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Association of anxiety and depressive symptoms and adiposity among adolescent females using Dual Energy X-ray Absorptiometry

Jennifer B. Hillman^{1,2}, Lorah D. Dorn^{1,2}, and Bin Huang^{2,3}

¹ Division of Adolescent Medicine, Cincinnati Children's Hospital Medical Center

² University of Cincinnati College of Medicine

³ Center for Epidemiology and Biostatistics, Cincinnati Children's Hospital Medical Center

Abstract

The purpose of this study is to evaluate the association between anxiety and depressive symptoms and obesity among adolescent females using objective measures of adiposity, and evaluate for moderating effects of race and age. This is a cross-sectional analysis of 198 females ages 11, 13, 15, and 17 years (mean 14.6, SD 2.2). Adiposity measures include BMI, BMI Z-score (BMI-Z), percent body fat from Dual Energy X-ray Absorptiometry (DXA), and fat distribution (fat mass upper vs. lower body regions from DXA). Symptoms of anxiety were measured with the State-Trait Anxiety Inventory; depressive symptoms with the Children's Depression Inventory. Trait anxiety and depressive symptoms were positively associated with BMI and percent body fat. No interaction of anxiety/depressive symptoms with race or age on measures of adiposity was detected. Symptoms of anxiety and depression are associated with percent body fat among adolescent females, linking psychological distress with a physiological measure of adiposity.

Keywords

anxiety; depression; obesity; adolescent females

Introduction

There is a high prevalence of obesity and mood disorders among adolescents, with both disorders imparting substantial costs to society and the individual.^{1, 2} Additionally, obesity and anxiety/depressive disorders may co-occur. Previous studies have evaluated the association between depressive symptoms and obesity in children, adolescents, and adults and the majority of studies have found a positive association between depressive symptoms and obesity,³⁻⁹ while fewer studies have found no clear association.¹⁰⁻¹³

Experts have called for more rigorous assessments of adiposity in studies involving children and adolescents, emphasizing that BMI and BMI-Z are surrogate measures for adiposity.¹⁴ Further, experts argue that excess adipose tissue, not lean mass, poses increased risk of adverse health outcomes. Additionally, visceral (central) versus peripheral adiposity is associated with increased risk of cardiovascular disease.¹⁵⁻¹⁷ However, little is known about visceral adiposity and its association with psychological disorders.

Few studies have evaluated the association of anxiety with adiposity during adolescence.^{3, 9} Anxiety is frequently co-morbid with other mood disorders. In particular, anxiety often precedes the development of depression in adolescent females.¹⁸ It is crucial to gain a better understanding of the relationship between anxiety *and* depressive symptoms and obesity in adolescence as this is a critical time for both physical and psychosocial development.

The literature evaluating the impact of race and/or age on the associations between anxiety/depressive symptoms and obesity in children and adolescents is sparse. It has been suggested that whites are more likely than blacks to experience psychological disturbance related to weight.^{9, 19, 20} However, the adult literature is conflicting. A recent study of adult men and women demonstrated young obese females of all ethnic groups and Hispanic males are at increased risk of depressed mood compared to their non-obese and racial/ethnic group counterparts.²¹ Another longitudinal study in adults suggested the influence of BMI on depressive symptoms was greater among blacks than whites.²² The adult literature may not completely transfer to adolescence, as adolescents place a significantly greater emphasis on physical appearance. Regarding age, Richardson and colleagues found an increased risk for obesity in adulthood among females with depressive symptoms during late adolescence compared to females with depressive symptoms during early adolescence.⁷ Evaluation of moderators of this association has significant clinical implications, as it may guide clinicians regarding screening efforts.

The primary aim of this study was to evaluate the association between anxiety and depressive symptoms and obesity in adolescent females using BMI, BMI-Z, percent body fat from DXA, and fat distribution (fat mass in the upper versus the lower body regions from DXA). The latter is similar to a waist-to-hip ratio and has been used as a measure of central adiposity.²³ As secondary aims, we explored whether these associations differed by race and age. We hypothesized that symptoms of anxiety and depression would be positively associated with all measures of adiposity. Based on previous literature, we anticipated a moderating effect of both race and age.

