Socioenvironmental, Personal, and Behavioral Correlates of Severe Obesity among an Ethnically/Racially Diverse Sample of US Adolescents

Katherine W. Bauer, PhD, MS,[1] Marsha D. Marcus, PhD,[2]
Nicole Larson, PhD, MPH, RDN,[3] and Dianne Neumark-Sztainer, PhD, MPH, RD[3]

Abstract

Background: Severe obesity among adolescents, also known as class 2 and 3 obesity, is increasing in prevalence, yet, little is known about adolescents with severe obesity. The objective of this study was to identify the socioenvironmental, personal, and behavioral correlates of severe obesity among an ethnically/racially diverse sample of US adolescents.

Methods: A cross-sectional analysis of data from participants in the EAT 2010 study ($n = 2706$) was conducted. Adolescents completed in-class surveys, and height and weight were measured. Severe obesity was defined as a BMI ≥120% of the 95th percentile or ≥35 kg/m^2; class 1 obesity as a BMI ≥95th percentile but below severe obesity cut points, overweight as a BMI <95th percentile but ≥85th percentile, and normal weight as a BMI <85th but >5th percentile. General linear models were used to identify differences between adolescents by weight status, adjusted for covariates.

Results: Nine percent of adolescents had severe obesity. Compared with peers of other weight statuses, a greater proportion of adolescents with severe obesity reported parental encouragement to diet and peer weight teasing. Adolescents with severe obesity also reported lower self-esteem and body satisfaction. Binge eating was three times as prevalent among adolescents with severe obesity compared with peers of normal weight and twice as prevalent as among peers with class 1 obesity.

Conclusions: Adolescents with severe obesity report several unique socioenvironmental, personal, and behavioral concerns that may diminish quality of life and may predict increased weight gain over time.

Keywords: adolescence; severe obesity; socioecological influences

Introduction

Although the prevalence of overweight and obesity has stabilized among many population groups in the United States over the past decade, the proportion of youth with severe obesity (also known as class 2 or 3 obesity), defined as a BMI ≥120% of the 95th percentile for age and sex or an absolute BMI ≥35 kg/m^2, continues to increase. In 2013–2014, 12.6% of adolescent boys and 15.1% of adolescent girls in the United States had severe obesity.[1] Adolescents with severe obesity are significantly more likely to have poor cardiovascular health profiles than adolescents with class 1 obesity (*i.e.*, an age- and sex-adjusted BMI between 100% and 120% of the 95th percentile), including elevated risk of hypertension, dyslipidemia, impaired glucose tolerance, and metabolic syndrome.[2,3] Adolescents with severe obesity are also more likely than their peers to experience physical comorbidities, including sleep apnea,[4] nonalcoholic fatty liver disease,[5] and musculoskeletal problems.[6] Severe obesity tracks strongly into adulthood; 100% of early adolescents with severe obesity in the Bogalusa Heart Study had obesity as adults.[2]

Despite the increased risk of health consequences associated with severe obesity, little is known about the health behaviors and social and personal experiences of adolescents with severe obesity. Research in this area has

[1]Department of Nutritional Sciences, University of Michigan School of Public Health, Ann Arbor, MI.
[2]Department of Psychiatry, University of Pittsburgh Medical Center, Western Psychiatric Institute and Clinic, Pittsburgh, PA.
[3]Division of Epidemiology and Community Health, School of Public Health, University of Minnesota, Minneapolis, MN.

been called for to inform the development of novel adolescent obesity treatment approaches,[7] which are essential given that youth with severe obesity respond poorly to standard lifestyle modification treatment protocols.[8] In addition, although pharmaceutical and surgical options are increasingly considered to treat severe obesity among adolescents,[9] these treatments are not feasible strategies to address severe obesity population-wide. However, among those for whom these types of interventions are appropriate, simultaneously addressing adolescents' social environments and maladaptive cognitions and behaviors is likely essential to contribute to the long-term success of these interventions. Finally, independent of participation in obesity treatment, it is crucial to understand the experiences of adolescents with severe obesity to remove barriers to improving overall physical and emotional health.

Among the small number of studies that have examined correlates of severe obesity among adolescents, findings demonstrate that youth with severe obesity experience poorer quality of life and lower school functioning,[10,11] report fewer romantic relationships,[12] and are more likely to demonstrate binge-eating symptoms[13] and suicidal ideation[14] than peers of normal weight or peers with class 1 obesity. However, nearly all studies of adolescents with severe obesity have been conducted among clinical, obesity treatment-seeking populations. These clinical populations are likely different than the general population of adolescents with severe obesity on important characteristics, including the duration or intensity of obesity, psychosocial experiences as an individual with obesity, and sociodemographic characteristics.

