UNIVERSITY OF CINCINNATI

Date: _____

I, _____,
hereby submit this work as part of the requirements for the degree of:

in:

It is entitled:

This work and its defense approved by:

Chair: _____

**The Association of Anxiety and Depressive Symptoms with Obesity Among
Adolescent Females: Looking Beyond Body Mass Index**

A thesis submitted to the
Graduate School
of the University of Cincinnati
in partial fulfillment of the
requirements for the degree of
MASTER OF SCIENCE
in the Department of Environmental Health,
Division of Epidemiology and Biostatistics,
of the College of Medicine

By

Jennifer B. Hillman, MD

MD, University of Missouri-Columbia School of Medicine, May 2001

BS, Biochemistry, University of Missouri-Columbia, May 1996

Committee Chair: Paul Succop, PhD

Abstract

Purpose: To evaluate the association between anxiety/depressive symptoms and obesity among adolescent females.

Design and Methods: Cross sectional, 199 adolescent females (mean age 14.5 years). Trait anxiety was measured with the State-Trait Anxiety Inventory (STAI) and depressive symptoms with the Children's Depression Inventory (CDI). Obesity was assessed with body mass index Z score (BMI-Z), percent body fat from dual energy x-ray absorptiometry (DEXA), and fat distribution (fat mass upper/lower body). Linear regression was used.

Results: Anxiety and depressive symptoms were associated with percent body fat, but not BMI-Z or fat distribution. A ten-point increase on the STAI and CDI was associated with 1.15 and 1.33 increase in percent body fat, respectively. Analysis by race and age revealed an association between depressive symptoms and percent body fat among whites and younger girls but not blacks or older girls.

Conclusions: Anxiety/depressive symptoms are associated with body composition in adolescent females.

Acknowledgements

This study was funded by the National Institutes of Health, R01 DA16402; Primary Investigator

Lorah D. Dorn, PhD.

Thanks to Dr. Susan Rose who provided ongoing support and mentorship for this project.

Introduction

Childhood and adolescent obesity continues to significantly increase; currently 17.1 percent of American children and adolescents are obese [1]. Obese children and adolescents are greater than ten times more likely to be obese in early adulthood compared to those children and adolescents that are not obese [2]. Numerous medical consequences of obesity are becoming increasingly evident during childhood and adolescence [3-5]. The cardiovascular risks associated with obesity in childhood have been shown to persist into adulthood, including elevated systolic and diastolic blood pressure, increased low density lipoprotein cholesterol (LDL), insulin resistance [2, 6, 7], and the metabolic syndrome [8, 9]. Moreover, mortality from coronary heart disease and atherosclerosis is increased among men and women who were obese during adolescence [10]. In addition to the medical complications, obesity is negatively associated with self-esteem and self worth [11], health-related quality of life [12], and behavioral, psychological and social problems throughout childhood and adolescence, particularly among females [13-16].

Specifically, anxiety and depressive disorders are more prevalent among adolescents with obesity, and depression and anxiety are thought to precede the development of obesity [13, 14, 17, 18]. Alternatively, in adulthood, obesity is thought to precede depression, particularly among females [19-21]. An adolescent with depression and obesity may be caught in a vicious cycle with worsening obesity and depression as they progress into young adulthood and beyond. Therefore, it is crucial to gain a better understanding of the relationship between anxiety and depressive disorders and obesity in childhood and adolescence.

Previous studies evaluating the association between anxiety, depression, and obesity have used body mass index (BMI) as the measure for obesity, as it is relatively simple and inexpensive to obtain [13-15, 17, 18, 22]. BMI is highly correlated with total body fat and percent body fat [23, 24]. However, BMI is also correlated with the fat-free body mass. In growing children and adolescents, the contribution of fat-free and fat mass to the BMI varies by age, race, and sexual maturational stage [23, 25]. Thus, using BMI as a measure of adiposity in studies of adolescents may have limitations.

