

Adolescent Obesity and Risk for Subsequent Major Depressive Disorder and Anxiety Disorder: Prospective Evidence

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Objective: To assess whether adolescent obesity is associated with risk for development of major depressive disorder (MDD) or anxiety disorder. Obesity has been linked to psychosocial difficulties among youth. **Methods:** Analysis of a prospective community-based cohort originally from upstate New York, assessed four times over 20 years. Participants ($n = 776$) were 9 to 18 years old in 1983; subsequent assessments took place in 1985 to 1986 ($n = 775$), 1991 to 1994 ($n = 776$), and 2001 to 2003 ($n = 661$). Using Cox proportional hazards analysis, we evaluated the association of adolescent (age range, 12–17.99 years) weight status with risk for subsequent MDD or anxiety disorder (assessed at each wave by structured diagnostic interviews) in males and females. A total of 701 participants were not missing data on adolescent weight status and had ≥ 1 subsequent assessments. MDD and anxiety disorder analyses included 674 and 559 participants (free of current or previous MDD or anxiety disorder), respectively. Adolescent obesity was defined as body mass index above the age- and gender-specific 95th percentile of the Centers for Disease Control and Prevention growth reference. **Results:** Adolescent obesity in females predicted an increased risk for subsequent MDD (adjusted hazard ratio (HR) = 3.9; 95% confidence interval (CI) = 1.3, 11.8) and for anxiety disorder (HR = 3.8; CI = 1.3, 11.3). Adolescent obesity in males was not statistically significantly associated with risk for MDD (HR = 1.5; CI = 0.5, 3.5) or anxiety disorder (HR = 0.7; CI = 0.2, 2.9). **Conclusion:** Females obese as adolescents may be at increased risk for development of depression or anxiety disorders. **Key words:** body mass index, depression, longitudinal study, obesity, prospective cohort, relative weight.

BMI = body mass index; **CDC** = Centers for Disease Control and Prevention; **CI** = confidence interval; **CIC** = Children in the Community Study; **DSM** = Diagnostic and Statistical Manual of Mental Disorders; **DISC** = Diagnostic Interview Schedule for Children; **HR** = hazard ratio; **SCID-IV** = Structured Clinical Interview for DSM-IV Disorders; **SD** = standard deviation; **SES** = socioeconomic status.

INTRODUCTION

Obesity is a major public health problem in the United States (1). The prevalence of obesity continues to increase in many segments of the US population, including children and adolescents (2). Obesity is associated with many health consequences in adulthood (3). For youth, the most immediate consequences are thought to be psychosocial (4),

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but whether adolescent overweight increases the risk for psychological disorders remains poorly understood.

Obese individuals, particularly youth, are often stigmatized in western societies (5–7). As a result of this bias and prejudice, it has been hypothesized that obese children and adolescents are at increased risk for poor body image, low self-esteem, and psychological disorders, especially depression. Although many cross-sectional studies have assessed associations between psychosocial correlates, psychological disorders, and weight status, findings have been inconsistent (8), and associations seen cross-sectionally cannot distinguish whether obesity is a consequence of, a contributor to, or a correlate of psychological disorders. Few prospective studies have evaluated whether obesity increases the risk for subsequent depression or anxiety disorders.

Adolescence is an important developmental period in which to study these associations because it represents a life stage during which concerns about appearance and peer approval are central (9). Obese adolescents are more likely to be teased, to have higher levels of body dissatisfaction (10), and to diet (11); negative self-appraisal and depressive symptoms may be linked with these factors (12).

The objective of the current study was to investigate, in a community-based prospective cohort, the association of adolescent obesity with risk for subsequent major depressive disorder (MDD) or anxiety disorder assessed using structured diagnostic interviews for Diagnostic and Statistical Manual of Mental Disorders (DSM). We hypothesized that adolescent obesity would affect the risk for MDD or anxiety disorder differently in males and females. We also hypothesized that, because weight concerns are more common in adolescent females than males (13), obesity in females would be more likely to increase their risk for MDD and anxiety disorder.