To our knowledge, only one community-based study examining a range of social and behavioral experiences of adolescents with severe obesity has been conducted. Among youth in New Zealand, 2.5% of whom experienced severe obesity based on the International Obesity Task Force definition, adolescents with severe obesity were more likely to smoke cigarettes; use extreme weight control methods such as skipping meals, fasting, and vomiting; and report that they have been bullied at school and by family members, compared with peers of normal weight.[15]

Given the limited understanding of the experiences of adolescents with severe obesity, the purpose of the current study is to examine socioenvironmental, personal, and behavioral correlates of severe obesity among a community-based sample of over 2700 middle- and high school-aged students from a large metropolitan area. Unlike previous studies of youth with severe obesity, which often only compared these youth with peers of normal weight, in the current study, three comparison groups are utilized: adolescents with class 1 obesity, adolescents with overweight, and adolescents of normal weight. Comparing adolescents with severe obesity with those with class 1 obesity, in particular, is essential, as it has been hypothesized that youth with severe obesity differ greatly from those who are obese but have lower relative weights, and these differences may contribute to the lower effectiveness of obesity treatment.

Materials and Methods

Cross-sectional data were drawn from the EAT 2010 study, an observational investigation of socioecological correlates of eating, physical activity, and weight-related topics among a diverse sample of adolescents from 20 public middle and high schools in the Minneapolis/St. Paul metropolitan area of Minnesota.[16] Students from selected health, physical education, and science classes were recruited to participate during the 2009–2010 school year. Adolescent assent and parental consent were obtained for 96.3% of those attending school during survey administration. Students completed surveys in school classrooms, and nearly all participants also had their height and weight measured ($n = 2740$ of 2793) in a private space within their school. Following survey completion, participants received a $10 gift card. The University of Minnesota Institutional Review Board approved the study protocol. In the current study, we additionally excluded adolescents who were underweight (BMI percentile <5) ($n = 36$), therefore, the final analytic sample was 2706.

Measures

The EAT 2010 survey is a 235-item self-report instrument assessing a range of factors of potential relevance to weight status and weight-related behaviors among adolescents. Development of the EAT 2010 survey has been described in detail previously.[17]

Socioenvironmental, personal, and behavioral characteristics. Items assessing the socioenvironmental, personal, and behavioral characteristics examined as potential correlates of severe obesity are presented in Table 1. Variable selection for the current analysis was guided by Social Cognitive Theory[18] as well as previous literatures identifying socioenvironmental, personal, and behavioral characteristics predictive of excess weight gain and obesity among adolescents.[19] One-week test–retest reliability of EAT 2010 survey items presented in Table 1 was obtained during pilot testing of the survey. Measures of internal consistency of study scales were calculated utilizing the complete EAT 2010 study sample.

Weight status. Adolescents' height and weight were assessed by trained research staff using standardized equipment and procedures.[20] Students were weighed such that they could not see their weight and were not told their weight unless they requested. Height was assessed to the nearest 0.1 cm using a Shorr board and weight to the nearest 0.1 kg using a calibrated scale. BMI and BMI percentile were calculated for each adolescent using the CDC guidelines.[21] Adolescents with severe obesity were identified as those with an age- and sex-adjusted BMI ≥120% of the 95th percentile or an absolute BMI ≥35 kg/m²[.7] Severe obesity as defined by these cut points corresponds to class 2 and 3 obesity.[3] Adolescents with class 1 obesity were identified as those with an age- and sex-adjusted BMI percentile between 100% and 120% of the 95th percentile, adolescents with overweight were identified as those

