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The Influence of Psychological Stress, Depressive Symptoms, and Cortisol on Body Mass and Central Adiposity in 10- to-12-Year-Old Children☆

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ABSTRACT

Purpose: The purpose of this study was to examine the influence of psychological stress and depressive symptoms on body mass and central adiposity in 10-to-12-year-old children and to determine the mediating role of cortisol in the relationships among psychological stress, depressive symptoms, body mass, or central adiposity.
Design and Methods: The convenience sample included 147 children (84 females; 63 males) who were recruited from one middle school and three elementary schools in a rural area of a southeastern state. Height, weight, waist circumference (WC), and salivary cortisol were measured. Children completed the Rating Scale for Pubertal Development for screening, Children's Depression Inventory, and the Feel Bad Scale. Bivariate correlation, multiple regression analyses, and univariate regression techniques were used in data analyses.
Results: A positive relationship between psychological stress and depressive symptoms ($r = 0.559$, $p < .001$) was found. Depressive symptoms explained a significant amount of the variance in body mass index (BMI) ($\beta = 0.37$, $p \leq .001$) and central adiposity ($\beta = 0.40$, $p \leq .001$) when sex, race/ethnicity, puberty, and socioeconomic status were controlled. No statistically significant relationships were found between psychological stress and cortisol or between depressive symptoms and cortisol.
Conclusions: Depressive symptoms were reported by normoweight, overweight, and obese children. Depressive symptoms accounted for variance in body mass and central adiposity.
Practice Implications
In addition to regular screening of BMI and WC, nurses and other health care professionals need to consider psychological factors that contribute to childhood obesity.

Introduction

Both elevated body mass and central adiposity have increased in U.S. school-age children, with 18.4% of 6–11-year-olds classified as obese in 2015–2016 based on body mass index (BMI), up from 17.4% in 2013–2014 (Centers for Disease Control and Prevention [CDC], 2018; Hales, Fryar, Carroll, Freedman, & Ogden, 2018). Additionally, 18.8% of children and adolescents aged 2–18 years were centrally or abdominally obese based on waist circumference (WC) measurements (Xi et al., 2014). Increases in BMI and central adiposity have resulted in increased health problems in children such as high blood pressure and type 2 diabetes that extend into adulthood (Simmonds, Llewellyn, Owen, & Woolacott, 2015). In addition to health problems, medical costs associated with childhood obesity are estimated at approximately $14 billion annually in direct healthcare expenses (Finkelstein, Graham, & Malhotra, 2014).

Body mass is commonly assessed by using BMI, defined as weight in kilograms divided by the square of the height in meters. Although BMI is often recognized as a representation of increased body mass, it does not provide information about the distribution of body fat (Janssen, Shields, Craig, & Tremblay, 2011). BMI is not an accurate measure of body fat content and does not account for critical factors that contribute to health or mortality, such as fat distribution and proportion of muscle to fat in adults (Ahima & Lazar, 2013). Because BMI cannot distinguish between lean and fat mass, an indication of central adiposity, defined as excessive accumulation of both central subcutaneous and visceral fat embedded in the abdominal area encasing the visceral organs

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(Schwandt, 2011), assessed by WC can be valuable in studies with children. Several studies have suggested that accumulation of body fat around the waist may present a higher risk to health than fat deposited in other parts of the body (Donoho, Weigensberg, Emken, Hsu, & Spruijt-Metz, 2011; Xi et al., 2014). Using an anthropometric measure such as WC as an indicator of central adiposity may be better than BMI alone for predicting risk of hypertension, type 2 diabetes, metabolic syndrome, cardiovascular disease (CVD), and all-cause mortality (Czernichow, Kengne, Stamatakis, Hamer, & Batty, 2011).

Having an elevated body mass and increased central adiposity involves multifactorial influences including genetic, behavioral, environmental, and cultural factors (Anderson et al., 2011; Andrea, Hooker, Messer, Tandy, & Boone-Heinonen, 2017; Petraviciene, Grazuleviciene, Andrusaityte, Dedele, & Nieuwenhuijsen, 2018; Waalen, 2014). Research aimed at understanding the etiology of obesity has focused on two conventional areas, which are poor nutrition and low physical activity, that have shown to influence body mass and central adiposity (Martin et al., 2018). Other common factors noted to influence body mass and central adiposity are sex, race/ethnicity, socioeconomic status (SES), and puberty (Jones, 2018; Prentice & Viner, 2013; Zhang et al., 2018). However, less is known about psychological factors, particularly psychological stress and depressive symptoms, that can lead to elevated BMI and increased WC. Psychological stress, defined as the relationship between the person and environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being (Lazarus & Folkman, 1984), may contribute to an increased body mass and central adiposity via underlying physiological mechanisms. Depressive symptoms include several dimensions that affect children psychologically, socially, and somatically. These different dimensions are negative mood, interpersonal problems, ineffectiveness, anhedonia, and negative self-esteem (Kovacs, 1992). Given the paucity of studies examining psychological factors and the underlying mechanisms that influence body composition in school-age children, we sought to determine the relationships among psychological stress, depressive symptoms, cortisol, body mass, and central adiposity.