To our knowledge, there have been no studies evaluating the association between anxiety and depressive disorders or symptoms and obesity using measures of obesity other than BMI. Our primary aim was to evaluate the association between a) anxiety and b) depressive symptoms and obesity in adolescent females using BMI, percent body fat from Dual Energy X-ray Absorptiometry (DEXA), and fat distribution derived from the ratio of fat mass in the upper versus the lower regions of the body from DEXA. The latter is similar to a waist to hip ratio. As secondary aims, we explored whether these associations differed by race and age, and compared obesity measures between groups with normal versus high depressive symptom scores.

We hypothesized that symptoms of anxiety and depression would be associated with all three measures of obesity. We anticipated that those with higher anxiety and depressive symptom scores would have higher obesity indices, and that this would hold true regardless of race or age.

Design and Methods

Study population

This is 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 adolescent females (R01DA16402) [26]. Adolescent females (n=199) in age cohorts 11, 13, 15, and 17 years of age were recruited from an outpatient teen health center and the surrounding community of a large city.

A brief screening questionnaire was administered by phone or in person to determine eligibility. Exclusion criteria included: 1) pregnancy or breast feeding within 6 months, 2) primary amenorrhea (>16 years), 3) secondary amenorrhea (<6 cycles/year), 4) body mass index < 5th percentile or weight >300 pounds (due to limitations of DEXA scanner table), 5) medication or medical disorder influencing bone health, and 6) psychological disabilities impairing comprehension of compliance. The study was approved by an Institutional Review Board. Parents provided informed consent and adolescents assent. All study visits were conducted in the General Clinic Research Center at a large children's hospital.

Measures

Trait anxiety

Symptoms of anxiety were measured using the Spielberger State-Trait Inventory for Children (STAIC) for girls 11 years old [27] and the State Trait Anxiety Inventory (STAI) was used for girls 12 years and older [28]. This self-administered questionnaire consists of 20 items

measuring state and 20 items measuring trait anxiety. Trait anxiety is thought to reflect how girls generally feel; state anxiety is more reflective of the participant's level of anxiety at the moment of assessment. Trait anxiety was used in the analyses. Reliability was high in this sample ($\alpha = 0.86 - 0.91$). T-scores (mean=50; SD=10) were used in the analyses.

Depressive symptoms

Symptoms of depression were assessed with the Children's Depression Inventory (CDI), a 27-item self-report measure [29]. The CDI, designed for school-aged children and adolescents, has been rigorously studied in normal and clinical pediatric populations with acceptable test-retest and concurrent validity [29]. Reliability was high in this sample ($\alpha = 0.90$).

Body Mass Index

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.

These measures were obtained three times, and the mean was used for data analyses. BMI was calculated as weight (kg) divided by height (meters squared). BMI-Z (BMI standard deviation) was calculated using publicly available programs (www.cdc.gov) based on the Centers for Disease Control and Prevention age and sex-specific standards [30].

Percent Body Fat

Dual Energy X-ray Absorptiometry (DEXA) 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).

Fat Distribution

Body composition data from DEXA were used to calculate fat distribution as has been previously described by Walton and colleagues [31] and utilized in subsequent studies [32, 33]. The fat mass (kg) in the upper body region was divided by the fat mass (kg) in the lower body region, analogous to the waist to hip ratio.

Socioeconomic status (SES)

The Hollingshead Four Factor Index of Social Status was used to determine SES, in which higher family score corresponds to greater SES [34].

Maturational stage

Pubertal stage was determined by breast palpation and physical examination of pubic hair distribution using staging described by Marshall and Tanner [35, 36]. Examinations were performed by a trained nurse practitioner or an adolescent medicine physician. Inter rater agreement was 100% in a non-random sample (n=23). We used Tanner stage of breast development in the analyses because adiposity may be associated with a hormonally mediated secular trend towards earlier puberty [37, 38] and because breast development is typically the first sign of puberty in girls [36].

Smoking status

Smoking was assessed by a questionnaire asking participants if they had ever smoked tobacco. They were grouped into “never” or one of four categories of smokers ranging from “even a puff”

to daily smoking. For these analyses, smoking was dichotomized into those who had ever smoked and those who had never smoked.