Table 1. Description of Constructs and Measures in EAT 2010

Construct	Measure with source and psychometric characteristics
Socioenvironmental	
Family functioning	Six-item scale assessing the extent to which adolescents agree with statements regarding family member acceptance and ability to make group decisions. Cronbach's $\alpha = 0.67$.
Weekly family meals	Past 7-day frequency with which the adolescents' family ate a meal together. Test–retest $r = 0.63$.
Healthy home food availability	Five-item measure of the frequency with which the following food types are available at home or served at meals: fruits and vegetables, fruit juice, milk, and whole wheat bread. Cronbach's $\alpha = 0.62$, test–retest reliability $= 0.76$.
Unhealthy home food availability	Four-item measure of the frequency with which the following food types are available at home: "junk food," potato chips or other salty snacks, chocolate or other candy, and soda pop. Cronbach's $\alpha = 0.79$, test–retest reliability $= 0.65$.
Parental encouragement of healthy eating	Two-item measure of parental encouragement to eat healthy foods. Test–retest reliability $= 0.47$ for mothers and 0.66 for fathers. Adolescents with mean score of "sometimes" or more frequently identified as encouraged to diet.
Family support for physical activity	Two-item measure of the extent, to which the adolescent's family does active things together and how much their family supports them being physically active. Test–retest reliability $= 0.73$. Adolescents with mean responses of "agree" or "strongly agree" identified as having support for physical activity.
Parental encouragement to diet	Two-item measure of parental encouragement of the adolescent to diet to control their weight. Test–retest reliability $= 0.66$ for mothers and 0.58 for fathers. Adolescents with mean score of "sometimes" or more frequently identified as encouraged to diet.
Family weight teasing	Report of whether the adolescent has ever been teased by their family members because of their weight. Test–retest percent agreement $= 96\%$.
Teased by peers about weight	Report of whether the adolescent has ever been teased by other children because of their weight. Test–retest percent agreement $= 98\%$.
Personal	
Weight concern	Three items of the extent to which the adolescent agrees with statements regarding thinking about being thinner, worried about gaining weight, and weighing themselves often. Cronbach's alpha $= 0.83$, test–retest reliability $= 0.77$.
Self-esteem	Six-item measure assessing the extent to which adolescents agree with statements such as, (1) On the whole, I am satisfied with myself and (2) I feel that I have a number of good qualities. Cronbach's $\alpha = 0.77$, test–retest reliability $= 0.69$.
Body satisfaction	Thirteen-item measure in which adolescents respond to the prompt, "How satisfied are you with your": for various body areas. Cronbach's $\alpha = 0.94$, test–retest $= 0.66$.
Depressive symptomology	Six-item measure of adolescents' frequency of depressive symptoms.[1] Cronbach's $\alpha = 0.83$, test-retest reliability $= 0.75$.
Behavioral	
Television use	Two items assessing the time the adolescent spent watching TV/DVDs/videos on an average weekday and weekend day. Total hours of TV use were calculated.
Moderate to vigorous physical activity	Two items assessing the time adolescents spent engaging in strenuous (vigorous) and moderate exercise. Total hours of moderate to vigorous physical activity were calculated. Test–retest reliability $= 0.73$.
Breakfast frequency	Measure asking adolescents to report during the past week, how many days they ate breakfast. Test–retest reliability $= 0.76$.
Fast food frequency	Five-item measure asking adolescents in the past month, how often they ate something from the following types of restaurants, including take-out and delivery: traditional "burger-and-fries" fast food, and Mexican fast food. Test–retest reliability $= 0.49$.
Healthy weight control behaviors	Six-item measure of past year frequency each of the following behaviors to lose weight or keep from gaining weight: exercised, ate more fruits and vegetables, ate less high-fat foods, ate less sweets, drank less soda pop, and watched portion sizes. Percent of adolescents reporting use of any behaviors "sometimes" or more frequently were identified as using healthy weight control behaviors. Cronbach's alpha $= 0.88$, test–retest percent agreement $= 91\%$.

Table 1. Description of Constructs and Measures in EAT 2010 *continued*

Construct	Measure with source and psychometric characteristics
Less extreme weight control behaviors	Four-item measure of past year frequency of each of the following behaviors to lose weight or keep from gaining weight: fasted, ate very little food, used a food substitute (*e.g.*, special drink), and skipped meals. Percent of adolescents reporting use of any behaviors "sometimes" or more frequently were identified as using less extreme weight control behaviors. Test–retest percent agreement=85%.
Extreme weight control behaviors	Proportion of adolescents who responded "yes" to using any of the following behaviors to lose weight or keep from gaining weight over the past year: took diet pills, made myself vomit, used laxatives, and used diuretics. Test–retest percent agreement=96%
Binge eating	Adolescents who responded "yes" to both of the following questions were identified as binge eating: "In the past year, have you ever eaten so much food in a short period of time that you would be embarrassed if others saw you (binge-eating)?" and [if yes], "During the times when you ate this way, did you feel you couldn't stop eating or control what or how much you were eating?"[2] Test–retest percent agreement=89%.
Average sleep	Four-item measure identifying the average time they go to bed to go to sleep and get out of bed to start their day on weekdays and weekends. A weighted average was used to calculate sleep across weekdays and weekends.

References

1. Kandel DB, Davies M. Epidemiology of depressive mood in adolescents: An empirical study. *Arch Gen Psychiatry* 1982;39:1205–1212.

2. Yanovski SZ, Nelson JE, Dubbert BK, Spitzer RL. Association of binge eating disorder and psychiatric comorbidity in obese subjects. *Am J Psychiatry* 1993;150:1472–1479.

with an age- and sex-adjusted BMI percentile ≥85 but <95, and adolescents of normal weight were identified as those with a BMI below the 85th percentile but ≥5th percentile. Thirty-six adolescents had a BMI percentile <the 5th percentile (underweight) and were excluded from the analyses.