Conceptual Framework

The conceptual framework used to guide this study is based on an Integrative Biobehavioral Interaction model undergirded by theoretical underpinnings from three classic theories of stress, Selye's stress theory, Lazarus and Folkman's transactional model of stress, appraisal, and coping, and McEwen's theory of allostasis and allostatic load (Kang, Rice, Park, Turner-Henson, & Downs, 2010). This model includes psychosocial, behavioral, individual, physiological, and environmental factors that can individually and/or interactively influence biological responses that can impact health outcomes (Kang et al., 2010). In our study, we proposed that psychosocial factors (psychological stress and depressive symptoms) directly influence health outcomes (body mass and central adiposity). We also hypothesized that these psychosocial factors would influence health outcomes through the mediation of cortisol, a physiological factor and biological marker of stress and depressive symptoms (Fig. 1).

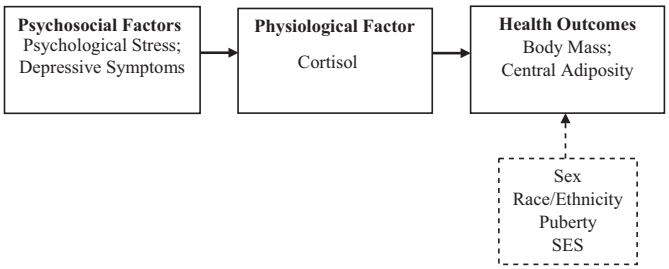

Fig. 1. Conceptual framework.

Review of Literature

Although several studies support a strong association between psychological stress and depressive symptoms in the adult population (Flouri, Narayanan, & Naerde, 2018; O'Dougherty, Hearst, Syed, Kurzer, & Schmitz, 2012), investigations of this relationship in children are less common. Findings in children have noted an association between psychological stress and depressive symptoms, with a focus on stressful life events (Bung, Saile, & Laessle, 2017; Dujardin et al., 2016; Mayer et al., 2009).

The relationships between psychological stress or depressive symptoms and body mass have also not been widely studied in children (Brumby, Kennedy, & Chandrasekara, 2013; De Vriendt, Moreno, & De Henauw, 2009; Van Jaarsveld, Fidler, Steptoe, Boniface, & Wardle, 2009). Studies with adults largely focused on work stress and its association with weight in adults, revealing differing outcomes by gender (Fujishiro, Lawson, Hilbert, Chavarro, & Rich-Edwards, 2015; Nyberg et al., 2012). In one of the few studies with children, Roemmich, Smith, Epstein, and Lambaise (2007) found that children aged 8–12 years who experienced larger increases in heart rate reactivity to an interpersonal stressor also had greater percentage body fat, BMI, and central adiposity. Likewise, depressive symptoms have been associated with body mass in a sample of 678 children and adolescents, aged 11-to-15-years (Cortese et al., 2009). In particular, fewer depressive symptoms were noted in those with moderately underweight status in comparison to those who were obese.

Studies of psychological stress or depressive symptoms and central adiposity are also less common in children. Positive relationships between stress and central adiposity were noted in 8–11-year-old Hispanic girls (Donoho et al., 2011) and in adolescents aged 11- to 15-years (Van Jaarsveld et al., 2009).

Similar to studies on BMI, the research on depressive symptoms and central adiposity is limited in children (Agarwal et al., 2016; Everson-Rose et al., 2009), and findings are equivocal based on sex. Bahreinian, Ball, Colman, Becker, and Kozyrskyi (2011) found an association between WC and depressive symptoms in 11–14-year-old girls whereas Olive, Telford, Byrne, Abhayaratna, and Telford (2017) found increases in depressive symptoms linked to increased percentage of body fat in boys in a study of 791 children (Grade 2 through 10).

The few studies of biological pathways that link psychological stress, depressive symptoms, cortisol, and body mass or central adiposity have been primarily limited to adults (Baltrus, Shim, Ye, Watson, & Davis, 2010; Olstad et al., 2016). However, stress has been associated with high cortisol awakening in children, which is the sharp increase in cortisol secretion following awakening in the morning (Donoho et al., 2011). Cortisol was a mediator in relationships between psychological stress and body mass in the middle school years through adolescence (Miller, Arbel, Shapiro, Han, & Margolin, 2018). Cortisol has also been suggested as a mediator of relationships between depressive symptoms and body mass or central adiposity in children (Dockray, Susman, & Dorn, 2009).