Physical Activity

Physical activity was assessed using the Physical Activity Questionnaire for Older Children (PAQ-C) [39]. Participants recalled amount of moderate to vigorous activity over the preceding 7 days. An average of PAQ-C items were used to create a score that ranged from 1 (low activity) to 5 (high activity).

Statistical Analysis

For our primary aim, to evaluate the associations between anxiety and depressive symptoms and obesity, distributions (means and standard deviations) were assessed for all primary variables and covariates. Scatter plots were created to assess for nonlinear relationships between anxiety and depressive symptoms and all measures of obesity. Data were examined for outliers and skew.

We estimated simple linear regression models to evaluate whether trait anxiety was associated with obesity. The independent variables were the T-scores from the STAI and the version for children (STAIC) and the dependent variables were the three measures of obesity (BMI-Z, percent body fat, and fat distribution). The same methodology was used to evaluate the association between depressive symptoms and obesity using the CDI T score as the measure of depressive symptoms. Separate analyses were conducted for anxiety and depressive symptoms to evaluate their independent effects on obesity measures.

Multiple linear regression analyses were then used to determine the overall effects of trait anxiety and depressive symptoms on obesity. Potential covariates and confounding variables explored in the analyses were selected based on previous literature and included age, race, socioeconomic status, Tanner stage (breast), smoking, and physical activity. The individual association of a covariate with the dependent variable was assessed with simple linear regression. A significant covariate was defined as a variable that was associated with the dependent variable at the $p < .10$ level of significance. A confounding variable was defined as one that changed the β -coefficient for a trait anxiety or depressive symptom effect on any of the obesity outcomes by more than 10% when it was added to the model. The variable selection strategy of backward elimination was used to determine the final statistical model. In the final model, only significant covariates and confounding variables were included.

Individual models were developed for each dependent variable (BMI-Z, percent body fat, and fat distribution). Age and race were included in all models due to biological plausibility. For the model with BMI-Z as the dependent variable, Tanner stage (breast) was a significant covariate and was included in the final model. For the model with percent body fat as the dependent variable, there were no significant covariates or confounders. Finally, for the model with fat distribution as the dependent variable, Tanner stage (breast) and socioeconomic status were significant covariates.

To address our secondary aims, to evaluate whether the associations between anxiety, depressive symptoms, and race differed by race and/or age, we conducted separate analyses for white

(n=124) and black (n=64) participants and for girls under 15 years (n=98) and those 15 years and older (n=101).

Lastly, to assess the differences among girls with normal and high depressive symptoms scores, a CDI T-score cutoff of 54 was used. The most accepted T-score cut-point for use in screening for depression in a general population of children is between 60 and 66 [29]. Screening for depression in a more homogenous sample, similar to clinical settings, a lower cut-point (raw score ~12 which is equivalent to a T score of 54) has been suggested, and has been supported by the literature [29]. Girls with a CDI T-score greater than or equal to 54 were considered to have a “high depressive symptoms score” (n=36); girls with a CDI T-score less than 54 (n=163) were considered to have a depressive symptom score within a normative range. Differences in the mean values for BMI z-score, percent body fat, and fat distribution between groups were assessed with a t-test. Level of significance was set at $p < .05$ for all of the above analyses.

Results

Table 1 displays the descriptive statistics of the key variables and demographic characteristics of the participants. Correlations between measures of obesity are shown in Table 2. All measures of obesity are moderately to highly correlated ($R^2 = 0.48 - 0.75$).

Primary aim: a) Association between anxiety and obesity

Simple regression analyses of trait anxiety and obesity are shown in Table 3. Trait anxiety was positively associated with percent body fat ($p = .01$). Neither BMI-Z nor fat distribution was significantly associated with trait anxiety. Results of multiple variable linear regression analyses

are shown in Table 4. After controlling for age and race, anxiety was significantly associated with percent body fat ($p = .03$) in a positive direction. A ten point increase in the T-score (one standard deviation) on trait anxiety was associated with a 1.15 percent increase in body fat. After adjusting for significant covariates and evaluating for confounders, there were no significant associations between BMI-Z and trait anxiety, or between fat distribution and trait anxiety.

