	N/A	N/A	1	N/A	N/A
Medium Obesity Prevalence	0.69	(0.44, 1.09)	0.112	0.87	(0.58, 1.31)	0.495
High Obesity Prevalence	0.62	(0.39, 1.01)	0.053	0.58	(0.36, 0.94)	**0.027**
Obese						
Low Obesity Prevalence	1	N/A	N/A	1	N/A	N/A
Medium Obesity Prevalence	0.56	(0.12, 2.76)	0.473	1.32	(0.69, 2.55)	0.390
High Obesity Prevalence	0.51	(0.11, 2.45)	0.392	0.95	(0.56 1.65)	0.870

[a] Point estimates derived from multivariate logistic models adjusted for potential confounders – age, grade, smoking status, race. All models utilized survey design adjusting for YRBS three-stage cluster design.

[b] Perceived weight status was the outcome variable; obesity prevalence was our primary predictor. Referent was low obesity prevalence.

[c] Odds ratio derived from exponentiated beta coefficients of the primary predictor and describes the effect of weight prevalence on perceived weight status.

Estimated Effect of Perceived Overweight on Weight Related Behaviors

In adjusted models, perceived overweight was negatively associated with meeting recommended physical activity in boys and girls (Table 5). Specifically, normal weight girls with perceived overweight were 29% less likely (OR=0.71) to meet physical activity recommendations than normal weight girls with perceived normal weight. This association was not apparent in overweight or obese girls (interaction p-value = 0.483). In contrast, the relationship was stronger among boys and similar across BMI categories (interaction p-value = 0.658).

Perceived overweight was positively associated with extreme dieting in boys and girls, primarily in those with normal BMI. Among normal weight girls and boys, those with perceived overweight were 2.83 and 2.61 times more likely, respectively, to engage in extreme dieting practice than those with perceived normal weight. In overweight girls, those with perceived overweight were 1.58 times more likely to engage in extreme dieting than those with perceived normal weights. The associations between normal weight and overweight girls were significantly different (interaction p-value = 0.030). Similarly for boys, we note significant differences among the BMI point estimates (interaction p-value = 0.002). Overweight perception and extreme dieting were unrelated among overweight boys, and obese girls and boys. The evidence supports our hypothesis that perceived overweight impacts weight-related behaviors differentially depending on behavior type and sex.

***Table 5**. Estimated Effect of Perceived Weight Status on Weight related Behaviors stratified by Sex and tested for BMI interaction, United States adolescent high school students, YRBS 2011*[a]

	Girls			Boys		
Model[b]	**OR**[c]	**95% CI**	**P-Value**	**OR**[c]	**95% CI**	**P-Value**
Physical Activity						
Normal Weight						
Perceived Normal Weight	1	N/A	N/A	1	N/A	N/A
Perceived Overweight	0.71	(0.59, 0.85)	**< 0.001**	0.40	(0.28, 0.58)	**< 0.001**
Overweight						
Perceived Normal Weight	1	N/A	N/A	1	N/A	N/A
Perceived Overweight	0.79	(0.55, 1.15)	0.216	0.48	(0.32, 0.72)	**0.001**
Obese						
Perceived Normal Weight	1	N/A	N/A	1	N/A	N/A
Perceived Overweight	1.22	(0.58, 2.57)	0.592	0.36	(0.24, 0.57)	**< 0.001**
Extreme Dieting						
Normal Weight						
Perceived Normal Weight	1	N/A	N/A	1	N/A	N/A
Perceived Overweight	2.83	(2.42, 3.32)	**< 0.001**	2.61	(1.82, 3.75)	**< 0.001**
Overweight						
Perceived Normal Weight	1	N/A	N/A	1	N/A	N/A
Perceived Overweight	1.58	(1.04, 2.42)	**0.035**	1.07	(0.65, 1.78)	0.777
Obese						
Perceived Normal Weight	1	N/A	N/A	1	N/A	N/A
Perceived Overweight	1.35	(0.55, 3.35)	0.505	0.93	(0.56, 1.57)	0.796

[a] *Estimates derived from multivariate logistic models adjusted for confounders (age, grade, smoking status, race). All models adjusted for YRBS three-stage cluster design.*
[b] *Two weight-related behaviors were assessed: physical activity and extreme dieting; perceived weight status was our primary predictor. Referent was perceived normal weight.*
[c] *Odds ratio derived from exponentiated beta coefficients of the primary predictor and describes the estimated effect of perceived overweight on weight related behaviors within BMI category.*

Estimated Effect of Obesity Prevalence on Weight Related Behaviors

Obesity prevalence was not associated with physical activity for either sex (Table 6). We did not observe any clear patterns across BMI.