Covariates. Adolescents self-reported their sex, race/ethnicity, and whether they were born in the United States. Due to small numbers, adolescents indicating that they belonged to two or more nonwhite racial/ethnic groups or were Native Hawaiian, American Indian, or other race/ethnicity were included in the "Mixed/Other" category. A five-category socioeconomic status (SES) indicator was formed using an algorithm composed of adolescent-reported parent education, eligibility for public assistance, eligibility for free/reduced-price school meals, and parent employment. In the current study, "low" and "low-middle" SES categories were combined and "high-middle" and "high" SES categories were combined to create a three-category indicator of SES. Adolescents' age was calculated from their self-reported birthdate and the date of survey administration.

Statistical Analyses

Descriptive statistics, including adolescents' socio-demographic characteristics, height, and weight, and BMI percentile, were calculated by weight status (normal weight, overweight, class 1 obesity, severe obesity). Separate general linear models were built to examine differences in the mean/proportion of the socioenvironmental, personal, and behavioral characteristics according to weight status. Adolescents' age, sex, SES, race/ethnicity, and US nativity were included in the models as covariates to reduce potential confounding. Adjusted means/proportions for each characteristic were calculated for adolescents with each weight status. In cases where differences between weight status categories were indicated by a statistically significant F statistic at $p < 0.05$, *post hoc* pairwise comparisons were conducted comparing the values for each weight status category. The potential for associations between weight status and the examined characteristics to differ by sex was considered; however, no discernable pattern of statistically significant interactions by adolescent sex were observed, therefore, nonsex stratified findings are presented. SAS 9.4 (Cary, NC) was used to conduct all analyses.

Results

Among EAT 2010 participants, 10.3% of boys and 8.1% of girls were categorized as having severe obesity (Table 2). Adolescents who identified as white were the least likely to have severe obesity, followed by adolescents who identified as Black/African American. Ten percent of adolescents born in the United States had severe obesity, compared with 4.0% of adolescents born outside the United States. The prevalence of severe obesity was higher among adolescents of low and middle SES (10.1% and 9.6%, respectively) compared with adolescents of high SES (6.0%).

Examining socioenvironmental characteristics, family meal frequency, availability of healthy and unhealthy food at home, parental encouragement of healthy eating, and weight teasing by a family member differed by adolescents' weight status with significant differences seen between

Table 2. Sociodemographic and Anthropometric Characteristics of EAT 2010 Sample by Weight Status

	Normal weight (BMI percentile <85th but ≥5th)	Overweight (BMI percentile ≥85th but <95th)	Class 1 obesity (BMI percentile ≥95th but <120% of 95th)	Severe obesity (BMI percentile ≥120% or 95th of BMI ≥35)
% (n)	57.1 (1544)	19.1 (516)	14.7 (397)	9.2 (249)
Age in years, mean (SD)	14.5 (2.0)	14.3 (2.0)	14.3 (1.9)	14.2 (1.9)
Sex, % (n)				
Male	54.9 (688)	17.5 (219)	17.2 (216)	10.5 (131)
Female	59.0 (856)	20.5 (297)	12.5 (181)	8.1 (118)
Race/ethnicity, % (n)				
White	67.1 (345)	15.8 (81)	11.3 (58)	5.8 (30)
Black/African American	56.2 (433)	21.5 (166)	13.5 (104)	8.8 (68)
Hispanic/Latino	50.2 (232)	21.0 (97)	18.6 (86)	10.2 (47)
Asian American	59.1 (321)	16.0 (87)	14.4 (78)	10.5 (57)
Mixed/other	51.1 (208)	20.6 (84)	17.0 (69)	11.3 (46)
US nativity, % (n)				
Born in the United States	56.1 (1250)	18.7 (416)	15.0 (334)	10.3 (230)
Born outside the United States	61.8 (291)	20.8 (98)	13.4 (63)	4.0 (19)
Socioeconomic status, % (n)				
Low	54.2 (874)	19.2 (310)	16.5 (266)	10.1 (162)
Middle	56.3 (258)	21.4 (98)	12.7 (58)	9.6 (44)
High	67.4 (362)	15.3 (82)	11.4 (61)	6.0 (32)
Weight, kg, mean (SD)	52.7 (10.0)	65.2 (9.8)	78.1 (12.5)	99.2 (17.2)
Height, cm, mean (SD)	161.0 (10.7)	161.7 (9.1)	163.3 (9.7)	165.0 (8.9)
Body mass index percentile, mean (SD)	55.2 (21.5)	90.5 (2.9)	97.1 (1.0)	99.2 (0.4)

adolescents of normal weight and those with severe obesity (Table 3). However, adolescents with severe obesity did not differ from their peers with overweight or class 1 obesity on these characteristics. Adolescents with severe obesity differed from their peers of normal weight, overweight and class 1 obesity in being more likely to report parental encouragement to diet and weight teasing by peers. For example, 69.0% of adolescents with severe obesity reported that they have ever been teased by other children because of their weight, compared with 46.9% of adolescents with moderate obesity, 23.7% of adolescents with overweight, and 17.0% of adolescents of normal weight ($p < 0.001$). No differences were observed in adolescents' report of family functioning or family support for physical activity by weight status.