Primary aim: b) Association between depressive symptoms and obesity

Simple regression models revealed a significant positive association between depressive symptoms and percent body fat ($p = .003$) and fat distribution ($p = .028$). Symptoms of depression were not significantly associated with BMI-Z. Results of multiple variable linear regression (controlling for age and race) showed that depressive symptoms were significantly associated with percent body fat ($p = .008$). A ten point increase in the T-score for depressive symptoms (one standard deviation) was associated with a 1.33 percent increase in body fat. After controlling for age, race, Tanner stage (breast), and socioeconomic status, the association between depressive symptoms and fat distribution became nonsignificant. There was no significant association between depressive symptoms and BMI-Z.

Secondary aims: Subgroup analyses

Race

Compared to white participants, black participants had a significantly lower mean value for socioeconomic status ($p < .0001$). The black participants also had statistically higher mean values for BMI ($p < .0001$), BMI-Z ($p < .0001$) and percent body fat ($p = .04$) than white

participants. There were no differences in whites vs. blacks with regards to age, trait anxiety T-score, depressive symptom T-score, and fat distribution.

Among white girls, there was a significant positive association between depressive symptoms and percent body fat ($p = .04$); this association was not observed among the black girls ($p = .16$). In fact, there were no associations between anxiety or depressive symptoms with any measure of obesity among the black girls. Evaluation for an interaction between depressive symptoms and race with percent body fat was not significant ($p = .72$).

Age

For analyses by age, the girls 15 years of age and older had a lower socioeconomic status ($p = .0002$) as compared to the girls under 15 years of age. In addition, the older girls had higher trait anxiety ($p < .0001$), depressive symptoms ($p = .0001$), BMI ($p < .0001$), percent body fat ($p = .01$), and fat distribution ($p = .01$) than the younger girls. There was no difference in the BMI-Z for the older vs. younger girls.

Among the younger girls, there was a significant positive association between depressive symptoms and percent body fat ($p = .006$), and between depressive symptoms and fat distribution ($p = .01$). Furthermore, there was a trend towards significance in the positive direction in the associations between anxiety and percent body fat ($p = .06$), and between depressive symptoms and BMI-Z ($p = .09$) among the younger girls. However, among the older girls, there were no significant associations between anxiety or depressive symptoms and any

measure of obesity. The interaction of age and depressive symptoms with percent body fat did not prove to be significant ($p = .17$).

Assessment of differences between girls with normal and high depressive symptom scores

Girls with higher depressive symptom T-scores ($n=36$) were older, had higher trait anxiety scores, higher percent body fat, and higher BMI as compared to the girls with a more normal depressive symptom CDI T-score ($n=163$). There was a trend for significance for the difference between groups for BMI-Z ($p = .10$). (See Figure 1)

Discussion

Primary aims: Associations of anxiety and depressive symptoms with obesity

This is the first study to evaluate the association between anxiety and depressive symptoms and obesity using percent body fat from DEXA as a measure of obesity. As hypothesized, trait anxiety and depressive symptoms were positively associated with percent body fat in this sample of adolescent girls. Higher anxiety and depressive symptoms were associated with a higher percent of body mass from fat. This remained true after controlling for age and race. Although in unadjusted models depressive symptoms were associated with fat distribution, after controlling for covariates, the association was no longer significant. In contrast to previous studies, we did not observe an association between anxiety and depressive symptoms and BMI-Z.

The association of anxiety and depressive symptoms and percent body fat (body composition) is remarkable, linking psychological distress with an objective and physiological measure of

adiposity. This study provided rigorous data collection and the ability to control for age, race, pubertal stage by physical examination, gender (only females included), smoking status, and physical activity. Because this study is cross-sectional, we cannot determine causal relationships. However, previous literature implies that symptoms of anxiety and depression precede the onset of obesity in the adolescent population [13, 14, 17, 18]. If this is true, then there may be important physiologic implications of psychological distress (anxiety, depression), including potential neuroendocrine mediators of body composition, or other metabolic changes. Longitudinal analyses will be important to confirm the temporal relationship between psychological distress and obesity. In addition, evaluation of potential mediators in this association will be important to identify potential important areas for intervention.