Among normal weight girls and boys, those living in areas of high obesity prevalence were 1.34 and 1.56 times more likely, respectively, to engage in extreme dieting practices compared to those living in areas of low obesity prevalence. In contrast, among obese girls and boys, greater obesity prevalence was related to lower odds of extreme dieting, but associations were not statistically significant.

***Table 6**. Estimated Effect of Obesity Prevalence on Weight related Behaviors stratified by Sex and tested for BMI interaction, United States adolescent high school students, YRBS 2011*[a]

Model[b]	Girls			Boys		
	OR[c]	95% CI	P-Value	OR[c]	95% CI	P-Value
Physical Activity						
Normal Weight						
Low Obesity Prevalence	1	N/A	N/A	1	N/A	N/A
Medium Obesity Prevalence	0.91	(0.65, 1.29)	0.611	1.03	(0.79, 1.35)	0.821
High Obesity Prevalence	0.81	(0.60, 1.11)	0.188	0.99	(0.76, 1.30)	0.949
Overweight						
Low Obesity Prevalence	1	N/A	N/A	1	N/A	N/A
Medium Obesity Prevalence	1.28	(0.88, 1.87)	0.183	1.02	(0.66, 1.60)	0.902
High Obesity Prevalence	1.16	(0.78, 1.73)	0.451	0.90	(0.53, 1.53)	0.699
Obese						
Low Obesity Prevalence	1	N/A	N/A	1	N/A	N/A
Medium Obesity Prevalence	0.95	(0.43, 2.13)	0.906	0.89	(0.55, 1.45)	0.633
High Obesity Prevalence	0.76	(0.40, 1.49)	0.428	0.96	(0.67, 1.39)	0.850
Extreme Dieting						
Normal Weight						
Low Obesity Prevalence	1	N/A	N/A	1	N/A	N/A
Medium Obesity Prevalence	1.18	(0.94, 1.50)	0.154	1.71	(1.10, 2.68)	**0.020**
High Obesity Prevalence	1.34	(1.10, 1.65)	**0.005**	1.56	(1.03, 2.36)	**0.035**
Overweight						
Low Obesity Prevalence	1	N/A	N/A	1	N/A	N/A
Medium Obesity Prevalence	1.13	(0.70, 1.85)	0.592	1.64	(0.91, 2.99)	0.100
High Obesity Prevalence	1.15	(0.72, 1.85)	0.551	1.06	(0.58, 1.98)	0.829
Obese						
Low Obesity Prevalence	1	N/A	N/A	1	N/A	N/A
Medium Obesity Prevalence	0.76	(0.40, 1.45)	0.405	0.76	(0.43, 1.36)	0.351
High Obesity Prevalence	0.82	(0.43, 1.55)	0.535	0.79	(0.47, 1.36)	0.392

[a] *Point estimates derived from multivariate logistic models adjusted for potential confounders – age, grade, smoking status, race. All models utilized survey design adjusting for YRBS three-stage cluster design.*

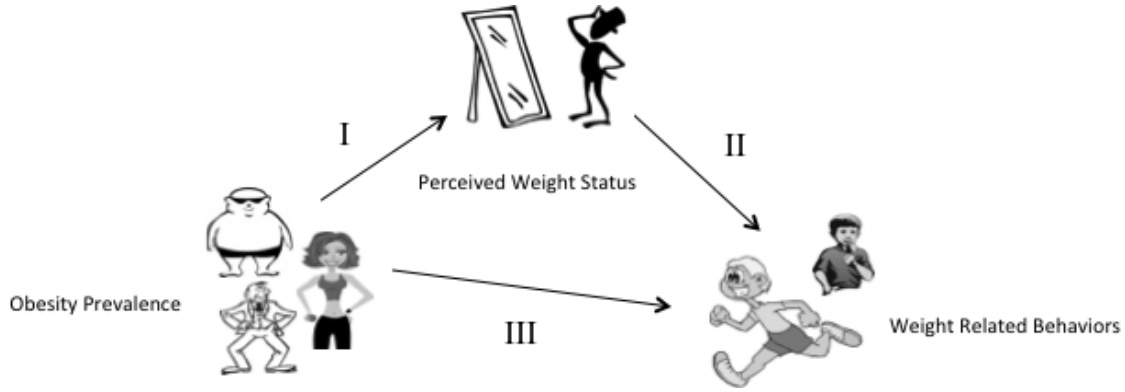
[b] *Two weight related behaviors were assessed: physical activity and extreme dieting; obesity prevalence was our primary predictor. Referent was low obesity prevalence.*