Methods

Study population

This was a cross-sectional analysis of data from a larger on-going study evaluating the relationship of psychological symptoms and smoking on reproductive and bone health of adolescents.²⁴ Healthy females (n=198) in age cohorts 11, 13, 15, and 17 years were recruited from an outpatient teen clinic and the surrounding community of a large Midwestern city (Table 1).

A screening questionnaire was administered to determine initial eligibility. Exclusion criteria included: 1) pregnancy or breast feeding within 6 months, 2) primary or secondary amenorrhea, 3) BMI $\leq$ 1st percentile or weight >300 pounds (limitation of DXA table), 4) medication or medical disorder influencing bone health, and 5) severe psychological disabilities impairing comprehension or compliance. All applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research. The study was approved by an Institutional Review Board. Parents provided informed consent and adolescents assent. A certificate of confidentiality was obtained to enhance protection of the adolescent's confidentiality. All study visits were conducted in the General Clinical Research Center at a large children's hospital. Parents and adolescents completed their portions of the study separately.

Measures

Psychological—Symptoms of anxiety were measured using the Spielberger State-Trait Anxiety Inventory for Children (STAIC) for females 11 years old²⁵ and the State Trait Anxiety Inventory (STAI) for females 12 years and older.²⁶ This self-report questionnaire consists of 20 items measuring state and 20 items measuring trait anxiety. Trait anxiety is thought to reflect how girls generally feel whereas state anxiety is more reflective of the participant's level of anxiety at the moment of assessment. Trait anxiety was used in the analyses as it was felt to be more relevant to measures of adiposity. Reliability was high in this sample ($\alpha = 0.86 - 0.91$). T-scores were used in analyses. By definition, T-scores have a mean of 50, standard deviation (SD) of 10, and adjust for age and gender based on a reference sample of healthy children and adolescents. They are commonly used when assessing psychologic constructs because they facilitate comparison and clinical interpretation. Symptoms of depression were assessed with the Children's Depression Inventory (CDI), a 27-item self-report measure.²⁷ The CDI, designed for school-aged children and adolescents, has been rigorously studied in normal and clinical populations with acceptable test-retest and concurrent validity.²⁷ Reliability was high in this sample ($\alpha = 0.90$).

Adiposity—Height was obtained by a wall-mounted stadiometer (Holtan Lts, United Kingdom), and weight by a digital scale (Scaletronix, Carol Stream, IL) without shoes, wearing minimal clothing. Measures were obtained three times, and the mean was used. BMI was calculated as weight (kg) divided by height (meters squared). BMI-Z was calculated based on the Centers for Disease Control and Prevention age and sex-specific standards (www.cdc.gov). Dual Energy X-ray Absorptiometry (DXA) Hologic QDR4500A (Hologic, Inc., Bedford, MA) was used to measure body composition. Scans were analyzed using software version 12.4. Percent body fat was derived from the total body fat (kg) divided by the total body mass (kg). Body composition data from DXA were used to calculate fat distribution as has been described by Walton and colleagues.²³ This method defines four regions of interest defined by anatomic landmarks: android subscapular, android waist, gynoid hip, and gynoid thigh. It is defined as the ratio of the fat mass in the two upper (android) body regions divided by the two lower (gynoid) body regions.²³ Fat distribution is analogous to a waist-to-hip ratio, and provides an objective assessment of the pattern of fat deposition. Higher values correspond to a greater degree of central adiposity.

Covariates—The Hollingshead Four Factor Index of Social Status based on parent's education and occupation was used to determine SES, in which a higher score corresponds to higher SES.²⁸ Pubertal stage was determined by breast inspection and palpation and evaluation of pubic hair distribution using criteria described by Marshall and Tanner.²⁹ Examinations were performed by a trained clinician. Interrater agreement was 100% in a non-random sample (n=23). We used Tanner stage (breast) in the analyses because breast development is typically the first sign of puberty in girls.²⁹ Physical activity was assessed using the Physical Activity Questionnaire for Older Children (PAQ-C).³⁰ Participants recalled amount of moderate to vigorous activity over the preceding 7 days. An average was used to create a score ranging from 1 (low) to 5 (high) activity. Reliability was high in this sample ($\alpha = 0.88$).