METHODS

Study Population

The Children in the Community Study (CIC) is a prospective cohort study of determinants and correlates of psychological health. CIC design and

PSYCHOLOGICAL CONSEQUENCES OF ADOLESCENT OBESITY

operations have been described previously (14,15). The cohort is based on a 1975 random sample of 976 families (with a 1- to 10-year-old child) residing in Upstate, New York. When follow-up began in 1983, 85% of the original respondents were located; of these, almost 90% were reinterviewed. Young, poor, urban families were disproportionately represented among those not reinterviewed; therefore, in 1983, the sample was supplemented by the addition of 54 new families from urban poverty neighborhoods. Including these new families, the sample was demographically representative of the area in 1983: 25% rural or small town, 21% poverty, and 25% upper middle class. The race/ethnicity of participants is representative of the region at the time (91% white and 8% black). In total, 820 participants were assessed during four assessment waves between 1983 (participants were 9–18 years) and 2003 (participants were 28–39 years). Wave 1 ($n = 776$) took place in 1983; wave 2 ($n = 775$) in 1985 to 1986; wave 3 ($n = 776$) in 1991 to 1994; and wave 4 ($n = 661$) in 2001 to 2003. Participant retention has been good (95% at waves 1–3, and 80% at wave 4); those not interviewed at wave 4 were more likely to be male. In-home interviews were conducted by extensively trained and supervised lay interviewers, with mothers and participants at wave 1 and wave 2, and with participants at wave 3 and wave 4. Written informed consent (or assent for children) was obtained at each wave. The Institutional Review Boards of the New York State Psychiatric Institute and the Tufts-New England Medical Center approved this study.

Assessment of Depression and Anxiety Disorders

MDD and anxiety disorders were assessed at each wave using structured diagnostic interviews for DSM disorders. The Diagnostic Interview Schedule for Children (DISC) (16) was administered, separately, to the participant and the participant's mother at wave 1 and wave 2. Respondents provided unique, nonoverlapping information (17), and in accordance with current practice, disorders were identified if DSM-III criteria reported by either informant met the minimum needed for diagnosis; to optimize the specificity of anxiety diagnoses, evidence of impairment was required and was defined as a combined symptom severity score of at least 1 standard deviation (SD) above the mean symptom level of the cohort at that assessment (18). At wave 3, the DISC, with minor adjustments for age appropriateness and DSM revisions, was administered to participants (14). At wave 4, disorders were assessed using the Structured Clinical Interview for DSM-IV Disorders (SCID-IV). The DISC and SCID-IV assessed symptoms consistent with a DSM disorder at any point during the year leading up to the interview. Additionally, during the wave 2 assessment, disorders were identified if they occurred at any point during the approximately 2-year period between wave 1 and wave 2.

MDD was assessed consistently, based on DSM criteria, at all waves. We categorized anxiety disorders as follows: at wave 1 and wave 2, social phobia, or overanxious disorder; at wave 3 and wave 4, social phobia, generalized anxiety disorder, obsessive-compulsive disorder, panic disorder, or agoraphobia. Separation anxiety was assessed at wave 1 and wave 2, but we did not classify an individual as having an anxiety disorder if separation anxiety was their only anxiety diagnosis because separation anxiety typically resolves before adulthood and is not generally diagnosed in adults (19). Thus, individuals with separation anxiety were considered at risk for subsequent development of an anxiety disorder. We are interested in the association of adolescent overweight and subsequent depression and anxiety disorders; therefore, we excluded from analyses individuals who, at their initial assessment, were observed with depression or an anxiety disorder. We chose to look at MDD and anxiety disorders as psychological consequences because depression is often cited as a health consequence of obesity (1). Previously, in this cohort, we studied the influence of childhood MDD and anxiety disorders on relative weight trajectory through adulthood (20).

Definition of Adolescent Weight Status

We focused on weight status during adolescence (age 12–17.99 years) as a risk factor for development of MDD or anxiety disorder. We assessed 746 individuals (91%) one or more times during adolescence; of these, 50% were adolescents at two waves and we defined their adolescent weight status as the higher of the two waves.

Weight and height of the participant were reported by the participant's mother (at wave 1) and by the participant at all subsequent waves. Following the recommended practice for assessment of weight status in youth (21,22), we used age- and gender-specific body mass index (BMI) z scores calculated relative to Centers for Disease Control and Prevention (CDC) gender-specific, BMI-for-age national reference data (23). Adolescent obesity is defined as a BMI z score ≥ 95 th percentile; overweight as a BMI z score ≥ 85 th percentile and < 95 th percentile; and nonoverweight as a BMI z score < 85 th percentile. BMI is a standard measure of weight adjusted for height that is calculated as (weight (kg)/(height (m)²).