[c] *Odds ratio derived from exponentiated beta coefficients of the primary predictor and describes the effect of obesity prevalence on weight related behaviors.*

Obesity Prevalence Mediation on Weight Related Behaviors by Weight Perception

Our study does not support the notion of perceived weight status to act as a mediator for the relationship between obesity prevalence and weight related behavior. The criteria for mediation were not met for any sex within a specific BMI level.[36] Among adolescents with normal BMI, the relationship between obesity prevalence and overweight perception was not found significant (Figure 3; relationship I); for overweight or obese adolescents, the relationship between obesity prevalence and either weight related behavior were not found significant (Figure 3; relationship III).

Figure 3*. Mediation by perceived weight status for the relationship between obesity prevalence and weight related behavior, United States adolescent high school students, YRBS 2011*[a]



[a] *Mediation was analyzed using regression models to assess the four components of the criteria outlined by Mackinnon et al. (2007). All models utilized survey design adjusting for YRBS three-stage cluster sampling design; models were stratified by sex, adjusted for potential confounding - age, grade, smoking status, race, and tested for BMI interaction. A significant relationship (relationship I) between obesity prevalence and perceived weight status was not found among adolescents with normal BMI. A significant relationship (relationship III) between obesity prevalence and outcome behaviors of physical activity or extreme dieting was not found among overweight or obese adolescents.*

Chapter 4 – Discussion

Over the past quarter century, obesity prevalence has dramatically increased throughout the United States. A multitude of associated medical complications have surfaced, making obesity a primary public health concern on a global scale. Environmental and psychological factors are now major areas of research focus. Our study estimated effects of obesity prevalence on weight related behaviors among adolescents and assessed whether overweight perception explained this relationship. To investigate the mediating role of perceived weight status, we investigated three relationships, stratified by sex: (a) obesity prevalence and perceived overweight, (b) perceived overweight and weight-related behavior, and (c) obesity prevalence and weight-related behavior. While we found several important relationships, overall our findings do not suggest perceived weight status to act as a mediator between obesity prevalence and weight related behavior.

Estimated Effects of Obesity Prevalence on Perceived Overweight

Compared to those exposed to low obesity prevalence, boys exposed to high obesity prevalence had lower odds of overweight perception. This relationship was also evident in overweight girls. Our results support our hypothesis and are consistent with prior studies investigating neighborhood contexts and weight perception.[22,30]

We also found differential relationships between overweight and obese adolescents. Obese adolescents exposed to areas of higher obesity prevalence were no less likely to

report overweight perception compared to those exposed to low obesity prevalence areas. A possible explanation may be due to potential ambiguous feelings towards weight among those classified as overweight. Consequently, those classified as overweight may be more sensitive to environmental characteristics. Alternatively, those classified as obese may be less likely to compare one's self with others as a result of having weights too divergent from the socially accepted norm within the community.

Environments with high obesity prevalence may therefore be important when considering factors that shape weight perception. With potential increases in obesity prevalence, there may be gradual increases in weight misperception in countries with growing obesity prevalence.