Statistical Analysis

Distributions were assessed for all primary variables and covariates. Adiposity measures were all normally distributed, except for BMI which was slightly skewed. Logarithm transformation of BMI resulted in normally distributed data, but re-analysis with this transformation did not change the results. Considering the difficulty in interpreting transformed data and the universal understanding of BMI we have used BMI (untransformed) in analyses. Anxiety and depressive symptoms were analyzed as separate constructs to evaluate the independent effects on measures of adiposity.

Multiple regression was used to determine the overall effects of trait anxiety and depressive symptoms on obesity after accounting for covariates. Potential covariates were selected based on previous literature and included age, race, socioeconomic status, Tanner stage (breast), and physical activity.^{3, 5-9, 20} Only significant covariates and confounding variables were retained in the final model. Age and race were included in all models due to biological plausibility. All measures of obesity (BMI, BMI-Z, percent body fat, fat distribution) in the current study were highly correlated ($r = 0.69 - 0.86$), and thus, repeated regression on each measure may increase type I error. To minimize this error, we conducted multivariate analysis of variance (MANOVA) including all obesity measures into one model.

For our secondary aims, we evaluated the interaction effects of race and age with anxiety/depressive symptoms on obesity measures. Race was classified as either white ($n=123$) or nonwhite ($n=75$). The nonwhite group consisted of 64 black and 11 biracial or other. Age was dichotomized into girls less than 15 years of age ($n=97$, early adolescence), and those 15 and older ($n=101$, late adolescence). The significance of the R^2 change for the interaction term was assessed.

Results

Primary aim: Trait anxiety and obesity

Descriptive statistics of key variables and demographic characteristics of the participants are shown in Table I. Trait anxiety was positively associated with percent body fat ($p=.02$) and BMI ($p=.002$). Neither BMI-Z nor fat distribution was significantly associated with trait anxiety (Table II).

After controlling for age, race, and Tanner stage (breast), trait anxiety was significantly associated with BMI ($p=.05$) in a positive direction. Additionally, controlling for age and race, trait anxiety was significantly associated with percent body fat ($p=.05$) in a positive direction. An increase of one standard deviation in the T-score for trait anxiety was associated with a 0.78 unit increase in BMI, and a 1.03 increase in percent body fat. There were no significant associations between BMI-Z or fat distribution and trait anxiety (Table III). Physical activity was not significant in any of the models, and was dropped from all models.

Primary aim: Depressive symptoms and obesity

Simple regression revealed significant positive associations between depressive symptoms and BMI ($p=.002$), percent body fat ($p=.004$), and fat distribution ($p=.03$). Symptoms of depression were not significantly associated with BMI-Z ($p=.10$). Controlling for age, race, and Tanner stage (breast), depressive symptoms were significantly associated with BMI ($p=.03$) and percent body fat ($p=.01$) in a positive direction. An increase of one standard deviation in the T-score for depressive symptoms was associated with a 0.84 unit increase in BMI and a 1.28 increase in percent body fat. After controlling for age, race, Tanner (breast), and socioeconomic status, the association between depressive symptoms and fat distribution became non-significant. There was no association between depressive symptoms and BMI-Z ($p=.14$).

Finally, results from MANOVA revealed a trend for an association between depressive symptoms and adiposity (BMI, BMI-Z, percent body fat, and fat distribution) after adjusting for age, race, Tanner (breast) and SES (Wilks' Lambda $F=2.10$, $p=.08$). Multivariate analyses of the effect of trait anxiety on adiposity was not significant (Wilks' Lambda = 1.00, $p=.40$).

Secondary aims: Effect of Race and Age

There were no significant interaction effects of race and anxiety/depressive symptoms with any measure of adiposity. Likewise, age was not a significant moderator of the association between anxiety/depressive symptoms and adiposity.

