Association of Depression and Anxiety Disorders With Weight Change in a Prospective Community-Based Study of Children Followed Up Into Adulthood

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**Objective:** To investigate childhood to adulthood weight change associated with anxiety and depression.

**Design:** The Children in the Community Study. A prospective longitudinal investigation.

**Setting:** Albany and Saratoga Counties, New York.

**Participants:** Eight hundred twenty individuals (403 females and 417 males) assessed at 4 time points: in 1983 when they were 9 to 18 years old (n=776), in 1985 to 1986 when they were 11 to 22 years old (n=775), in 1991 to 1994 when they were 17 to 28 years old (n=776), and in 2001 to 2003 when they were 28 to 40 years old (n=661).

**Main Exposures:** Anxiety disorders and depression assessed by structured diagnostic interview.

**Main Outcome Measures:** Centers for Disease Control and Prevention body mass index z score (BMIz), a measure of weight status; and association of anxiety and depression with BMIz level and annual change.

**Results:** In females, anxiety disorders were associated with higher weight status, a BMIz of 0.13 (95% confidence interval, 0.01-0.25) units higher compared with females without anxiety disorders. Female depression was associated with a gain in BMIz of 0.09 units/y (95% confidence interval, 0.03-0.15 units/y), modified by the age when depression first observed, such that early depression onset was associated with a higher subsequent BMIz than depression onset at older ages. In males, childhood depression was associated with a lower BMIz (~0.46; 95% confidence interval, ~0.93 to 0.02 units lower at the age of 9 years), but BMIz trajectories for males with or without depression converged in adulthood; male anxiety disorders were not substantively associated with weight status.

**Conclusions:** Anxiety disorders and depression were associated with a higher BMIz in females, whereas these disorders in males were not associated with a higher BMIz. These results, if causal and confirmed in other prospective studies, support treating female anxiety and depression as part of comprehensive obesity prevention efforts.


The prevalence of obesity among US children, adolescents, and adults represents a public health crisis. Obesity often has roots early in life, and if present in adolescence is likely to persist into adulthood. Understanding the predictive factors associated with weight gain is important for obesity prevention; obesity treatment will be most effective when targeted, and informed by understanding of etiologic pathways and correlates.

Evidence suggests that a child's social and psychological environment contributes to obesity risk. Psychosocial difficulty during childhood is associated with increased risk for adult obesity, and with rapid weight gain in children. Physical or verbal abuse, and parental neglect, are associated with a higher obesity risk, as is poor quality of a child's home environment. Thus, childhood adversity can increase risk for later obesity; these associations may be mediated by negative psychological symptoms.

That psychopathological dysfunction and obesity are associated has long been hypothesized, but studies have yielded conflicting results. Some cross-sectional population-based studies show associations between poorer psychological functioning and obesity, while others do not. Similar variability exists among studies conducted of pediatric populations. Evidence from the few prospective studies conducted suggests that psychological disorders are associated with weight gain. Limitations of these studies include having observations at only 2 time points, relatively short periods of follow-up, and clinical rather than population-based samples.

Our objectives were to evaluate the association of anxiety disorders and major depressive disorder (depression), defined based on Diagnostic and Statistical
Manual of Mental Disorders (DSM) diagnostic criteria, with weight trajectory in a community-based cohort of children followed up into adulthood.

STUDY POPULATION

The Children in the Community Study is a prospective cohort study of determinants and correlates of psychological health. In these analyses, we have examined the influence of depression and anxiety disorders on childhood to adulthood weight trajectory. Children in the Community Study design and operations have been described previously. Briefly, 976 families with children born between 1965 and 1974, residing in Albany and Saratoga Counties in Upstate New York, were sampled in 1973. The sample was demographically representative of the area, and was primarily of white race/ethnicity (91.5%). Participants were assessed in 1983 (wave 1, n=776) when they were 9 to 18 years old, in 1985 to 1986 (wave 2, n=775) when they were 11 to 22 years old, in 1991 to 1994 (wave 3, n=776) when they were 17 to 28 years old, and in 2001 to 2003 (wave 4, n=661) when they were 28 to 40 years old. Trained interviewers conducted in-home interviews with participants at waves 1 to 4, and a parent (usually the mother) at waves 1 to 3. Informed consent (or assent for children) was obtained at each wave. The institutional review boards of the New York State Psychiatric Institute and Tufts–New England Medical Center, Boston, approved this study.