Estimated Effects of Overweight Perception on Weight Related Behaviors

Our results contradict our hypothesis where overweight perception was thought to be a "motivator" for physical activity. Compared to those with normal weight perception, those with overweight perception were less likely to meet physical activity recommendations. Other studies also conclude that overweight perception is associated with lower physical activity. Using the Australian National Health Survey, Atlantis et al. (2008) found lower odds of meeting recommended leisure-time physical activity among overweight men who perceive themselves to be overweight.[22] Another study concluded that feeling "too fat" to exercise was a common barrier among overweight women.[23]

Interestingly, we also found this relationship to be stronger and more consistent among boys. While we can only hypothesize mechanisms underlying this finding, overweight perception in boys may be related to lower self-confidence in performing well on sports teams or fear of stigma from teammates.

In accordance with our hypothesis, we found those with overweight perception to be more likely to engage in extreme dieting. Compared to those with normal weight perception, adolescents with overweight perception were more likely to engage in extreme dieting behaviors. A significant relationship was found for both normal weight girls and boys, and overweight girls. Estimated effects were strongest among those with normal BMI. A likely explanation may be due to stronger emphasis placed on ideal body weight and shape for normal weight students. Sciacca et al. (1991) found that perceived overweight was linked with harmful eating disorders in university students.[25] Another study using YRBS 2003 also demonstrated a significant and greater likelihood of normal weight adolescents with overweight misperceptions engaging in extreme dieting compared to those with normal weight perception.[24]

The evidence regarding the relationship between weight perception and weight-related behavior suggests that overweight perception is detrimental to health and counterproductive to weight loss. This is in direct contrast to our study hypothesis, as well as commonly used behavioral models – health belief model, social cognitive theory – that provide useful frameworks for assessments in behavior. Overweight perception may be linked with obesity stigma, leading to physiological distress and ultimately,

disengagement from physical activity and initiation of more extreme means of weight loss.

Estimated Effects of Obesity Prevalence on Weight Related Behaviors

Our study did not find any evidence to support the relationship between obesity prevalence and meeting physical activity recommendation among adolescents; however, the relationship between obesity prevalence and extreme dieting was found to be significant. Contrary to our hypothesis, we found those exposed to areas of high obesity prevalence were more likely to engage in extreme dieting. It is important to note that this relationship was found only among boys and girls with normal BMI. This finding, to our knowledge, has not been reported and extends the current literature.

Deviance regulation theory is a model with a framework designed to assess the effects of community social norms on behavior and may help interpret these findings. The theory postulates that others may want to distinguish themselves from a group by deviating from established group norms. One specific aspect of the theory is the case when deviating from existing behavioral norms is viewed as a positive.[37,38] That is, deviating from obesogenic behavioral norms is viewed as positive in the context of a "thin ideal." Normal weight individuals exposed to areas of higher obesity prevalence areas may value normal weights or even underweights more, due to fear of gaining weight and facing weight related stigma, or fear of having an unsatisfactory body shape similar to those in their community. As a result, normal weight adolescents exposed to areas of higher

obesity prevalence may view deviation as a positive, that is, maintaining normal or under weights as a positive, and will maintain this deviation through extreme measures in order to be distinguished from the group.

Subpopulations with currently high obesity prevalence may have increased rates of extreme dieting among normal weight adolescents. Further, a potential future public health concern may be increases in extreme dieting behavior along with the projected increases in obesity prevalence, leading to detrimental weight related behaviors.

Public Health Implications

Targeting accurate weight perception among those overweight or obese may discourage the use of physical activity and encourage the use of extreme dieting as an alternative form of weight loss. Consequently, accurate weight perception among those overweight or obese may lead to decreased physical and mental health, and lead to weight gain. A likely mechanism for such processes involves obesity stigma.

An important consideration related to the topic of obesity is the role of stigma on psychological distress and subsequently, weight related behavior. Obesity stigma is well documented and pervasive in the United States, growing considerably over the past decade.[39] Studies have consistently shown that stigma is a threat to psychological and physical health and has been linked to extreme dieting and reductions in physical activity.[40–44]

Due to the complicating nature of stigma, public health efforts approaching issues of weight perception in obesity related interventions or health campaigns should exercise sensitivity by avoiding inherent stigmatizing messages (e.g. creating environments that support and encourage healthy lifestyles for all, as opposed to promoting weight loss among those who are overweight or obese). Clinicians may also need to approach weight related issues carefully with patients (emphasizing improved health outcomes over improved weight and shape). Alternatively, our results may also suggest intervention efforts that bypass individual level factors of weight gain and focus on broader system level changes (e.g. access to healthy foods, environments that promote physical activity). By targeting system level changes beyond the control of an overweight or obese individual, public health efforts may be more effective in combating the obesity epidemic by avoiding issues of stigma.