Discussion

This is the first study to evaluate the association between anxiety and depressive symptoms and obesity among adolescent females using adiposity measures from DXA as well as more standard measures such as BMI calculated from measured height and weight. As hypothesized, trait anxiety and depressive symptoms were positively associated with BMI and percent body fat. Higher anxiety and depressive symptoms were associated with an increased BMI, and a higher percent of body mass from fat. This association remained significant after controlling for covariates. Although in unadjusted models, depressive symptoms were associated with fat distribution, after controlling for covariates, the association was no longer significant. In contrast to some previous studies,^{3, 5} we did not observe an association between anxiety and depressive symptoms and BMI-Z. Further, there was no evidence of an interaction effect between anxiety/depressive symptoms and race on obesity; nor between anxiety/depressive symptoms and age on obesity.

The association of anxiety and depressive symptoms and percent body fat is noteworthy, linking psychological distress with a more objective and physiological measure of adiposity. The clinical implications of our findings are important, because we have shown that as early as adolescence, increased symptoms of anxiety and depression are associated with a higher percent of body mass from fat and higher BMI. For example, for an average height (160cm, 5' 3") adolescent female with a BMI of 20, an increase of one SD in her depressive symptoms T-score would be associated with 4.7 pounds greater weight, representing 4 percent of her body weight. In turn, increases in adiposity may continue on an interval basis as the adolescent reaches adulthood and beyond, compounding the effect of anxiety and depressive symptoms on adiposity.

Explanations for the association between anxiety/depressive symptoms and percent body fat are unclear at the present time, however several hypotheses exist. It is known that various substances are regulated by the body in response to the degree of adiposity. For example, leptin secretion is higher with a greater percentage of body fat.^{31, 32} In addition to leptin, there are other behavioral and neuroendocrine factors that may mediate this association, including sedentary and physical activity, caloric intake, the hypothalamic-pituitary-adrenal (HPA) axis, and insulin. Furthermore, a recent study among a large cohort of Swedish children (N=7443) has demonstrated that psychological stress in early childhood may be a contributing factor to the development of obesity as early as age 5 years.³³ Future research is needed to identify mediators between adiposity and anxiety/depression and to better understand the association between psychological stress, mood disorders, and obesity.

The association between symptoms of trait anxiety and percent body fat has not been previously described. Two earlier studies have found an association between anxiety and BMI-Z.^{3, 9} Anderson *et al* reported higher BMI-Z among females with anxiety disorders compared to females of the same age and socioeconomic status who did not have anxiety disorders. In this study, authors included a wide range of anxiety disorders in the analyses including social phobia, overanxious disorder, separation anxiety, and obsessive-compulsive disorder. Young-Hyman *et al* evaluated the association between trait anxiety and BMI-Z in a similar manner to the current study, noting a significant positive association with BMI-Z, but did not control for covariates.⁹

We identified an association between anxiety/depressive symptoms and percent body fat, but not with BMI-Z. Previous studies of adolescents have noted an association between depressive symptoms and BMI/BMI-Z.³⁻⁹ Our study found an association between depressive symptoms and BMI, but not between depressive symptoms and BMI-Z. Three published studies have found no association between depressive symptoms and BMI-Z.¹⁰⁻¹² Differences between our study and previous findings could be explained by several factors. First, earlier studies utilized self-reported height and weight,^{3, 5, 8} or used a combination of measured and self-reported height and weight.⁴⁻⁶ Only one study utilized solely measured height and weight.⁷ A strength of our study is that height and weight were measured in a systematic fashion by trained research staff.

A second difference from the previous literature is that other studies evaluated the association between depression and obesity using adolescents diagnosed with Major Depressive Disorder,^{3, 5-7} not depressive symptoms. Our study was designed to enroll a more representative group of girls in the population with variability in depressive symptoms. The presence of an association in adolescents with subclinical symptoms of anxiety and depression is significant.

Lastly, our sample is relatively obese with 39.9% overweight or obese and a mean BMI-Z of 0.7. There are 38 girls (19.2%) with a BMI-Z greater than the 95th percentile for age and gender. At extreme degrees of obesity, BMI-Z may not adequately describe and quantify the degree of excess adiposity.³⁴ The advantage of using percent body fat as a measure of adiposity is that it allows for a broader range in adiposity, particularly at the extremes. The ability of percent body fat to better characterize the degree of adiposity in the severely obese girls may have provided more power to detect an association with anxiety and depressive symptoms.