We hypothesize a relative weight threshold, above which obesity may increase the risk for psychological disorders; therefore, in our primary analyses, we have categorized adolescent weight status based on BMI z score thresholds of the 85th and 95th percentiles of the CDC BMI-for-age reference. These cut-points are recommended for use in clinical practice (21); they are well established in the pediatric obesity research literature; and they have been linked with physical health, social, and economic consequences (4,24). In additional analyses, we have treated adolescent BMI z score as a continuous variable in nonlinear models.

Covariates

We controlled for the following variables that were considered potential confounders due to their association both with weight and depression or anxiety disorders. Socioeconomic status (SES) was assessed as an index of family occupational status (highest of father's or mother's classified by Duncan's 1961 system) (25), family income (eight ordered categories standardized and expressed as a z score), and average parental years of education (expressed as a z score). All families were assessed at a mean participant age of 16 years, and a standardized index of SES (mean = 10, SD = 1) was created because evidence suggests that such a measure is more reflective of the influence of SES than any of the single components (26). The participant's race/ethnicity was reported by the parent at the initial interview and was categorized as white or nonwhite. At each wave, we assessed smoking status by self-report and categorized individuals as current smokers or nonsmokers; we categorized individuals as ever-smokers if they reported smoking at any wave.

Parental psychopathology is well established as a risk factor for offspring psychopathology (27) and could be a confounder of associations between adolescent weight and subsequent psychological disorders if parental psychopathology affected development of obesity, and adolescent obesity did not directly increase risk for MDD or anxiety disorder (for example, as a consequence of weight stigma). At wave 1, mothers reported whether they or the child's father had had serious emotional problems between 1975 and 1983. Parental emotional problems were indicated if either parent reported serious emotional problems.

Statistical Analysis

Participants were included in the analyses if they were not missing data on adolescent weight status and were assessed at one or more subsequent waves. We examined descriptive characteristics for males and females overall and by adolescent weight status category. We compared differences in mean values with 2-sided *t* tests, and differences in proportions with Fisher's Exact Test. Cox proportional hazards analyses, with age as the metric of time, were used to calculate hazard ratios (HRs) and 95% confidence intervals for the influence of adolescent obesity and overweight on subsequent MDD or anxiety disorder. HRs can be interpreted as relative risks (28). Multivariate Cox regression models were adjusted for SES, race/ethnicity, and smoking status. We also explored models that adjusted for parental emotional problems. Separate models were conducted for the outcomes of MDD, anxiety disorder (with and without comorbid MDD), and a combined MDD or anxiety disorder outcome variable (outcome deemed present if either MDD or anxiety disorder was indicated). Analyses were stratified by gender a priori because we hypothesized that the psychological consequences of adolescent obesity would differ by gender.

We also conducted analyses in which adolescent BMI z score was treated as a continuous predictor variable; we modeled BMI z score with a linear and quadratic term to allow for a nonlinear association between adolescent BMI z score and subsequent psychological disorder. We conducted sensitivity

analyses to determine whether our analyses were sensitive to the age range used to define adolescence, or the BMI z score cut-points used to define weight status categories. Analyses were performed using SAS v8.1 (SAS Institute, Inc., Cary, North Carolina).

RESULTS

Analyses included 701 individuals (351 females, 350 males) who were not missing adolescent weight status and were assessed at ≥ 1 subsequent waves. We found 4% of females and 9% of males were obese, and 15% of females and 16% of males were overweight in adolescence (Table 1). The average age of participants was 14.7 years at assessment of adolescent weight status. Adolescent weight status was defined as wave 1 for 71% of females and 61% of males, wave 2 for 24% of females and 34%

of males, and wave 3 for 5% of females and 5% of males. At their initial assessment, 19 females and 8 males were assessed with MDD and thus were excluded from analyses of adolescent weight status and risk for subsequent MDD. For anxiety disorder analyses, 88 females and 54 males with anxiety disorder at initial assessment were excluded.

Adolescent Weight Status and Risk for MDD

Of 332 females with no evidence of current or prior MDD at assessment of adolescent weight status, 68 (20%) were subsequently identified with MDD; for 84% of these females, the first observed onset of MDD was at wave 3 or wave 4. Of 342 males included in MDD analyses, 32 (9%) were subse-

TABLE 1. Demographic Characteristics, Adolescent Weight Status, and Psychological Disorders of Females and Males in the Children in the Community Study by Analysis Inclusion