Examining personal and behavioral characteristics, adolescents with severe obesity reported greater weight concern and higher depressive symptomatology than their peers with overweight and of normal weight, but did not differ from their peers with class 1 obesity on these characteristics. Similarly, adolescents with severe obesity reported eating breakfast and fast food less frequently, engaging in healthier, less extreme, and extreme weight control behaviors, and sleeping less than adolescents of normal weight, but did not differ from their peers with class 1 obesity and often did not differ from peers with overweight, on these characteristics. Differences between adolescents with severe obesity and class 1 obesity were observed for self-esteem and body satisfaction and prevalence of binge eating. Nearly twice as many adolescents with severe obesity reported binge eating as adolescents with class 1 obesity (17.1% vs. 9.9%), while 6.1% of adolescents of normal weight reported binge eating ($p < 0.001$).

Discussion

The objective of this study was to examine a wide range of socioenvironmental, personal, and behavioral correlates of severe obesity among a community-based sample of adolescents, comparing youth with severe obesity with those of normal weight, with overweight, and with class 1

Table 3. Socioenvironmental, Personal, and Behavioral Characteristics of Youth by Weight Status						
	Scale range or units reported	Normal weight (BMI percentile <85th but ≥5th percentile) (n = 1578)	Overweight (BMI percentile ≥85th but <95th) (N = 516)	Class I obesity (BMI percentile ≥95th but <120% of 95th) (n = 397)	Severe obesity (BMI percentile ≥120% or 95th of BMI ≥35) (n = 249)	
		Mean (SE) or %				$p_{df = 3}$
Socioenvironmental						
Family functioning	Range: 6–24	18.1 (0.1)	17.8 (0.2)	18.0 (0.2)	17.5 (0.2)	0.05
Weekly family meals	Range: 0–8	4.2 (0.1)[a]	4.0 (0.1)[ab]	3.8 (0.1)[b]	3.7 (0.2)[b]	0.003
Healthy home food availability	Range: 5–20	14.9 (0.1)[a]	14.5 (0.1)[b]	14.7 (0.1)[b]	14.7 (0.2)[b]	0.04
Unhealthy home food availability	Range: 4–16	10.4 (0.1)[a]	9.7 (0.1)[b]	9.8 (0.1)[b]	9.5 (0.2)[b]	<0.001
Parental encouragement of healthy eating	%	86.1[a]	89.6[b]	90.0[b]	91.4[b]	0.02
Family support for physical activity	%	62.2	64.0	58.7	57.3	0.20
Parental encouragement to diet	%	25.4[a]	44.6[b]	63.5[c]	76.3[d]	<0.001
Family weight teasing	%	17.7[a]	24.9[b]	36.4[c]	42.5[c]	<0.001
Teased by peers about weight	%	17.0[a]	23.7[b]	46.9[c]	69.0[d]	<0.001
Personal						
Weight concern	Range: 0–9	3.9 (0.05)[a]	5.0 (0.1)[b]	5.9 (0.1)[c]	6.0 (0.1)[c]	<0.001
Self-esteem	Range: 6–24	18.3 (0.1)[a]	18.0 (0.2)[a]	17.3 (0.2)[b]	16.6 (0.2)[c]	<0.001
Body satisfaction	Range: 13–65	47.4 (0.3)[a]	42.8 (0.5)[b]	37.6 (0.6)[c]	34.4 (0.8)[d]	<0.001
Depressive symptomology	Range: 6–18	10.0 (0.1)[a]	10.2 (0.1)[a]	10.6 (0.1)[b]	10.9 (0.2)[b]	<0.001
Behavioral						
Television use	Hours/week	17.4 (0.3)	16.7 (0.5)	17.9 (0.6)	17.0 (0.8)	0.48
Moderate to vigorous physical activity	Hours/week	5.9 (0.1)	5.8 (0.2)	5.6 (0.2)	5.7 (0.3)	0.69
Breakfast frequency	Times/week	4.4 (0.1)[a]	4.0 (0.1)[b]	3.8 (0.1)[b]	3.8 (0.2)[b]	<0.001
Fast food frequency	Times/month	16.1 (0.5)[a]	12.1 (0.8)[b]	13.1 (0.9)[b]	13.0 (1.2)[b]	<0.001
Healthy weight control behaviors	%	44.2[a]	58.6[b]	62.4[b]	63.7[b]	<0.001
Less extreme weight control behaviors	%	31.2[a]	55.1[b]	62.4[c]	69.7[c]	<0.001
Extreme weight control behaviors	%	4.4[a]	8.4[b]	13.5[c]	13.2[bc]	<0.001
Binge eating	%	6.1[a]	7.9[ab]	9.9[b]	17.1[c]	<0.001
Average sleep	hours/day	9.6 (0.05)[a]	9.5 (0.9)[ab]	9.6 (0.1)[ab]	9.3 (0.1)[b]	0.03