Previous studies of adolescents have noted an association between anxiety and depressive symptoms and BMI-Z [13-15, 17, 18, 22]. Our study did not find this association, and this could be due to several factors. First, some previous studies calculated BMI from a self-reported height and weight [13, 14, 22], and other studies used a combination of measured (initial visit) and self-reported height and weight (follow-up visit) to determine BMI [17, 18]. In previous literature of adolescents, self-reported measures of height and weight have a significant error component [40]. Females and overweight youth tend to underestimate their weight more than male and normal-weight youth, respectively [40-43]. Only one study utilized solely measured height and weight in calculation of BMI [22]. In order to avoid an under- or overestimation of the association, we measured height and weight for all participants in a systematic fashion. Secondly, other studies evaluated the association between depression and obesity using a sample of adolescents diagnosed with Major Depressive Disorder (MDD) [13-15, 18], not depressive

symptoms. Our study did not enroll by diagnostic category and thus we had relatively few adolescents with MDD leaving it impossible to conduct a similar analysis. However, we had a full range of depressive symptom T-scores (continuous data) and linear regression should have maximized the ability to detect an association.

Although our study and others have demonstrated that percent of body mass from fat is highly correlated to BMI [23, 24], we found divergent results when examining the association of these two measures of adiposity with psychological distress (anxiety and depressive symptoms). It is unclear why there was a significant association between trait anxiety and depressive symptoms with percent body fat, but not between trait anxiety and depressive symptoms and BMI-Z.

Changes in body composition related to symptoms of anxiety and depression may occur earlier than changes in BMI-Z, particularly during adolescence. Girls with MDD or longstanding depressive symptoms (chronic depression) may exhibit changes in both percent body fat and BMI. Body composition may be related metabolically to some other biomarker involved in the pathophysiology of anxiety and depression.

Secondary Aims: Associations of anxiety and depressive symptoms and obesity by race

Subgroup analyses by race (white vs. black) revealed an association between depressive symptoms and percent body fat only among the white girls. This would suggest that there is some impact of race on psychological distress and body composition. Previous researchers have specifically evaluated the association between obesity and psychological disturbance by race during adolescence [11, 12, 16, 17, 44]. Overall, there is a suggestion that whites are more likely than blacks to experience psychological disturbance related to weight and adiposity. Three

studies suggest a weaker but still positive association between obesity and psychological disturbance among black vs. white adolescent females (more disturbance with increasing obesity) [11, 12, 16]. One study found no association with race [17], and another study found a positive association between self esteem and obesity among black African adolescent females (higher self esteem with increasing weight) [44] .

Our study was consistent with other studies [11, 12, 16, 44] in that obesity (percent body fat) was associated with anxiety and depressive symptoms, particularly among the white vs. black participants. Furthermore, these findings provide some support of existing evidence of greater acceptance of increased weight and body size among nonwhite cultures. This is particularly important because rates of obesity are the highest among nonwhite adolescent females [1]. Further understanding of this cultural acceptance for obesity may help guide public health and primary prevention efforts.

Secondary Aims: Associations of anxiety and depressive symptoms and obesity by age

The association between anxiety and depressive symptoms and percent body fat was significant among the girls less than 15 years of age, but not among girls 15 years of age and older. This finding indicates some influence of age with anxiety/depression and body composition. Our findings may reflect the findings of previous literature; depression may precede obesity in children and be a result of obesity in adulthood [13, 14, 17-21]. The girls 15 years of age and older may be more representative of an adult population in terms of the temporal association of obesity and depression, but the obesity may not be chronic enough to have resulted in depression. Another explanation for the association among the younger girls is that depressive

symptoms during earlier adolescence may represent a more severe phenotype of depression, which may be more strongly associated with a predisposition for obesity.

One longitudinal study specifically examined the role of depression in early (age 11-15 years) and late (age 18-21 years) adolescence on the development of adult obesity [15]. Richardson and colleagues found an association between depression and subsequent risk for obesity among the late adolescent females, but not among the early adolescent females. Our study divided the girls into those younger than 15 years and those 15 years and older because the majority of girls 15 years of age have begun menstruation and are in the later stages of puberty based on Tanner criteria. Differences in age cut-offs between our study and Richardson's may explain the differences in our findings. In addition, our study was not longitudinal so direct comparison is not possible.