	Females			Males		
	Full Analytic Sample ^a	Included in MDD Analyses	Included in Anxiety Disorder Analyses	Full Analytic Sample ^a	Included in MDD Analyses	Included in Anxiety Disorder Analyses
<i>n</i>	351	332	263	350	342	296
Obese in adolescence ^b , <i>n</i> (%)	13 (4%)	10 (3%)	8 (3%)	32 (9%)	32 (9%)	24 (8%)
Overweight in adolescence, <i>n</i> (%)	54 (15%)	52 (16%)	33 (12%)	55 (16%)	55 (16%)	48 (16%)
Age at adolescent weight status, mean \pm SD, years	14.7 \pm 1.8	14.7 \pm 1.8	14.7 \pm 1.8	14.6 \pm 1.8	14.6 \pm 1.8	14.7 \pm 1.8
Wave of adolescent weight status						
Wave 1 (%)	71	71	75	61	61	64
Wave 2 (%)	24	24	21	34	34	31
Wave 3 (%)	5	5	4	5	5	5
Race/ethnicity, nonwhite, %	9	9	9	9	9	9
Ever-smoker, %	53	52	52	53	53	54
SES, mean \pm SD	10.0 \pm 1.0	10.0 \pm 1.0	10.0 \pm 1.0	10.0 \pm 1.0	10.0 \pm 1.0	10.1 \pm 1.0
Parental emotional problems (1975 to 1983), %	16	16	15	11	11	10
Initial ^c MDD, <i>n</i> (%)	19 (5%)	0	11 (4%)	8 (2%)	0	5 (2%)
Initial ^c anxiety disorder, <i>n</i> (%)	88 (25%)	78 (23%)	0	54 (15%)	52 (15%)	0
Initial ^c MDD comorbid with anxiety, <i>n</i> (%)	8 (2%)	0	0	3 (1%)	0	0
Subsequent ^d MDD, <i>n</i>	68	68	39	32	32	22
Onset wave 2, <i>n</i> (%)		11 (16%)			3 (9%)	
Onset wave 3, <i>n</i> (%)		27 (40%)			13 (41%)	
Onset wave 4, <i>n</i> (%)		30 (44%)			16 (50%)	
Subsequent ^d anxiety disorder, <i>n</i>	71	63	71	36	34	36
Onset wave 2, <i>n</i> (%)			26 (37%)			15 (42%)
Onset wave 3, <i>n</i> (%)			27 (38%)			12 (33%)
Onset wave 4, <i>n</i> (%)			18 (25%)			9 (25%)

MDD = major depressive disorder; SD = standard deviation; SES = socioeconomic status (index of family income, parental education and occupation).

^a Inclusion criteria = not missing adolescent weight status and having at least one follow-up observation.

^b Adolescence defined as age 12–17 years at last birthday.

^c Disorder identified at same wave as adolescent weight status or at a prior wave. Initial cases of MDD were excluded from MDD analyses; initial cases of anxiety disorder were excluded from anxiety disorder analyses.

^d Disorder first identified at a wave after assessment of adolescent weight status.

PSYCHOLOGICAL CONSEQUENCES OF ADOLESCENT OBESITY

quently identified with MDD (Table 1). Compared with nonoverweight adolescents, females who were overweight as adolescents had lower SES ($p < .05$), but were not statistically significantly different in age, race/ethnicity, smoking status, or history of parental emotional problems (Table 2). Obese adolescent females had lower SES compared with nonoverweight females and were more likely to be of nonwhite race/ethnicity; these results were of borderline ($p < .1$) statistical significance (Table 2). Obese adolescent males were on average younger than nonoverweight males, had lower SES, and were more likely to be of nonwhite race/ethnicity (Table 2).

In age-adjusted Cox regression analyses, females who were obese in adolescence were almost three times as likely as nonoverweight females to be identified with subsequent MDD; multivariate-adjustment for SES, race/ethnicity, and smoking status strengthened this association (Table 3). Females who were overweight in adolescence were not at increased risk for subsequent MDD. In males, weight status was not statistically significantly associated with risk for MDD (Table 3). Adjustment for parental emotional problems—in addition to SES, race/ethnicity, and smoking—attenuated the association between female adolescent obesity and subsequent depression; the HR remained statistically significant (HR =

3.2; $p = .036$; 95% CI = 1.1–9.5). When adolescent BMI z score was modeled as a continuous nonlinear predictor of MDD in models adjusted for SES, race/ethnicity, and smoking status, the results were consistent with those that modeled obesity as a categorical variable. As expected, the nonlinear BMI z score quadratic term was statistically significant (HR = 1.3; $p = .015$; 95% CI = 1.1–1.6), and the linear term was not statistically significant (HR = 1.0; $p = .88$; 95% CI = 0.8–1.3). Based on this model, an adolescent girl with a BMI z score at the 97th percentile (z-score = 1.88) would be 2.5 times as likely as an adolescent girl with a BMI z score at the 50th percentile (z-score = 0) to develop MDD. Additional adjustment for parental psychopathology did not change these results.