All models adjusted for age, sex, socioeconomic status, race/ethnicity, and US nativity. Adjusted means with differing superscript letters were different at an alpha level of $p < 0.05$.

obesity. Severe obesity was prevalent among this sample, occurring among 8.1% of girls and 10.5% of boys. This prevalence among the study sample of adolescents from the Minneapolis/St. Paul metropolitan area was slightly lower than the 2013–2014 national prevalence estimates for 12–19 year olds of 15.1% among girls and 12.6% among boys,[1] but similar to the prevalence estimate of 7.8% found by Ogden et al. using nationally representative data from 2011 to 2014. White, non-US born, and high-SES adolescents had the lowest prevalence of severe

obesity, reflecting trends observed in other US-based samples of adolescents.[1,22,23] Many socioenvironmental and behavioral factors often targeted for improvement by obesity interventions differed between adolescents of normal weight and those with severe obesity, but not those with class 1 obesity versus severe obesity, including frequency of family meals, experience of family weight teasing, and use of extreme weight control methods. These findings are similar to those of Farrant et al.[15] in their community-based study of adolescents from New Zealand, in which they compared adolescents with severe obesity to those of normal weight. Adolescents with severe obesity were more likely than those with class 1 obesity to experience weight teasing by peers, parental encouragement to diet, low self-esteem, and body dissatisfaction. This higher risk of peer harassment and poor psychosocial health aligns with evidence from clinical samples of adolescents with severe obesity[10–14] and reinforces that there is great heterogeneity in the experiences of adolescents with obesity. Together, these findings suggest that differentiating adolescents with obesity by degree of obesity provides important insight to inform health promotion interventions.

Frequent weight teasing by peers and parental encouragement to diet experienced by adolescents with severe obesity can be harmful to emotional health and may interfere with efforts to improve weight.[24] Parental encouragement of their child to diet likely rises out of great concern about their child's obesity status and a belief that encouraging dieting is a positive action that will help their child lose weight. However, encouragement of children to diet has been associated with children's weight gain, not weight loss, over time,[19,25] as well as higher use of unhealthy weight control approaches, body dissatisfaction, and binge eating.[26]

Although outcomes of behavioral weight loss programs have been less effective at promoting weight loss than desired among youth with severe obesity,[27] current pediatric obesity treatment guidelines recommend that adolescents with severe obesity engage in a structured weight management program if the adolescent and family are sufficiently motivated.[28] Such programs have demonstrated positive impacts not only on adolescents' weight but also body satisfaction and self-esteem.[29] Efforts to help parents of adolescents with severe obesity to recognize not only the value of family participation in obesity treatment but also the potential harms of encouraging their adolescents to lose weight without the support of an evidence-based program are important. Furthermore, eliminating family weight teasing, which can frequently occur among siblings or by parents,[30] has great potential to improve quality of life and enhance efforts to improve overall health among adolescents with severe obesity. Neumark-Sztainer has made five recommendations for healthcare providers aimed at preventing both obesity and eating disorders: (1) discourage unhealthy dieting; (2) promote a positive body image; (3) encourage more frequent and more enjoyable family meals; (4) encourage families to talk less about weight and do more at home to facilitate healthy eating and physical activity; and (5) assume that overweight teens have experienced

weight mistreatment and address this issue with teens and their families.[31] Given the results of this study, these recommendations may similarly have relevance for the treatment of obesity, including the treatment of severe obesity.

Among the study sample, 17.1% of adolescents with severe obesity reported binge eating, nearly twice the prevalence among adolescents with class 1 obesity and three times the prevalence among adolescents of normal weight. Although it is important to note that assessments of binge eating that rely on self-report may overestimate binge eating compared to gold standard clinical interviews,[32,33] previous studies of clinical samples of adolescents with severe obesity have similarly observed a high prevalence of binge eating or loss of control eating.[34–36] Furthermore, a relationship between self-report of disordered eating behaviors and higher levels of distress and dysfunction has been extensively documented in the peer-reviewed literature.[37] Binge eating may therefore be a distinguishing factor in regard to risk for progressing from class 1 to severe obesity and an important contributor to treatment challenges. A propensity for binge eating among individuals with obesity has been shown to inhibit weight loss during behavioral[38] and surgical[39] approaches to obesity treatment. Lack of sufficient attention to addressing binge eating in existing pediatric obesity treatment programs may serve to explain why these protocols tend to be less successful for adolescents with severe obesity than adolescents with class 1 obesity. Further research is needed to understand if addressing binge eating among adolescents in the context of obesity treatment leads to greater and more sustainable improvements in weight than previously observed, or if interventions that target binge eating alone, not in the context of obesity treatment, have a positive effect on adolescents with severe obesity.