In summary, our study showed trait anxiety and depressive symptoms are associated with increased percent body fat among adolescent females. This association may be stronger among whites vs. blacks, and among younger adolescents vs. older adolescents. Future studies evaluating the longitudinal nature of this association, and evaluating for potential mediators of this association would be useful to guide intervention efforts.

References

1. Ogden C, Carroll M, Curtin L, McDowell M, Tabak C and Flegal K. Prevalence of Overweight and Obesity in the United States, 1999-2004. JAMA 2006;295:1549-1555

2. Thompson DR, Obarzanek E, Franko DL, et al. Childhood overweight and cardiovascular disease risk factors: the National Heart, Lung, and Blood Institute Growth and Health Study. *J Pediatr* 2007;150:18-25
3. Barlow SE. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. *Pediatrics* 2007;120 Suppl 4:S164-92
4. Daniels SR, Arnett DK, Eckel RH, et al. Overweight in children and adolescents: pathophysiology, consequences, prevention, and treatment. *Circulation* 2005;111:1999-2012
5. Dietz WH. Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics* 1998;101:518-25
6. Srinivasan SR, Myers L and Berenson GS. Temporal association between obesity and hyperinsulinemia in children, adolescents, and young adults: the Bogalusa Heart Study. *Metabolism* 1999;48:928-34
7. Steinberger J, Moran A, Hong CP, Jacobs DR, Jr. and Sinaiko AR. Adiposity in childhood predicts obesity and insulin resistance in young adulthood. *J Pediatr* 2001;138:469-73
8. Morrison JA, Friedman LA, Wang P and Glueck CJ. Metabolic Syndrome in Childhood Predicts Adult Metabolic Syndrome and Type 2 Diabetes Mellitus 25 to 30 Years Later. *J Pediatr* 2008;152:201-206
9. Sun SS, Liang R, Huang TT, et al. Childhood Obesity Predicts Adult Metabolic Syndrome: The Fels Longitudinal Study. *J Pediatr* 2008;152:191-200 e1
10. Must A, Jacques PF, Dallal GE, Bajema CJ and Dietz WH. Long-term morbidity and mortality of overweight adolescents. A follow-up of the Harvard Growth Study of 1922 to 1935. *N Engl J Med* 1992;327:1350-5

11. Kimm SY, Barton BA, Berhane K, Ross JW, Payne GH and Schreiber GB. Self-esteem and adiposity in black and white girls: the NHLBI Growth and Health Study. *Ann Epidemiol* 1997;7:550-60
12. Fallon EM, Tanofsky-Kraff M, Norman AC, et al. Health-related quality of life in overweight and nonoverweight black and white adolescents. *J Pediatr* 2005;147:443-50
13. Anderson SE, Cohen P, Naumova EN and 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 Adol Med* 2006;160:285-291
14. 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
15. Richardson LP, Davis R, Poulton R, et al. A longitudinal evaluation of adolescent depression and adult obesity. *Arch Pediatr Adolesc Med* 2003;157:739-45
16. Young-Hyman D, Tanofsky-Kraff M, Yanovski SZ, et al. Psychological status and weight-related distress in overweight or at-risk-for-overweight children. *Obesity (Silver Spring)* 2006;14:2249-58
17. Franko DL, Striegel-Moore R, Thompson D, Schreiber GB and Daniels SR. Does adolescent depression predict obesity in black and white young adult women? *Psychol Med* 2005;35:1505-1513
18. Pine DS, Goldstein RB and Wolk S. The association between childhood depression and adulthood body mass index *Pediatrics* 2001;107:1049-1056
19. Carpenter KM, Hasin DS, Allison DB and Faith MS. Relationships between obesity and DSM-IV major depressive disorder, suicidal ideation, and suicide attempts: results from a general population study *Am J Public Health* 2000;90:251-257