Adolescent Weight Status and Risk for Anxiety Disorders

Of 263 females with no evidence of current or prior anxiety disorder at assessment of adolescent weight status, 71 were subsequently identified with an anxiety disorder; for 63% of these females, the first observed onset of anxiety disorder was at wave 3 or wave 4 (Table 1). Of 296 males included in anxiety disorder analyses, 36 were subsequently identified

TABLE 2. Descriptive Characteristics in Adolescence of Children in the Community Study Participants Included in Analyses for Major Depressive Disorder or Anxiety Disorder by Gender and Adolescent Weight Status Category

Adolescent ^a Weight Status ^b	Females			Males		
	Nonoverweight	Overweight	Obese	Nonoverweight	Overweight	Obese
Major depressive disorder analyses,^c						
<i>n</i> (%)	270 (81%)	52 (16%)	10 (3%)	255 (75%)	55 (16%)	32 (9%)
Age, mean ± SD (years)	14.8 ± 1.8	14.3 ± 1.8	15.3 ± 1.9	14.7 ± 1.8	14.6 ± 1.8	13.9 ± 1.7**
Age, range (years)	12.0–18.0	12.1–18.0	12.3–17.5	12.0–18.0	12.0–17.8	12.3–18.0
BMI z score, mean ± SD	−0.1 ± 0.7	1.3 ± 0.2**	1.9 ± 0.2**	0.0 ± 0.9	1.3 ± 0.2**	2.1 ± 0.3**
SES, mean ± SD	10.0 ± 1.0	9.7 ± 1.0**	9.5 ± 1.1*	10.1 ± 1.0	10.1 ± 1.0	9.4 ± 1.0**
Nonwhite race/ethnicity, <i>n</i> (%)	23 (9%)	5 (10%)	3 (30%)*	17 (7%)	7 (13%)	6 (19%)**
Ever-smoker, <i>n</i> (%)	140 (52%)	28 (54%)	4 (40%)	135 (53%)	27 (49%)	19 (59%)
Parental emotional problems, <i>n</i> (%)	39 (14%)	10 (19%)	3 (30%)	28 (11%)	4 (7%)	5 (16%)
Anxiety disorder analyses,^d						
<i>n</i> (%)	222 (84)	33 (12)	8 (3)	224 (76)	48 (16)	24 (8)
Age, mean ± SD (years)	14.8 ± 1.8	14.4 ± 1.9	15.0 ± 2.0	14.8 ± 1.8	14.6 ± 1.8	14.3 ± 1.8
Age, range (years)	12.0–18.0	12.1–18.0	12.3–17.5	12.0–18.0	12.0–17.8	12.3–18.0
BMI z score, mean ± SD	−0.1 ± 0.7	1.3 ± 0.2**	2.0 ± 0.2**	0.0 ± 0.8	1.3 ± 0.2**	2.0 ± 0.3**
SES, mean ± SD	10.1 ± 1.0	9.7 ± 1.1**	9.5 ± 1.2	10.1 ± 1.0	10.0 ± 1.1	9.6 ± 0.9**
Nonwhite race/ethnicity, <i>n</i> (%)	15 (7)	4 (12)	3 (38)**	16 (7)	6 (13)	5 (21)**
Ever-smoker, <i>n</i> (%)	115 (52)	17 (52)	5 (63)	119 (53)	27 (56)	12 (50)
Parental emotional problems, <i>n</i> (%)	28 (13)	7 (21)	3 (38)*	21 (9)	4 (8)	3 (13)

Nonoverweight = BMI z score <85th percentile; overweight = BMI z score ≥85th and <95th percentile; obese = BMI z score ≥95th percentile; SD = standard deviation; SES = socioeconomic status (index of family income, parental education and occupation).

^a Adolescence defined as age 12–17 years at last birthday.

^b Body mass index (BMI) z scores based on Centers for Disease Control and Prevention BMI-for-age reference.

^c Females, *N* = 332; males, *N* = 342.

^d Females, *N* = 263; males, *N* = 296.

* $p < .1$; ** $p < 0.5$ comparison to nonoverweight.