Obesogenic environments, "the sum of influences" in the environment that promotes obesity, is a growing topic of epidemiologic research and has been linked to matters of adolescent weight status.[45–47] Our study suggests that obesity prevalence is a potentially important contextual factor that may ultimately promote weight gain. That is, extreme dieting is a strong risk factor for weight gain[48]. Highlighting the association between contextual factors of the environment and detrimental weight behaviors provides more evidence for system level changes, not only as a potential preventive or intervention measure for obesity, but also, eating disorders. Until obesity stigma is no longer a factor,

dismantling obesogenic environments may be a more effective approach to safely combat obesity.

Limitations and Strengths

We recognize the limitations of self-reported data, especially when contrasting weight perception and objective weights, both of which were self-reported. Studies report that survey respondents tends to overestimate height and underestimate weight, leading to underestimated BMI measurements.[8] However, self-reported BMI is commonly used in medical and epidemiologic literature and has been shown to be correlated with true heights and weights.[49]

Weight related behavior may be misreported differentially by weight perception. For example, it is possible that individuals with overweight perception over report extreme dieting due to decreased self-esteem, while those with normal weight perception underreport physical activity. However, we note that our study remains consistent with other current literature.[22,33]

Another limitation of the study was our inability to account for socioeconomic status, which may be related to our three primary study relationships. YRBS does not collect information that pertains to socioeconomic status. Further, as with all studies utilizing survey material, it is possible that despite controlling for demographic factors, residual confounding may still exist.

Potential misclassification bias may also result if adolescents recently relocate to different neighborhoods. For example, it is possible for an adolescent to previously live in an area with high obesity prevalence and locate to an area of low obesity prevalence immediately prior to the survey.

Another important statistical limitation to consider was the use height and weight data for two measures used in modeling: BMI and obesity prevalence. The correlation between these two variables may cause an overestimation of point estimates. However, this study design is commonly used in epidemiology assessing neighborhood socioeconomic status in relation to individual level factors.[50,51]

Despite study limitations, the strength of our study is a thorough investigation of obesity prevalence as an environmental exposure to, two weight related behaviors, stratifying by sex and investigating modifying effects of BMI classification. We are also the first to investigate the nature of perceived weight status as a potential mediator. Previous research investigates weight perception as either a primary exposure or primary outcome.[18,31] Additionally, we utilize nationally representative data, allowing us to generalize results to enrolled adolescent students grades 9 through 12. Finally, our study uses spatial differences by utilizing different geographic areas with varying obesity prevalence; in contrast with previous studies that examine temporal variation in perceived overweight.[28,29]

Future Studies

Future studies should incorporate longitudinal data and environmental information at several geographic areas simultaneously. This will enable temporality to be established between exposure and outcome variables. More accurate exposure measurements (e.g., duration living in a defined community or duration exposed to external stimuli such as time spent at school or outside the home) may reveal interesting results. Smaller and more defined communities may better reflect an individual's common environment. Future studies should also capture and compare detrimental dieting behaviors alongside other dieting practices (e.g. consumption frequency of healthy foods versus processed food or eating at home meals versus prepared meals) to further explore the spectrum of dietary behavior. Finally, studies must also capture relevant control factors such as individual or community wide socioeconomic status measures and investigate other potential mediators linking obesity prevalence and weight related behaviors.

Study Conclusions

Obesity prevalence may be an important contextual environmental factor that shapes weight perception. Increases in obesity prevalence may lead to increases in perceived weight underestimations among overweight individuals. Overweight perception was not found as a mediator between obesity prevalence and weight related behaviors, but was found as a factor associated with greater extreme dieting and lower physical activity.

Obesity prevalence was also linked with extreme dieting, suggesting obesity prevalence as an important contextual environmental factor for extreme dieting.

Weight perception is a sensitive topic in the context of body weight and shape, and weight related behavior. Weight perception should be approached cautiously or even avoided when attempting to address weight loss or maintenance in either public health or healthcare sectors. Addressing obesogenic environments for broad, system level changes may be safe alternative considering public health implications of obesity stigma.