Eight hundred twenty individuals (403 females and 417 males) were 20 years or older, as have others.42 Because BMI is not a good measure of weight status comparable across waves because it increases with age, independent of adiposity, during childhood. Instead, in children, it is recommended that weight status be determined relative to age- and sex-specific reference data. Therefore, we used the Centers for Disease Control and Prevention BMI-for-age reference data, which are available for children and adolescents aged 2 to 20 years, to calculate a BMI z score (BMIz) for each participant at each wave. The BMIz scores correspond with growth chart percentiles and allow for tracking a child’s relative weight through childhood and adolescence. A BMIz of 0 equals the 50th percentile; 1.04, the 85th percentile; and 1.65, the 95th percentile. To provide continuity from childhood to adulthood, we used the age 20 reference to calculate BMIz when individuals were 20 years or older, as have others. Because BMIz is a continuous measure of relative weight adjusted for age and sex, we were able to assess the association of depression and anxiety disorders on weight trajectory over an age range spanning childhood, adolescence, and adulthood.

MAIN EXPOSURES

Depression and anxiety disorders were assessed using structured diagnostic interviews for DSM disorders. The Diagnostic Interview Schedule for Children97 was administered, separately, to a parent and the participant at waves 1 and 2. Parents and children provide unique nonoverlapping information, and in accordance with current practice, disorders were identified if either reported a minimum number of items meeting DSM-III criteria and the combined parent-child symptom score was at least 1 SD above the mean. At wave 3, the Diagnostic Interview Schedule for Children, with minor adjustments made for age appropriateness and comparability across DSM revisions, was administered to participants. At wave 4, disorders were assessed using the Structured Clinical Interview for DSM-IV. The Diagnostic Interview Schedule for Children and the Structured Clinical Interview for DSM-IV assessed whether an individual had symptoms consistent with a DSM disorder at any point during the year leading up to the interview. In addition, during the wave 2 assessment, disorders were identified if they occurred at any point between waves 1 and 2.

For each participant, we determined if the participant was observed to have met the diagnostic criteria for an anxiety disorder or depression at any of the 4 interviews. If the diagnostic criteria were met, the age of the participant at the interview during which the disorder was first identified was designated as the age of observed onset. For example, if a participant did not meet the diagnostic criteria for depression at wave 1 or 2, and did meet the diagnostic criteria for depression at wave 3, we defined the age we first observed depression in this individual as his or her age at wave 3.

The specific disorders that could be considered “anxiety” were not identical across waves. We defined anxiety as follows: at waves 1 and 2, separation anxiety, social phobia, or overanxious disorder; and at waves 3 and 4 (when participants were adults), social phobia, generalized anxiety disorder, obsessive-compulsive disorder, panic disorder, or agoraphobia.

Depression is often accompanied by symptoms of anxiety, some of which may be severe enough to meet the diagnostic criteria for an anxiety disorder. Thus, we do not attempt to separate depression from comorbid anxiety.