Given the gaps in knowledge related to psychological stress, depressive symptoms, cortisol, body mass, and central adiposity in children, the purpose of this study was to examine the influence of psychological stress and depressive symptoms on body mass and central adiposity in 10-to-12-year-old children and to determine the mediating role of cortisol in the relationships among psychological stress, depressive symptoms, body mass, or central adiposity. Specifically, we sought to address the following research questions in 10-to-12-year-old children: 1) What is the relationship between psychological stress and depressive symptoms? 2) How much of the variance in body mass and central adiposity is explained by psychological stress and depressive symptoms after controlling for sex, puberty, race/ethnicity, and SES? and 3) Does cortisol mediate the relationships between psychological stress, depressive symptoms, and body mass or central adiposity after controlling for sex, puberty, race/ethnicity, and SES?

Methods

Design and Sample

Using a descriptive, cross-sectional design, a convenience sample of 147 (ages 10–12) participants were recruited from fifth and sixth grades in one middle school and three elementary schools in a rural southeastern city school system in the U.S. Children in the schools were from various racial, ethnic, cultural, and socioeconomic groups. Schools selected were chosen by the school district superintendent and administrators based on the age groups and racial and ethnic diversity of the schools. A calculated sample size of 136 participants indicated adequate power for analyses of research questions but not on subgroup analyses by sex or ethnic groups (Hintze, 2013).

Inclusion criteria included: being 10–12 years of age, able to speak and understand English, mentally capable of signing assent, and having parental consent. This age group is important to study because children undergo a transitional stage of development from middle childhood to adolescence, marked by physical and psychosocial changes (Ball, Bindler, & Cowen, 2015). This period is a turning point in the lives of children in which they experience developmental transitions that can contribute to psychological stress (Washington, 2009). Children's move from elementary to middle school can be perceived as stressful. Children often experience bodily changes from prepuberal to pubertal status. Children aged 10–12 years are in Erikson's Stage of Industry, which is a critical period when they learn to develop a sense of self-worth (Ball et al., 2015). Children tend to suffer from the social stigma connected to overweight or obesity; thus, a child's self-worth may be negatively impacted.

Procedure

Approval for this study was obtained from the University Institutional Review Board. Prior to data collection, consent from the participants' parents and assent from participants were obtained. Demographic information (e.g., child's age, grade level, race/ethnicity, sex, parents' occupation, and level of education) were collected from the parents at the time of consent. Height, weight, WC, saliva for cortisol, and children's self-report of pubertal status, depressive symptoms, and psychological stress were obtained from the children during one session in classrooms during non-academic elective courses. Participants completed self-report questionnaires after physical measurements were obtained. Parents and children were informed through the consent process that questions on the self-report questionnaires could elicit emotional reactions and that, if the child became upset or desired to stop, they could stop, and school counselors would be notified. No items on the instruments addressed self-harm thoughts or suicide.

Measures

Socioeconomic Status

Socioeconomic status was determined with the use of the Nam-Powers-Boyd occupational status tool (Nam & Boyd, 2004). Parents self-reported occupation on a demographics questionnaire. The occupations were assigned a score based on the occupation listed on the Nam-Powers-Boyd Scale, and then arranged into low, middle, and high socioeconomic classifications.

Rating Scale for Pubertal Development

Participants were screened for pubertal development with the use of a self-report rating scale, A Self-Administered Rating Scale for Pubertal Development (Carskadon & Acebo, 1993). The rating scale was developed individually for females and males based on five indices of pubertal growth. All participants were asked about growth, body hair, and skin changes. Each scale item was followed by five possible choices, allowing the child to select the one that most closely represented his or her physical growth. Each response has an assigned numerical value. Scores are summed and range from 0 to 20 with higher scores indicating a great level of pubertal maturation. In previous studies, alpha coefficients for internal consistency ranged from 0.67 to 0.70 (Carskadon & Acebo, 1993). The alpha coefficient for this study was 0.75.

Psychological Stress

Psychological stress was conceptualized as events or situations that the children perceived as stressful and was measured by the Feel Bad Scale (FBS) (Lewis, Siegel, & Lewis, 1984). The FBS has 20 items that originated from focus groups on fifth and sixth graders' interviews about situations that "made them feel bad" (Lewis et al., 1984). Participants were asked to report how they would feel if the situation described happened to them and rate it on a Likert-type scale. Participants first rated the intensity of the item by using a 5-point scale with 1 representing *not bad* to 5 representing *terrible*. Next, participants were asked to indicate how often, if ever, the situation had occurred on a 5-point scale with 1 for *never* to 5 for *always*. Lewis et al. (1984) reported the ratings of internal consistency of coefficient alpha at 0.82 in a sample of ethnically diverse group of children, and factor analysis supported construct validity of the FBS. In this study, the Cronbach's alpha coefficient was 0.89.