The cross-sectional design of our study presents a limitation in that causality cannot be determined. Second, we had a smaller number of nonwhite (n=75) vs. white girls (n=123). Therefore, this study may not have been powered to detect moderation effects by race. Our sample consisted only of female participants so we cannot conclude anything about adolescent males in terms of the associations between anxiety/depressive symptoms and adiposity. However, previous literature has demonstrated that this association has a significantly greater impact on females compared to males. Although we demonstrated a trend for significance in the association between depressive symptoms and all measures of adiposity using multivariate analyses (MANOVA), this robust statistical technique still substantiates our findings in terms of depressive symptoms to some extent. In terms of anxiety, results of MANOVA did not substantiate an overall association between trait anxiety and adiposity.

Conclusions

In summary, trait anxiety and depressive symptoms are associated with a higher BMI and percent body fat among adolescent females. The fact that we found a significant association between BMI and percent body fat and anxiety/depressive symptoms and not between BMI-Z and anxiety/depressive symptoms suggests that either there is some physiological impact of body fat that relates to anxiety/depression, and/or there are differences in these two measures of adiposity. Alternatively, it may be reflective of statistical limitations with use of BMI-Z in obese samples. Studies evaluating associations between obesity and other disorders should consider utilizing a direct means of assessing adiposity, especially among children and adolescents, where the use of BMI/BMI-Z may be less accurate. Future studies evaluating potential neuroendocrine and behavioral mediators of this association may help determine a common pathway between these two disorders and may lead to a means of prevention and treatment.

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References

1. Allison DB, Zannolli R, Narayan KM. The direct health care costs of obesity in the United States. *American Journal of Public Health* 1999;89(8):1194–1199. [PubMed: 10432905]
2. Druss BG, Rosenheck RA, Sledge WH. Health and disability costs of depressive illness in a major U.S. corporation. *Am J Psychiatry* 2000;157(8):1274–1278. [PubMed: 10910790]
3. Anderson SE, Cohen P, Naumova EN, Must A. Association of depression and anxiety disorders with weight change in a prospective community-based study of children followed up into adulthood. *Arch Pediatr Adolesc Med* 2006;160(3):285–291. [PubMed: 16520448]
4. Franko DL, Striegel-Moore R, Thompson D, Schreiber GB, Daniels SR. Does adolescent depression predict obesity in black and white young adult women? *Psychol Med* 2005;35:1505–1513. [PubMed: 16164774]
5. Goodman E, Whitaker RC. A prospective study of the role of depression in the development and persistence of adolescent obesity. *Pediatrics* 2002;110:497–504. [PubMed: 12205250]
6. Pine DS, Goldstein RB, Wolk S. The association between childhood depression and adulthood body mass index. *Pediatrics* 2001;107:1049–1056. [PubMed: 11331685]
7. Richardson LP, Davis R, Poulton R, McCauley E, Moffitt TE, Caspi A, et al. A longitudinal evaluation of adolescent depression and adult obesity. *Arch Pediatr Adolesc Med* 2003;157(8):739–745. [PubMed: 12912778]
8. Richardson LP, Garrison MM, Drangsholt M, Mancl L, LeResche L. Associations between depressive symptoms and obesity during puberty. *Gen Hosp Psychiatry* 2006;28(4):313–320. [PubMed: 16814630]
9. Young-Hyman D, Tanofsky-Kraff M, Yanovski SZ, Keil M, Cohen ML, Peyrot M, et al. Psychological status and weight-related distress in overweight or at-risk-for-overweight children. *Obesity (Silver Spring)* 2006;14(12):2249–2258. [PubMed: 17189553]
10. Pine DS, Cohen P, Brook J, Coplan JD. Psychiatric symptoms in adolescence as predictors of obesity in early adulthood: a longitudinal study. *American Journal of Public Health* 1997;87(8):1303–1310. [PubMed: 9279265]
11. Lamertz CM, Jacobi C, Yassouridis A, Arnold K, Henkel AW. Are obese adolescents and young adults at higher risk for mental disorders? A community survey. *Obes Res* 2002;10(11):1152–1160. [PubMed: 12429879]
12. Renman C, Engstrom I, Silfverdal SA, Aman J. Mental health and psychosocial characteristics in adolescent obesity: a population-based case-control study. *Acta Paediatr* 1999;88(9):998–1003. [PubMed: 10519343]
13. Tanofsky-Kraff M, Cohen ML, Yanovski SZ, Cox C, Theim KR, Keil M, et al. A prospective study of psychological predictors of body fat gain among children at high risk for adult obesity. *Pediatrics* 2006;117(4):1203–1209. [PubMed: 16585316]
14. Prentice AM, Jebb SA. Beyond body mass index. *Obes Rev* 2001;2(3):141–147. [PubMed: 12120099]
15. Gelber RP, Gaziano JM, Orav EJ, Manson JE, Buring JE, Kurth T. Measures of obesity and cardiovascular risk among men and women. *J Am Coll Cardiol* 2008;52(8):605–615. [PubMed: 18702962]
16. Rexrode KM, Carey VJ, Hennekens CH, Walters EE, Colditz GA, Stampfer MJ, et al. Abdominal adiposity and coronary heart disease in women. *Journal of the American Medical Association* 1998;280(21):1843–1848. [PubMed: 9846779]
17. Walker SP, Rimm EB, Ascherio A, Kawachi I, Stampfer MJ, Willett WC. Body size and fat distribution as predictors of stroke among US men. *American Journal of Epidemiology* 1996;144(12):1143–1150. [PubMed: 8956626]