MAIN OUTCOMES

Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters, from height and weight reported at each wave. At wave 1, a parent reported the participant’s height and weight. At wave 2, a parent and the participant reported the participant’s height and weight. At waves 3 and 4, participants self-reported their height and weight. Agreement between participant- and parent-reported height and weight at wave 2 was high (intraclass correlation coefficient for height, 0.92; and for weight, 0.95). At wave 2, we used the participant’s report of height and weight if the participant was older than 13 years; otherwise, we used the parent report. Reported height for individuals across waves was examined for consistency and implausible values, such as decreases in height over time. Approximately 30% of individuals reported a decrease in height; however, in all except 64 individuals, the difference was 1 inch or less (≤2.54 cm). Height decreases were adjusted by substituting a “stable adult height” if the participant reported 2 or more identical heights; otherwise, the mean of reported adult heights was used. Adult was defined herein as follows: for males, those older than 17 years; and for females, those older than 15 years. Similar methods were used to stabilize height for 18 individuals reporting growth of greater than 1 inch (>2.54 cm) between 2 waves after the age of 20 years. Observations (<1%) were not included in analyses if implausible and not accompanied by stable estimates.

Participants were observed during childhood and adulthood, necessitating a measure of weight status comparable throughout this period. Body mass index is commonly used to assess weight status in adults, but BMI is not a good measure for comparison of relative weight status among children of different ages because it increases with age, independent of adiposity, during childhood. Instead, in children, it is recommended that weight status be determined relative to age- and sex-specific reference data. Therefore, we used the Centers for Disease Control and Prevention BMI-for-age reference data, which are available for children and adolescents aged 2 to 20 years, to calculate a BMI z score (BMIz) for each participant at each wave. The BMIz scores correspond with growth chart percentiles and allow for tracking a child’s relative weight through childhood and adolescence. A BMIz of 0 equals the 50th percentile; 1.04, the 85th percentile; and 1.65, the 95th percentile. To provide continuity from childhood to adulthood, we used the age 20 reference to calculate BMIz when individuals were 20 years or older, as have others. Because BMIz is a continuous measure of relative weight adjusted for age and sex, we were able to assess the association of depression and anxiety disorders on weight trajectory over an age range spanning childhood, adolescence, and adulthood.

COVARIATES

Socioeconomic status was defined by an index (mean, 10; SD, 1) of family income, parental education, work status, occupation, and receipt of public assistance. Potential confounding variables included whether medications were taken for emotional or behavioral problems before the age of 21 years, assessed by self-report at wave 4, and whether the participant reported being a

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of the study, 310 individuals (119 males and 191 females) met the diagnostic criteria for an anxiety disorder; of these
women and 211 (68.1%) of the men had a BMI of 25 or greater.

We used linear mixed models to estimate differences in BMI level and annual change in BMI. We controlled for socioeconomic status in all models. The trajectory of BMI was defined as a cubic function of age. We determined the effect of anxiety disorders and depression on BMI level and annual change in BMI, and assessed whether the participant’s age at the wave in which anxiety or depression was first recognized modified these associations. We assessed potential confounding variables (current smoking and early medication use) by determining whether their inclusion changed model estimates. We identified those individuals with an anxiety disorder who did not meet criteria (at any point in the study) for depression, and evaluated the result of using this more restricted definition of anxiety.

### RESULTS

### CHARACTERISTICS OF STUDY PARTICIPANTS

The mean BMI for males and females increased by greater than 0.5 units between waves 3 and 4 (Table 1). During the study, 310 individuals (119 males and 191 females) met the diagnostic criteria for an anxiety disorder; of these individuals, 86 males and 116 females did not also meet the criteria for depression. The mean age at the wave in which an anxiety disorder was first recognized was 17.5 years in females (range, 9.4–38.0 years) and 16.8 years in males (range, 9.3–39.4 years). One hundred forty-eight individuals (50 males and 98 females) met the diagnostic criteria for depression during the study. The mean age at the wave in which depression was first identified was 23.8 years in females (range, 9.7–38.4 years) and 23.5 years in males (range, 10.1–37.5 years).