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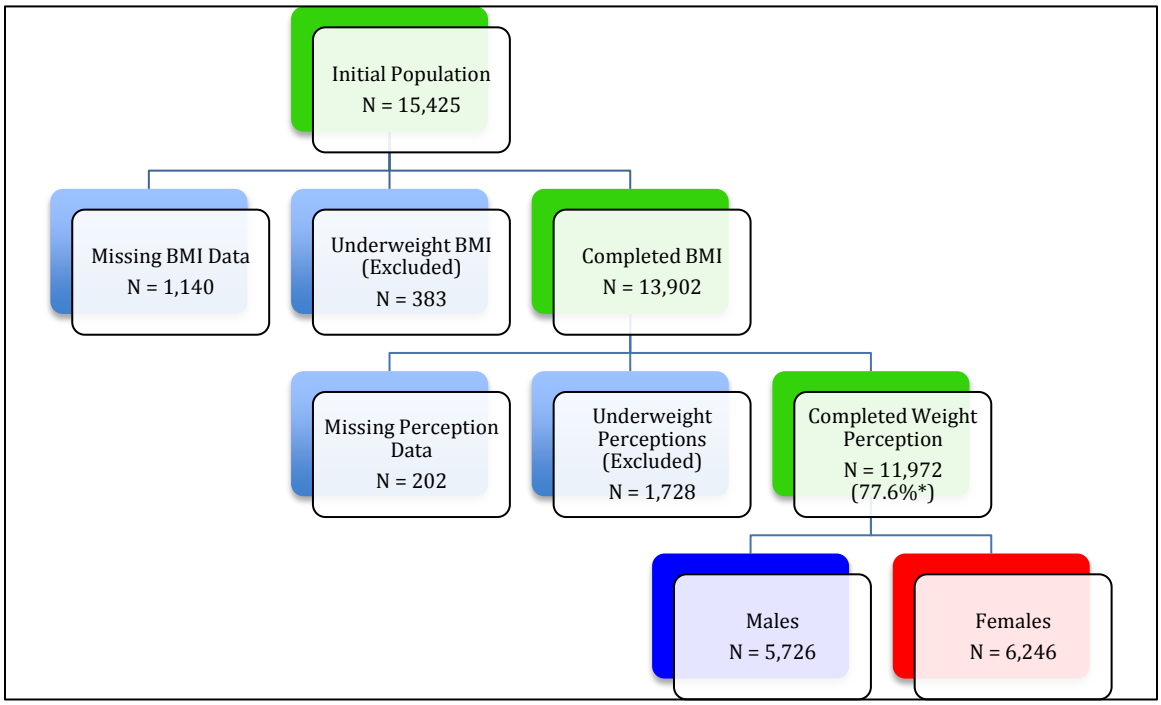
Appendix

Figure 4*. Study subject flow diagram, United States adolescent high school students, YRBS 2011* [a]



[a] *The study population was restricted to United States adolescents with reported normal, overweight, or obese BMI, and reported normal or overweight perceptions.*

** Percentage of initial population.*

Table 8*. Diagnostic procedures, goodness-of-fit and Receiver Operating Characteristic (ROC) curves, for study models, United States adolescent high school students, YRBS 2011* [a]

Model	ROC	Hosmer and Lemeshow Goodness-of-Fit Test
Girls		
Obesity Prevalence to Perceived Weight Status	0.784	0.666
Perceived Weight Status to Physical Activity	0.546	**< 0.001**
Perceived Weight Status to Extreme Dieting	0.616	0.406
Obesity Prevalence to Physical Activity	0.611	0.232
Obesity Prevalence to Extreme Dieting	0.627	0.654
Boys		
Obesity Prevalence to Perceived Weight Status	0.848	0.336
Perceived Weight Status to Physical Activity	0.585	**0.017**
Perceived Weight Status to Extreme Dieting	0.611	0.14
Obesity Prevalence to Physical Activity	0.569	0.015
Obesity Prevalence to Extreme Dieting	0.671	0.061

[a] *Diagnostic procedures were performed to assess goodness-of-fit and model discriminatory capacity by generating Receiver Operating Characteristic curves. The area under the ROC curve per specific model is reported.*