20. Onyike CU, Crum RM, Hochang BL, Lykestsos CG and Eaton WW. Is obesity associated with major depression? Results from the National Health and Nutrition Examination Survey. *Am J Epidemiol* 2003;158:1139-1147
21. Roberts RE, Deleger S, Strawbridge WJ and Kaplan G. Prospective association between obesity and depression: evidence from the Alameda county study. *Int J Obesity* 2003;27:514-521
22. Richardson LP, Garrison MM, Drangsholt M, Mancl L and LeResche L. Associations between depressive symptoms and obesity during puberty. *Gen Hosp Psychiatry* 2006;28:313-20
23. Daniels SR, Khoury PR and Morrison JA. The utility of body mass index as a measure of body fatness in children and adolescents: differences by race and gender. *Pediatrics* 1997;99:804-7
24. Pietrobelli A, Faith MS, Allison DB, Gallagher D, Chiumello G and Heymsfield SB. Body mass index as a measure of adiposity among children and adolescents: a validation study. *J Pediatr* 1998;132:204-10
25. Maynard LM, Wisemandle W, Roche AF, Chumlea WC, Guo SS and Siervogel RM. Childhood body composition in relation to body mass index. *Pediatrics* 2001;107:344-50
26. Dorn LD. Smoking and Metabolic Complications in Adolescent Girls: Funded by NIDA, 5/10/03 - 4/30/08
27. Spielberger CD, Edwards CD, Lushene RE, Montuori J and Platzek D. STAIC Preliminary Manual. Palo Alto, CA: Consulting Psychologists Press, 1973
28. Spielberger CD. Manual for the State-Trait Anxiety Inventory (STAI). Palo Alto, CA: Consulting Psychologists Press, Inc., 1968
29. Kovacs M. Children's Depression Inventory Manual. North Tonawanda, NY Multi-Health Systems, Inc., 1992

30. Ogden CL, Kuczmarski RJ, Flegal KM, et al. Centers for Disease Control and Prevention 2000 growth charts for the United States: improvements to the 1977 National Center for Health Statistics version. *Pediatrics* 2002;109:45-60
31. Walton C, Lees B, Crook D, Worthington M, Godsland IF and Stevenson JC. Body fat distribution, rather than overall adiposity, influences serum lipids and lipoproteins in healthy men independently of age. *Am J Med* 1995;99:459-64
32. Barat P, Gayard-Cros M, Andrew R, et al. Truncal distribution of fat mass, metabolic profile and hypothalamic-pituitary adrenal axis activity in prepubertal obese children. *J Pediatr* 2007;150:535-9, 539 e1
33. Daniels SR, Morrison JA, Sprecher DL, Khoury P and Kimball TR. Association of body fat distribution and cardiovascular risk factors in children and adolescents. *Circulation* 1999;99:541-5
34. Hollingshead AB. Four-Factor Index of Social Status. New Haven: Yale University CT Press, 1975
35. Marshall WA, Tanner J. Variations in the pattern of pubertal change in boys. *Archives of Disease in Childhood* 1970;45:13-23
36. Marshall WA, Tanner JM. Variations in pattern of pubertal changes in girls. *Archives of Disease in Childhood* 1969;44:291-303
37. Kaplowitz PB, Slora EJ, Wasserman RC, Pedlow SE and Herman-Giddens ME. Earlier onset of puberty in girls: relation to increased body mass index and race. *Pediatrics* 2001;108:347-53
38. Wong WW, Nicolson M, Stuff JE, et al. Serum leptin concentrations in Caucasian and African-American girls. *J Clin Endocrinol Metab* 1998;83:3574-7