18. Parker G, Wilhelm K, Asghari A. Early onset depression: the relevance of anxiety. *Soc Psychiatry Psychiatr Epidemiol* 1997;32(1):30–37. [PubMed: 9029985]
19. Fallon EM, Tanofsky-Kraff M, Norman AC, McDuffie JR, Taylor ED, Cohen ML, et al. Health-related quality of life in overweight and nonoverweight black and white adolescents. *J Pediatr* 2005;147(4):443–450. [PubMed: 16227028]
20. Kimm SY, Barton BA, Berhane K, Ross JW, Payne GH, Schreiber GB. Self-esteem and adiposity in black and white girls: the NHLBI Growth and Health Study. *Ann Epidemiol* 1997;7(8):550–560. [PubMed: 9408551]
21. Heo M, Pietrobelli A, Fontaine KR, Sirey JA, Faith MS. Depressive mood and obesity in US adults: comparison and moderation by sex, age, and race. *Int J Obes (Lond)* 2006;30(3):513–519. [PubMed: 16302017]
22. Sachs-Ericsson N, Burns AB, Gordon KH, Eckel LA, Wonderlich SA, Crosby RD, et al. Body mass index and depressive symptoms in older adults: the moderating roles of race, sex, and socioeconomic status. *Am J Geriatr Psychiatry* 2007;15(9):815–825. [PubMed: 17804833]
23. Walton C, Lees B, Crook D, Worthington M, Godsland IF, Stevenson JC. Body fat distribution, rather than overall adiposity, influences serum lipids and lipoproteins in healthy men independently of age. *Am J Med* 1995;99(5):459–464. [PubMed: 7485201]
24. Dorn, LD. National Institute on Drug Abuse. Smoking and metabolic complications in adolescent girls (R01DA16402).
25. Spielberger, CD.; Edwards, CD.; Lushene, RE.; Montuori, J.; Platzeck, D. STAIC Preliminary Manual. Palo Alto, CA: Consulting Psychologists Press; 1973.
26. Spielberger, CD. Manual for the State-Trait Anxiety Inventory (STAI). Palo Alto, CA: Consulting Psychologists Press, Inc.; 1968.
27. Kovacs, M. Children's Depression Inventory Manual. North Tonawanda, NY: Multi-Health Systems, Inc.; 1992.
28. Hollingshead, AB. Four-Factor Index of Social Status. New Haven: Yale University CT Press; 1975.
29. Marshall WA, Tanner JM. Variations in pattern of pubertal changes in girls. *Archives of Disease in Childhood* 1969;44:291–303. [PubMed: 5785179]
30. Crocker PR, Bailey DA, Faulkner RA, Kowalski KC, McGrath R. Measuring general levels of physical activity: preliminary evidence for the Physical Activity Questionnaire for Older Children. *Med Sci Sports Exerc* 1997;29(10):1344–1349. [PubMed: 9346166]
31. Blum WF, Englaro P, Hanitsch S, Juul A, Hertel NT, Muller J, et al. Plasma leptin levels in healthy children and adolescents: dependence on body mass index, body fat mass, gender, pubertal stage, and testosterone. *J Clin Endocrinol Metab* 1997;82(9):2904–2910. [PubMed: 9284717]
32. Blum WF. Leptin: the voice of the adipose tissue. *Horm Res* 1997;48(Suppl 4):2–8. [PubMed: 9350438]
33. Koch FS, Sepa A, Ludvigsson J. Psychological stress and obesity. *J Pediatr* 2008;153(6):839–844. [PubMed: 18657829]
34. Woo J. Using BMI Z-score among severely obese adolescents: A cautionary note. *International Journal of Pediatric Obesity*. 2009 In Press.