The current study had a number of strengths, including a large, population-based sample of adolescents and measurement of a wide range of factors potentially associated with severe obesity. However, several limitations must be noted. While overall, the study's sample size was large, and there were not a sufficient number of adolescents with severe obesity to separately examine those with class 3 obesity (BMI percentile ≥140% of the 95th percentile or BMI > 40), who may experience the greatest physical health burden of obesity.[3] The study is cross sectional, and therefore, no determination can be made regarding the temporal associations between the socioenvironmental, personal, and behavioral characteristics and adolescents' weight status. In addition, with the exception of anthropometric data, all information was self-reported by adolescents. Although for most of constructs examined the use of self-report measures is the standard, and is often required, especially among large cohorts, this measurement approach may have led to differential reporting among adolescents by obesity status. Test–retest reliability for some of the self-report measures was also lower than ideal; study findings should be interpreted with this limitation in mind. Finally, the study sample was recruited from the

Minneapolis/St. Paul metropolitan area in 2009–2010 and, therefore, may not be representative of more recent samples of adolescents and those from other geographic areas.

Among this community-based sample of US adolescents, severe obesity was prevalent, particularly, among racial/ethnic minority, US-born, and low and middle SES youth. Although similarities were observed between adolescents with class 1 and severe obesity, experiencing peer weight teasing, encouragement to diet by parents, having lower self-esteem and body satisfaction, and engaging in binge eating differentiated youth with severe obesity. These experiences may contribute to lower quality of life and weight gain and reduce the effectiveness of standard behavioral obesity treatment approaches. Future longitudinal research is needed to understand how experiences such as these may contribute to the development of severe obesity among adolescents. Such research to identify determinants of severe obesity or excess weight gain among adolescents with existing obesity is rare.

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References

1. Skinner AC, Perrin EM, Skelton JA. Prevalence of obesity and severe obesity in US children, 1999–2014. *Obesity (Silver Spring)* 2016;24:1116–1123.

2. Freedman DS, Mei Z, Srinivasan SR, et al. Cardiovascular risk factors and excess adiposity among overweight children and adolescents: The Bogalusa Heart Study. *J Pediatr* 2007;150:12–17.e2.

3. Skinner AC, Perrin EM, Moss LA, Skelton JA. Cardiometabolic risks and severity of obesity in children and young adults. *N Engl J Med* 2015;373:1307–1317.

4. Kalra M, Inge T. Effect of bariatric surgery on obstructive sleep apnoea in adolescents. *Paediatr Respir Rev* 2006;7:260–267.

5. Xanthakos S, Miles L, Bucuvalas J, et al. Histologic spectrum of nonalcoholic fatty liver disease in morbidly obese adolescents. *Clin Gastroenterol Hepatol* 2006;4:226–232.

6. Bhatia NN, Pirpiris M, Otsuka NY. Body mass index in patients with slipped capital femoral epiphysis. *J Pediatr Orthop* 2006;26:197–199.

7. Kelly AS, Barlow SE, Rao G, et al. Severe obesity in children and adolescents: Identification, associated health risks, and treatment approaches: A scientific statement from the American Heart Association. *Circulation* 2013;128:1689–1712.

8. Kalarchian MA, Levine MD, Arslanian SA, et al. Family-based treatment of severe pediatric obesity: Randomized, controlled trial. *Pediatrics* 2009;124:1060–1068.

9. Thakkar RK, Michalsky MP. Update on bariatric surgery in adolescence. *Curr Opin Pediatr* 2015;27:370–376.

10. Schwimmer JB, Burwinkle TM, Varni JW. Health-related quality of life of severely obese children and adolescents. *JAMA* 2003;289:1813–1819.

11. Phillips BA, Gaudette S, McCracken A, et al. Psychosocial functioning in children and adolescents with extreme obesity. *J Clin Psychol Med Settings* 2012;19:277–284.

12. Becnel JN, Zeller MH, Noll JG, et al. Romantic, sexual, and sexual risk behaviours of adolescent females with severe obesity. *Pediatr Obes* 2016. [Epub ahead of print; PMID 27237983.]

13. Wilfley D, Berkowitz R, Goebel-Fabbri A, et al. Binge eating, mood, and quality of life in youth with type 2 diabetes: Baseline data from the today study. *Diabetes Care* 2011;34:858–860.

14. Zeller MH, Reiter-Purtill J, Jenkins TM, Ratcliff MB. Adolescent suicidal behavior across the excess weight status spectrum. *Obesity (Silver Spring)* 2013;21:1039–1045.