39. Crocker PR, Bailey DA, Faulkner RA, Kowalski KC and McGrath R. Measuring general levels of physical activity: preliminary evidence for the Physical Activity Questionnaire for Older Children. *Med Sci Sports Exerc* 1997;29:1344-9
40. Sherry B, Jefferds ME and Grummer-Strawn LM. Accuracy of adolescent self-report of height and weight in assessing overweight status: a literature review. *Arch Pediatr Adolesc Med* 2007;161:1154-61
41. Brener ND, McManus T, Galuska DA, Lowry R and Wechsler H. Reliability and validity of self-reported height and weight among high school students. *J Adolesc Health* 2003;32:281-7
42. Goodman E, Hinden BR and Khandelwal S. Accuracy of teen and parental reports of obesity and body mass index. *Pediatrics* 2000;106:52-8
43. Strauss RS. Comparison of measured and self-reported weight and height in a cross-sectional sample of young adolescents. *Int J Obes Relat Metab Disord* 1999;23:904-8
44. Viner RM, Haines MM, Taylor SJ, Head J, Booy R and Stansfeld S. Body mass, weight control behaviours, weight perception and emotional well being in a multiethnic sample of early adolescents. *Int J Obes (Lond)* 2006;30:1514-21

Table 1

Descriptive statistics (means and standard deviations) of the key variables and demographics of the participants

	N (%)	Mean (SD)
Age (years)		14.5 (2.2)
Race		
Caucasian	124 (62.3)	
African American	64 (32.2)	
Other	11 (5.5)	
Socioeconomic status (Hollingshead criteria)		38.7 (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)	
Smoking Status		
Never smoked	106 (53.3)	
Ever smoked	93 (46.7)	
Physical Activity (PAQ-C) total activity score		2.1 (0.6)
Anxiety symptom T-score (STAI and STAIC)		46.4 (10.8)
Depressive symptom T-score (CDI)		46.0 (11.0)
Obesity measures		
Body Mass Index		23.5 (6.3)
Body Mass Index Z-score		0.7 (1.0)
Percent body fat		28.7 (7.6)
Body fat distribution [§]		0.6 (0.2)

NOTE: SD = Standard deviation, PAQ-C = Physical Activity Questionnaire for Older Children, STAI = Spielberger State Trait Anxiety Inventory, STAIC = Spielberger State Trait Anxiety Inventory for Children, CDI = Children's Depression Inventory

§ Fat distribution is defined as the ratio of fat mass (kg) in the upper body region divided by fat mass (kg) in lower body region.

Table 2

Squared correlations (R^2) between obesity measures

Variables	Squared correlations (R^2)
BMI and BMI-Z	.75
Percent body fat and BMI	.69
Percent body fat and BMI-Z	.63
Percent body fat and fat distribution	.54
Fat distribution [§] and BMI	.48
Fat distribution [§] and BMI-Z	.53

[§] Fat distribution defined as the ratio of fat mass (kg) in the upper body divided by the fat mass (kg) in the lower body.

Table 3

Simple linear regression analyses: associations between depressive symptoms, trait anxiety, and measures of obesity

Dependent variable	Trait Anxiety			Depressive symptoms		
	B	SE (B)	p value	B	SE (B)	p value
BMI-Z	.011	.007	.106	.011	.007	.102
Percent Body Fat	.129	.050	.010	.147	.048	.003
Fat distribution [§]	.003	.002	.105	.003	.002	.028

B = unstandardized beta coefficient, SE = Standard Error

[§] Fat distribution defined as the ratio of fat mass (kg) in the upper body divided by the fat mass (kg) in the lower body.

Table 4

Multiple variable linear regression analyses with depressive symptoms and trait anxiety and measures of obesity

	Trait Anxiety			Depressive symptoms		
	B	SE (B)	p value	B	SE (B)	p value
Dependent variable						
BMI-Z ¹	.009	.007	.165	.009	.006	.156
Percent Body Fat ²	.115	.052	.029	.133	.050	.008
§Fat distribution ³	.001	.002	.431	.002	.002	.128

B = unstandardized beta coefficient, SE = Standard Error

¹ Adjusted for age, race, Tanner stage (breast)

² Adjusted for age, race

³ Adjusted for age, race, Tanner stage (breast), and socioeconomic status

§ Fat distribution defined as the ratio of fat mass (kg) in the upper body divided by the fat mass (kg) in the lower body.

Figure 1

Differences in mean values of key variables for “normal” vs. “high” depressive symptoms T-scores

* $p < .05$

High depressive symptom T-score was defined as Children's Depression Inventory (CDI) T-score ≥ 54

Normal depressive symptom T-score was defined as CDI T-score < 54