TABLE 3. Age- and Multivariate-Adjusted Cox Proportional Hazard Models: Adolescent Weight Status and Risk for Major Depressive Disorder and/or Anxiety Disorder by Gender in the Children in the Community Study (1983–2003)

Adolescent ^a Weight Status ^b	Females				Males			
	<i>n</i>	<i>n</i> Cases	Age-Adjusted Analysis, HR (95% CI)	Multivariate ^c Analysis, HR (95% CI)	<i>n</i>	<i>n</i> Cases	Age-Adjusted Analysis, HR (95% CI)	Multivariate ^c Analysis, HR (95% CI)
Major depressive disorder								
Nonoverweight ^d	270	54	1	1	255	22	1	1
Overweight	52	10	0.9 (0.5–1.8)	0.9 (0.5–1.8)	55	5	0.9 (0.3–2.4)	0.9 (0.3–2.4)
Obesity	10	4	2.8 (1.0–7.8)	3.9 (1.3–11.8)	32	5	1.5 (0.6–4.0)	1.3 (0.5–3.5)
Anxiety disorder								
Nonoverweight	222	58	1	1	224	29	1	1
Overweight	33	9	0.9 (0.4–1.9)	0.9 (0.4–1.8)	48	5	0.8 (0.3–2.0)	0.8 (0.3–2.0)
Obesity	8	4	2.4 (0.9–6.7)	3.8 (1.3–11.3)	24	2	0.6 (0.2–2.7)	0.7 (0.2–2.9)
Anxiety disorder (excluding comorbid MDD)								
Nonoverweight	184	39	1	1	205	22	1	1
Overweight	26	7	1.1 (0.5–2.6)	1.2 (0.5–2.8)	46	4	0.8 (0.3–2.4)	0.8 (0.3–2.5)
Obesity	5	2	2.1 (0.5–8.9)	6.0 (1.1–32.3)	22	1	0.4 (0.1–3.3)	0.5 (0.1–3.7)
Either MDD or anxiety disorder								
Nonoverweight	213	68	1	1	220	37	1	1
Overweight	32	13	1.2 (0.7–2.3)	1.3 (0.7–2.3)	47	5	0.6 (0.2–1.4)	0.6 (0.2–1.5)
Obesity	7	4	2.3 (0.9–6.5)	4.8 (1.6–14.4)	24	3	0.8 (0.2–2.4)	0.7 (0.2–2.5)

HR = hazard ratio; CI = confidence interval; MDD = major depressive disorder.

^a Adolescent defined as age 12–17 years at last birthday.

^b Body mass index (BMI) z scores based on Centers for Disease Control and Prevention BMI-for-age reference. Nonoverweight = BMI z-score <85th percentile; overweight = BMI z score ≥85th and <95th percentile; obesity = BMI z score ≥95th percentile.

^c Adjusted for socioeconomic status, race (white, nonwhite), smoking status (never, ever).

^d Nonoverweight = reference category.

with an anxiety disorder (Table 1). Compared with nonoverweight adolescents, females who were overweight as adolescents had on average lower SES ($p < .05$), but were not statistically significantly different in age, race/ethnicity, smoking status, or history of parental emotional problems (Table 2). Obese adolescent females compared with nonoverweight females were more likely to be of nonwhite race/ethnicity, and were more likely to have a parent with reported emotional problems (this latter result was of borderline statistical significance, $p < .1$). Obese adolescent males had lower SES, and were more likely to be of nonwhite race/ethnicity than nonoverweight males (Table 2).

In Cox regression analyses adjusted for age, SES, race/ethnicity, and smoking, females who were obese as adolescents were almost four times as likely as nonoverweight females to be identified with a subsequent anxiety disorder (Table 3). In males, weight status was not statistically significantly associated with risk for anxiety disorder. When we excluded individuals (48 females, 23 males) with comorbid MDD from models predicting anxiety disorders, the pattern of results was generally unchanged; the point estimate of the HR for females was strengthened and remained statistically significant, although with a wide confidence interval (Table 3). Adjustment for parental emotional problems in addition to SES, race/ethnicity, and smoking status attenuated the association between female adolescent obesity and subsequent anxiety disorder in multivariate models; the HR remained

statistically significant (HR = 3.2; $p = .049$; 95% CI = 1.0–9.9). When adolescent BMI z score was modeled as a continuous nonlinear predictor of anxiety disorders in models adjusted for SES, race/ethnicity, and smoking status, the results were consistent with those that modeled obesity as a categorical variable. The nonlinear BMI z score quadratic term for females was statistically significant (HR = 1.3; $p = .01$; 95% CI = 1.1–1.6), and the linear term was not statistically significant (HR = 1.0; $p = .73$; 95% CI = 0.8–1.3). Based on this model, an adolescent girl with a BMI z score at the 97th percentile (z -score = 1.88) would be 2.5 times as likely as an adolescent girl with a BMI z score at the 50th percentile (z score = 0) to develop an anxiety disorder. Additional adjustment for parental psychopathology did not change these results.