15. Farrant B, Utter J, Ameratunga S, et al. Prevalence of severe obesity among New Zealand adolescents and associations with health risk behaviors and emotional well-being. *J Pediatr* 2013;163:143–149.

16. Bauer KW, Hearst MO, Escoto K, et al. Parental employment and work-family stress: Associations with family food environments. *Soc Sci Med* 2012;75:496–504.

17. Arcan C, Larson N, Bauer K, et al. Dietary and weight-related behaviors and body mass index among Hispanic, Hmong, Somali, and white adolescents. *J Acad Nutr Diet* 2014;114:375–383.

18. Bandura A. Social cognitive theory. In: Vasta R (ed), *Annals of Child Development. Vol. 6. Six Theories of Child Development. Vol 6.* JAI Press: Greenwich, CT, 1989, pp. 1–60.

19. Haines J, Neumark-Sztainer D, Wall M, Story M. Personal, behavioral, and environmental risk and protective factors for adolescent overweight. *Obesity* 2007;15:2748–2760.

20. Gibson R. *Principles of Nutritional Assessment.* Oxford University Press: New York, New York, 1990.

21. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, et al. CDC growth charts: United States. *Adv Data* 2000:1–27.

22. Singh GK, Kogan MD, Yu SM. Disparities in obesity and overweight prevalence among US immigrant children and adolescents by generational status. *J Community Health* 2009;34:271–281.

23. Chung A, Backholer K, Wong E, et al. Trends in child and adolescent obesity prevalence in economically advanced countries according to socioeconomic position: A systematic review. *Obes Rev* 2016;17:276–295.

24. Saltzman JA, Liechty JM. Family correlates of childhood binge eating: A systematic review. *Eat Behav* 2016;22:62–71.

25. Balantekin KN, Savage JS, Marini ME, Birch LL. Parental encouragement of dieting promotes daughters' early dieting. *Appetite* 2014;80:190–196.

26. Neumark-Sztainer D, Bauer KW, Friend S, et al. Family weight talk and dieting: How much do they matter for body dissatisfaction and disordered eating behaviors in adolescent girls? *J Adolesc Health* 2010;47:270–276.

27. Kelly AS. The harsh reality of severe obesity. *J Pediatr* 2013;163:6–8.

28. Barlow SE. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: Summary report. *Pediatrics* 2007;120 Suppl 4:S164–S192.

29. Nobles J, Radley D, Dimitri P, Sharman K. Psychosocial interventions in the treatment of severe adolescent obesity: The SHINE program. *J Adolesc Health* 2016;59:523–529.

30. Berge JM, Hanson-Bradley C, Tate A, Neumark-Sztainer D. Do parents or siblings engage in more negative weight-based talk with

children and what does it sound like? A mixed-methods study. *Body Image* 2016;18:27–33.

31. Neumark-Sztainer D. Preventing obesity and eating disorders in adolescents: What can health care providers do? *J Adolesc Health* 2009;44:206–213.

32. Wilfley DE, Schwartz MB, Spurrell EB, Fairburn CG. Assessing the specific psychopathology of binge eating disorder patients: Interview or self-report? *Behav Res Ther* 1997;35:1151–1159.

33. Decaluwe V, Braet C. Assessment of eating disorder psychopathology in obese children and adolescents: Interview versus self-report questionnaire. *Behav Res Ther* 2004;42:799–811.

34. Gowey MA, Reiter-Purtill J, Becnel J, et al. Weight-related correlates of psychological dysregulation in adolescent and young adult (AYA) females with severe obesity. *Appetite* 2016;99:211–218.

35. Zeller MH, Roehrig HR, Modi AC, et al. Health-related quality of life and depressive symptoms in adolescents with extreme obesity presenting for bariatric surgery. *Pediatrics* 2006;117:1155–1161.

36. Utzinger LM, Gowey MA, Zeller M, et al. Loss of control eating and eating disorders in adolescents before bariatric surgery. *Int J Eat Disord* 2016;49:947–952.

37. Glasofer DR, Tanofsky-Kraff M, Eddy KT, et al. Binge eating in overweight treatment-seeking adolescents. *J Pediatr Psychol* 2007;32:95–105.

38. Teixeira PJ, Going SB, Houtkooper LB, et al. Pretreatment predictors of attrition and successful weight management in women. *Int J Obes Relat Metab Disord* 2004;28:1124–1133.

39. Sysko R, Devlin MJ, Hildebrandt TB, et al. Psychological outcomes and predictors of initial weight loss outcomes among severely obese adolescents receiving laparoscopic adjustable gastric banding. *J Clin Psychiatry* 2012;73:1351–1357.

Address correspondence to:
Katherine W. Bauer, PhD, MS
Department of Nutritional Sciences
University of Michigan School of Public Health
3854 SPH I, 1415 Washington Heights
Ann Arbor, MI 48109-2029

E-mail: kwbauer@umich.edu