### ANXIETY DISORDERS: ASSOCIATION WITH BMI

In females, anxiety disorders were associated with higher weight status; our model estimated that the mean BMI for females observed as having had an anxiety disorder was 0.13 units higher compared with females of the same age and socioeconomic status who were not observed as having had an anxiety disorder (Table 2). This difference of 0.13 units, comparing females with an anxiety disorder with females without an anxiety disorder, was unrelated to the number of years elapsed since observed anxiety disorder onset (ie, annual change in BMI was estimated to be essentially the same, a difference in annual BMI change of −0.0002 units/y, regardless of whether the participant had been recognized as having an anxiety disorder). In males, anxiety disorders were not associated with a substantive or statistically significant difference in BMI level or annual change in BMI compared with males without an anxiety disorder (Table 2). We found no evidence that the association of BMI with anxiety disorders in either females or males was related to age at first recognition of anxiety. Controlling for cigarette smoking or early medication use did not substantively change results.

Using a definition of anxiety disorder restricted to females who had never met the diagnostic criteria for depression disorders in either females or males was related to age at first recognition of anxiety.
Table 2. Estimated Difference in BMIz Trajectory (Level and Annual Change) Associated With Anxiety Disorder and Depression*

<table>
<thead>
<tr>
<th>BMIz Variable</th>
<th>Anxiety Disorders</th>
<th>Anxiety Disorders Not Comorbid With Depression†</th>
<th>Depression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Level</td>
<td>0.13</td>
<td>0.004</td>
<td>0.18</td>
</tr>
<tr>
<td>(0.01 to 0.25)†</td>
<td>(-0.16 to 0.17)</td>
<td></td>
<td>(-0.20 to 0.18)‡</td>
</tr>
<tr>
<td>Change (per year)</td>
<td>-0.0002</td>
<td>0.01</td>
<td>-0.003</td>
</tr>
<tr>
<td>(-0.01 to 0.01)</td>
<td>(-0.004 to 0.02)</td>
<td></td>
<td>(-0.01 to 0.01)‡</td>
</tr>
<tr>
<td>Level × age (in years) interaction</td>
<td>£</td>
<td>£</td>
<td>£</td>
</tr>
<tr>
<td>Change (per year) × age (in years) interaction</td>
<td></td>
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</tbody>
</table>

Abbreviation: BMIz, body mass index z score.

*Data are given as mean difference in BMIz (95% confidence interval). The BMIz scores were obtained from the Centers for Disease Control and Prevention BMI-for-age growth reference.1 Anxiety disorders and depression were based on Diagnostic and Statistical Manual of Mental Disorders diagnostic criteria, as assessed by structured diagnostic interview. Estimates from linear mixed-effects models of BMIz assessed at 4 waves; all models were adjusted for age, age², and socioeconomic status. We subtracted 9 (age of the youngest individual at wave 1) from age to maximize the interpretability of variable estimates.44
†Individuals who met the criteria for an anxiety disorder and did not meet the criteria for depression during the study.
‡Statistically significant estimates (α = .05).
§Addition of term for interaction between age and BMIz level did not improve model fit.
||Addition of term for interaction between age and BMIz annual change did not improve model fit.

**Figure 1.** Mean difference calculated from model estimates of body mass index z score (BMIz) with age for females with depression first recognized at the ages of 9, 14, or 18 years compared with females without depression (reference line at 0). The linear mixed-effects model was as follows:

\[
BMIz = 1.77 - [0.14(Age - 9)] + [0.01(Age - 9)^2] - [0.0002(Age - 9)^3] - [0.12(Socioeconomic Status)] - [0.07(Depression)] + [0.09(Years of Depression)] - [0.003(Age - 9)(Years of Depression)].
\]

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\]

**PRESSURE:**

The addition of term for interaction between age and BMIz level did not improve model fit.