Adolescent Weight Status and Risk for Either MDD or Anxiety Disorders

In analyses where we considered diagnosis of MDD or an anxiety disorder as the outcome, 252 females and 291 males were included; 85 cases of MDD or anxiety disorder in females and 45 in males were subsequently identified (Table 3). Female adolescent obesity was associated with increased risk for subsequent MDD or anxiety disorder (Table 3). As in previous models, neither male adolescent obesity nor overweight in either gender was statistically significantly associated with disorder risk.

PSYCHOLOGICAL CONSEQUENCES OF ADOLESCENT OBESITY

Sensitivity Analyses

To assess the degree to which our results were sensitive to our definition of adolescence as 12 to 17 years (age at last birthday), we conducted analyses in which adolescence was defined as 11 to 17, 11 to 18, 12 to 18, 13 to 18, and 13 to 19 years; our results were not substantively changed. We also investigated whether our results were sensitive to the BMI z score cut-point used to define "obesity"; we systematically increased the BMI z score cut-point for "obesity" to the 97th percentile and then reduced it to the 90th percentile. The higher the threshold used to define "obesity," the greater the hazard ratio for the association of adolescent "obesity" to risk for MDD in females; above the 92nd percentile, the estimate was statistically significant (results not shown). We also explored lowering the BMI z score threshold for "overweight" to the 75th percentile; this did not affect our results.

DISCUSSION

Obesity and depression are each complex multifactorial conditions that often have roots in childhood, and are influenced by genetics as well as family, social, and environmental context (29). Depression is frequently listed as a health consequence of obesity but empirical evidence from prospective studies is sparse. In this report, we present results from prospective analyses of a community-based cohort followed-up over two decades. Our findings suggest that adolescent obesity among females is associated with an increased risk for MDD and anxiety disorders. Obese adolescent girls were estimated to be at almost four times the risk for subsequent development of MDD or anxiety disorder compared with nonoverweight adolescent girls. For males, our results indicate that adolescent obesity is unlikely to be associated with an increased risk for subsequent MDD or anxiety disorder.

That females would be more vulnerable to psychological consequences of obesity may not be surprising, given the relatively greater social pressure for, and importance to self-concept of, thinness for girls and women in Western society (30). Adolescent females at any weight tend to have greater body dissatisfaction and to rate their body image lower than do adolescent males (13).

Previous prospective studies of obesity and risk for depression or anxiety disorders have shown inconsistent findings, and direct comparison is difficult because of differences in assessment of psychological disorders, obesity definition, and age-range studied. Consistent with our results, but among men and women >50 years, obesity was associated with twice the risk for MDD after 5 years of follow-up (31). In a Finnish cohort, high BMI at age 14 years was associated with depressive symptoms at age 31 years, but not with antidepressant use or depression diagnosis (32). In contrast to our results, but in a study without long-term follow-up, boys, but not girls, who were chronically obese from age 9 to 16 years were more likely to also have had MDD over that time period (33). In the National Longitudinal Study of Adolescent Health (Add Health), adolescent obesity was not predictive of depression 1

year later (34), but associations may not be evident over such a short follow-up period.

Our objective in these analyses was to investigate the psychological consequences of adolescent obesity. Parental psychopathology is known to increase the risk for psychological disorders in youth, and some cross-sectional studies of treatment-seeking obese youth have found that parental psychopathology explains much of the variability in observed child psychological problems (35,36). Parental psychopathology may be associated with offspring obesity through maladaptive parenting behavior or neglect (36–39). We were able to control for the presence of severe parental emotional problems; these data were collected in 1983 and covered a recall period of 1975 to 1983 (a time period preceding assessment of adolescent weight status); thus, these parental emotional problems are unlikely to be a reaction to the adolescent's weight status. Adjustment for parental emotional problems attenuated our results slightly.