Table I

Descriptive statistics of key variables and demographics of the participants

	N (%)	Mean (SD)
Age (years)		14.6 (2.2)
Race		
White	123 (62.1)	
Nonwhite	75 (37.9)	
Socioeconomic status (8-66) ^a		38.6 (13.5)
Tanner Stage (breast)		
1	5 (2.5)	
2	4 (2.0)	
3	25 (12.6)	
4	34 (17.1)	
5	131 (65.8)	
Trait Anxiety symptom T-score		46.4 (10.8)
Depressive symptom T-score		46.0 (11.0)
Obesity measures		
Body Mass Index		23.7 (6.3)
Body Mass Index Z-score		0.7 (1.0)
Percent body fat from DEXA		28.9 (7.7)
^b Body fat distribution		0.6 (0.2)
Weight category		
Normal weight (BMI < 85%)	119 (60.1)	
Overweight (≥ 85% BMI < 95%)	41 (20.7)	
Obese (BMI ≥ 95%)	38 (19.2)	

NOTE: SD = Standard deviation, white = caucasian, nonwhite = black and other, or mixed race

^a Socioeconomic status measured with Hollingshead criteria.³⁰^b Fat distribution = fat mass upper/lower body regions (from Dual Energy X-ray Absorptiometry).

Table II
Simple regression: Associations between depressive symptoms, trait anxiety, and measures of adiposity

Independent variable	Measures of adiposity											
	BMI			BMI-Z			Percent body fat			<i>a</i> Fat distribution		
	β	B	SE (B)	β	B	SE (B)	β	B	SE (B)	β	B	SE (B)
Trait Anxiety	.216	.368**	.119	.113	.010	.007	.168	.121*	.050	.115	.003	.002
Depressive symptoms	.217	.377**	.121	.117	.011	.006	.205	.144**	.049	.157	.003*	.002

* p< .05,
** p≤.01

β = standardized coefficient; B = unstandardized coefficient; SE = Standard Error

^aFat distribution = fat mass upper/lower body regions (from Dual Energy X-ray Absorptiometry).

Table III
Multiple regression: Associations between depressive symptoms, trait anxiety, and measures of adiposity

Independent variable	Measures of adiposity									
	BMI ¹		BMI-Z ²		Percent body fat ³		^a Fat distribution ⁴		β	SE (B)
	β	SE (B)	β	SE (B)	β	SE (B)	β	SE (B)		
Trait Anxiety	.132	.078*	.102	.009	.143	.103*	.047	.001	.047	.002
Depressive symptoms	.146	.084*	.102	.009	.182	.128**	.105	.002	.105	.002

* p≤.05,
** p≤.01

β = standardized coefficient; B = unstandardized coefficient; SE = Standard Error

^aFat distribution = fat mass upper/lower body regions (from Dual Energy X-ray Absorptiometry).

¹Significant covariates retained in the model were age, race, Tanner stage (breast)

²Significant covariates retained in the model were age, race, Tanner stage (breast)

³Significant covariates retained in the model were age, race

⁴Significant covariates retained in the model were age, race, Tanner stage (breast), and socioeconomic status