**PREDICTION OF**

The estimated mean difference in BMIz for females observed as having had depression was greater by 0.09 units/y than the annual change in BMIz for females who had never been identified as having had depression. The magnitude of this annual BMIz change was modified by age at first recognition of depression and by the number of years elapsed since depression was recognized; the estimated yearly gain in BMIz was reduced by 0.003 units for each additional year of age a female was when depression was first recognized and each year elapsed since then (Table 2 and Figure 1). In males, the first recognition of depression was of borderline statistical significance (P=.06) and predicted a lower BMIz compared with males without depression. Childhood depression was associated with the greatest estimated difference in BMIz (a 9-year-old boy with depression would be estimated to have a BMIz of 0.46 units lower than a boy of the same age without depression). The BMIz trajectories converged with increasing age for males with and without a history of depression; each additional year of age reduced the difference between estimated BMIz for males with depression compared with males without depression by 0.02 units (Table 2 and Figure 2). Controlling for cigarette smoking or early medication use did not substantively change results.

**COMMENT**

We found that DSM disorders of anxiety or depression were associated in females with a higher BMIz. The BMIz was predicted to be 0.13 or 0.18 units higher, depending on depression comorbidity, for females recognized as having had an anxiety disorder compared with the BMIz level of similar females without an anxiety disorder. The estimated annual change in BMIz was essentially the same for females irrespective of whether they had been observed as having had an anxiety disorder and, thus,
The linear mixed-effects model was as follows:

\[ z = 1.78 - [0.13(Age - 9)] + [0.01[(Age - 9)^2] - [0.002(Age - 9)] - [0.11 (Socioeconomic Status)] - [0.46(Depression)] - [0.005(Years of Depression)] + [0.02(Age - 9) (Depression)]. \]

The estimated mean difference of 0.13 or 0.18 units was maintained over time. A 0.18-unit difference in BMI would translate, depending on initial BMI, to a difference in adult BMI of, for example, approximately 25 to 26, 28 to 30, or 30 to 32. For a woman with a height of 64 inches (163 cm) (the average height of US women aged 20-40 years), these BMI changes correspond to 2.7-, 4.2-, and 5.3-kg weight differences, respectively. Although these average weight differences are not large, obesity results from incremental increases in weight, and successful prevention is likely to require interventions targeted toward many factors, no one of which, alone, is sufficient to prevent obesity.

The association of female depression with BMI depended on age at first recognition of depression and the number of years since elapsed. Our model predicted that a 30-year-old woman first recognized with depression at the age of 14 years would have a BMI that was 0.34 units higher than a similar woman without depression; if depression were first recognized at the age of 18 years, the estimated difference in BMI at the age of 30 years would be reduced to 0.23 units. A 0.34-unit difference in BMI translates to a difference in BMI of approximately 24 to 26, 25 to 27, or 27 to 30; for a woman of average height, these values represent weight differences of 4.8, 5.3, and 7.4 kg, respectively. Our model estimated that differences in BMI were largest for adolescents and young adults when depression was present at an early age (Figure 1); irrespective of the age of depression recognition, differences between BMI trajectories for women with and without a history of depression lessened as women approached their 30s. However, statistical power at later ages was not as great as at younger ages.

In males, the association of anxiety disorders with BMI was small and not statistically significant. Thus, our results suggest that anxiety disorders do not greatly influence weight status in males. Childhood depression for males was associated with lower weight; the magnitude of the difference was inversely related to age. Our results for male depression were of borderline statistical significance. Our model predicted that a 14-year-old male with depression would have a BMI of 0.36 units lower than a similar male without depression; however, by the age of 30 years, the BMI difference between these men would be reduced to 0.12 units, and by the age of 35 years, to less than 0.05 units. In adult males, a 0.12-unit difference in BMI translates to a difference in BMI of approximately 25 to 24.5 or 29 to 28; for a man with a height of 69 inches (176 cm) (the average height of US men aged 20-40 years), these BMI differences represent weight differences of 1.5 and 2.2 kg, respectively.

The literature describing associations between obesity and psychological disorders is replete with cross-sectional and clinical studies, but contains fewer prospective studies. Several of these studies use symptom scales that are not directly comparable to DSM criteria, and others are limited to observations at 2 time points. Our analyses of the association of anxiety and depression with weight are unique in using structured diagnostic interviews to assess DSM disorders in a community-based cohort studied at 4 occasions spanning childhood and early adulthood.