The literature on obesity and psychological disorders contains many cross-sectional and clinical studies (40), but prospective studies are critical to understanding the interrelationships between obesity and development of depression and other psychological disorders. There is evidence of a bidirectional association between these conditions. Obesity may increase the risk for MDD and anxiety disorders, and depression has been observed to increase the risk for obesity (34,41,42). In previous analyses, in this cohort, we found that for females, MDD in childhood or adolescence predicted higher relative weight in adulthood and a more steeply rising relative weight trajectory; anxiety disorders were also associated with higher relative weight in females (20). These results suggest that MDD and anxiety disorders may operate both as antecedents and as consequences of overweight in females. Further research is needed to elucidate the mechanisms linking obesity and psychological disorders in adolescent females, and to determine familial, psychological, and social factors that help to buffer obese adolescents from the negative effects of weight stigma.

Strengths of the current study include analysis of a community-based cohort observed at four time points over a 20-year period. Study of a community-based cohort rather than a clinical sample seeking treatment either for obesity or psychological disorders is expected to increase the generalizability of findings, as it has been demonstrated that individuals seeking treatment differ in important ways from individuals with the same condition who do not seek treatment (43). A further strength of our analyses is assessment of MDD and anxiety disorders using structured diagnostic interviews consistent with DSM criteria. In addition, we excluded from analyses individuals with a history of MDD or anxiety disorder before adolescence, and controlled for the effects of SES, race/ethnicity, smoking status, and parental emotional problems.

Several limitations of our analyses are noteworthy. First, we modeled the risk for development of MDD or anxiety disorder in individuals initially free of the disorder, but be-

cause there are gaps in our assessment of psychological disorders, it is possible that some individuals were misclassified as free of the disorder in adolescence and thus at risk for MDD or anxiety disorder. Some instances of MDD or anxiety disorder may not have been identified; for example, if a disorder began after wave 3 and remitted before wave 4, or, in the case of acute or posttraumatic stress disorders, which were not assessed.

Second, height and weight were reported (by participants and mothers during face-to-face interviews) rather than measured; numerous studies of reported height and weight in adults and adolescents have documented that reported weight is slightly lower and reported height is slightly higher than measured (44,45). This systematic bias results in underestimation of obesity prevalence when relative weight is categorized based on BMI (46,47). In the Third National Health and Nutrition Examination Survey, obesity status was correctly classified based on reported height and weight for 94% of 12- to 16-year-old individuals studied (44), and obesity status was also correctly classified for 96% of 7th to 12th graders studied in Add Health (47). Some degree of misclassification of adolescent weight status is to be expected, but our results are likely to be conservative because such misclassification would tend to dampen estimates. For this misclassification to bias our results, the likelihood of future MDD or anxiety disorder would need to be associated with likelihood of error in classification of adolescent weight status; although this is possible, it would not be expected.

Third, 4% of females were classified as obese in adolescence; thus, confirmation of our results in a cohort containing a greater number of obese adolescent females will be important and will allow for greater precision in estimates of risk. The prevalence of obesity observed in adolescent females in our cohort is similar to national estimates from that time. As a comparison, national surveys that preceded and followed the time period of adolescence in this cohort indicated that 4.2% of female adolescents (12–17 years) in the US were obese in 1976 to 1980, and 9.4% were obese in 1988 to 1994 (48). Latest estimates (2003–2004) indicated that 16.4% of adolescent girls were obese (2). The psychological consequences of obesity for today's adolescent girls are unknown, but understanding these associations will be critical, given that more adolescents are obese today than previously.

Fourth, although we controlled for SES, race/ethnicity, smoking status, and parental emotional problems, it is possible that our results are biased by residual confounding due to imperfect measurement of these variables or the lack of measurement of other confounders. Our measure of parental emotional problems was not a diagnostic assessment and the age range over which it was assessed varied between children. Further research is needed to elucidate what are likely to be complex and dynamic interactions between parental psychopathology, adolescent weight status, and subsequent depression or anxiety disorder.

Finally, we studied a community-based sample of individuals from upstate New York. The racial/ethnic variability in

this cohort was limited and did not allow us to study whether associations differed by race/ethnicity. Thus, it will be important to confirm our findings in a diverse and large sample that would allow for stratified analyses.

CONCLUSION

Adolescent obesity may increase the risk for subsequent MDD or anxiety disorders, but these psychological consequences seem to be limited to females with very high relative weights in adolescence. Health professionals, educators, parents, and other adults in contact with adolescents should be aware of the potential psychological consequences of obesity.

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PSYCHOLOGICAL CONSEQUENCES OF ADOLESCENT OBESITY

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