Our results are broadly consistent with other prospective studies in finding that psychological distress, especially when present in childhood, predicts higher weight. The study most methodologically comparable to ours found that adolescent depression increased risk for later obesity in girls, but not boys. However, anxiety disorders were not studied, and the study outcome was obesity at the age of 26 years. In an earlier analysis that used data from the 1983 and 1991 to 1994 waves of the Children in the Community Study, young adulthood BMI was associated with symptoms of conduct disorder and depression.

The relationship of depression to BMI we observed in males was fundamentally different from that observed in females. Our results are consistent with those of other investigators in reporting null or inverse associations between depressive symptoms and weight in males. Differences in results in these mainly cross-sectional studies could be due to influences of age and sex on the association of depression with weight.

Longitudinal studies of anxiety and weight are rare. Mustillo et al observed no association between children’s weight trajectory and DSM anxiety disorders; however, comparability to our results is limited by differences in objective and approach. Cross-sectional studies of anxiety and weight provide inconsistent results; in 2 studies, anxiety symptoms were inversely associated with weight. Like ours, more recent studies observed positive associations between obesity and anxiety, particularly in women.

Depression and anxiety are often comorbid disorders. An estimated 60% of adults with depression have had an anxiety disorder, and up to 40% of adults with anxiety disorders have had depression. In our study, 66.0% of males and 76.5% of females with depression also met the diagnostic criteria for an anxiety disorder. Attempting to separate the influence of depression on weight...
from the influence of anxiety on weight is counterproductive because “pure” depression is not common. In contrast, only 27.7% of males and 39.3% of females with an anxiety disorder met the diagnostic criteria for depression; that results of our female anxiety model were strengthened in this subset counters the potential argument that our observed association between anxiety and BMI was due primarily to depression.

By early adulthood, females with depression outnumber males by approximately 2:1. Atypical depression, characterized by increased appetite, hypersomnia, and decreased activity level, is more common in women than men, suggesting a potential mechanism for the association we observed.

Our analyses provide evidence that anxiety disorders and depression are associated with higher weight in females. A strength of our study is assessment of depression and anxiety disorders consistent with DSM criteria. In contrast to symptom scales, use of DSM diagnostic criteria facilitates interpretability and generalizability of results.

There were several limitations of our analyses. First, we modeled the association of first recognition of anxiety or depression with BMI, but it is unlikely that we captured true disorder onset, and some individuals with depression or anxiety were likely not identified (eg, if a disorder began after wave 3 and remitted well before wave 4). Also, because we did not continuously assess weight and do not know the true age of disorder onset, we cannot decisively establish whether weight change preceded or followed anxiety or depression onset. Second, height and weight were self-reported; self-reported height and weight have been shown to be accurate in adults and older teenagers. In younger adolescents (aged 12-16 years), accuracy is related to age, with values for younger youth more likely to be inaccurate. Third, it is possible that missing data biased our results. However, we assessed 94.6% of participants at waves 1, 2, and 3 and 80.6% of participants at wave 4; participants missing data at wave 4 did not differ substantially in age or BMI at waves 1, 2, or 3. Finally, although we controlled for socioeconomic status, smoking, and medication use, 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 unknown confounders.

In conclusion, our analysis of a community-based cohort studied from childhood until adulthood provides evidence that, in females, anxiety disorders and depression are associated with higher weight. The potential for sex and age to influence whether an association between weight and anxiety disorders or depression is seen cross-sectionally or in short-term studies underscores the necessity of applying a life-course approach. Our results suggest that efforts to improve mental health in populations may also help prevent female obesity; consideration of the potential for psychological antecedents and correlates of obesity could improve prevention and treatment.

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Author Contributions: Ms Anderson and Dr Must had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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