Depressive Symptoms

Depressive symptoms were measured by The Children's Depression Inventory (CDI), a 27-item self-report questionnaire designed to measure depressive symptoms in children aged 7–17 years-old (Kovacs, 1992). The instrument encompasses cognitive, affective, and behavioral functioning of depression. Each item describes a depressive symptom such as disturbance in mood, sleep, appetite, or interpersonal relationships. Scores range from 0 to 52 with higher scores indicating increasing depressive symptoms. A cutoff score of 13 has been suggested to indicate children with mild depressive symptoms and a cutoff of 19 to denote children with severe symptoms (Kovacs, 1992). In previous studies, the alpha coefficients for internal consistency ranged from 0.74 to 0.83 (Kovacs, 1992). The alpha coefficient for this sample was 0.90.

Height and Weight

Height was measured to the nearest ¼ inch using a portable stadiometer, and weight was measured to the nearest ¼ pound by use of a freestanding balance beam scale according to established recommendations by Heyward and Wagner (2004). Measurements were converted to metric units for analyses. BMI was calculated based on the following formula: weight in kilograms (kg) divided by the square of height in meters (m^2), with overweight defined as a BMI in the 85th to 94th percentile and obesity defined as a BMI at or above the 95th percentile (Centers for Disease Control and Prevention, 2015).

Waist Circumference

WC, an indicator of central adiposity, was measured according to protocol by Heyward and Wagner (2004). WC was measured twice to the nearest 1/16 in. and converted to centimeters. An average reading from the two measurements was calculated. Anthropometric reference data to include WC percentiles established from the NHANES (National Health and Nutrition Examination Surveys) studies based on age and sex were used in analysis (Fryar, Gu, Ogden, & Flegal, 2016).

Cortisol

Salivary specimens for cortisol were obtained using the passive drool method and collected at mid-morning (9:30 AM–11:00 AM), at least one hour after breakfast and prior to lunch, to potentially minimize circadian variability and standardize the collection time. Collection, transfer, and storage of saliva specimens were followed by the

Parameter Cortisol Assay protocol (R & D Systems, 2012) and the literature (Hanneman, Cox, Green, & Kang, 2011). Cortisol level was determined by a standard two-step sandwich enzyme-linked immunosorbent assay (ELISA) using commercially prepared high-sensitivity kits (R & D Systems, MN, USA). To help ensure intra-assay accurateness, samples were assayed in duplicate. The assay sensitivity for salivary cortisol was 0.07 ng/ml and mean intra- and inter-assay coefficients of variation were 6.9% and 13.6%, respectively, indicating high sensitivity and precision.

Analysis

To address the research questions, SPSS (Statistical Package for Social Sciences) 23.0 (IBM Corp., Armonk, NY) was used to calculate descriptive statistics including means, standard deviations, and ranges. Bivariate correlation using Pearson's product-moment correlation was used to address the first research question, and hierarchical multiple regression analyses were used to address the second research question. For research question three, based on the principles of the mediation model proposed by Baron and Kenny (1986), simple linear regression and multiple regression analyses were planned. Cortisol is deemed to function as a mediator a) if there is a significant relationship between the independent variables and the hypothesized mediator; b) if there is a significant relationship between the independent variables and the dependent variables and; c) if there is a significant relationship between the hypothesized mediator and the independent variables.

Results

The final sample included 147 completed data sets. Of the 147 children, 84 were female and 63 male (60 ten-year-olds [35 female, 25 male]; 64 eleven-year-olds [36 female, 28 male]; and 23 twelve-year-olds [13 female, 10 male]). The mean age was 10.75 years (*SD* 0.71). Demographic data including age, sex, race/ethnicity, pubertal status, and socioeconomic status are presented in Table 1. Descriptive statistics for BMI, WC, cortisol, depressive symptoms, and psychological stress appear in Table 2. The majority of children (57.8%) were overweight (17.7%) or obese (40.1%) based on BMI percentiles for age and sex (Centers for Disease Control and Prevention, 2015). Using anthropometric percentiles for WC, the mean WC for the sample was at the 75th percentile (Fryar, Carroll, & Ogden, 2016), with 38% ($n = 56$) of children with WC values at or above this percentile.

Table 1
Sample characteristics (N = 147).

Variable		*n* (%)
Age	10	60 (40.8)
	11	64 (43.5)
	12	23 (15.6)
Sex	Females	84 (57.1)
	Males	63 (42.9)
Race/Ethnicity	African American	17 (11.6)
	Asian	3 (2.0)
	Caucasian	99 (67.3)
	Hispanic	26 (17.7)
	More than one race	2 (1.4)
Puberty	Prepubescent	70 (47.6)
	Females	24 (34.3)
	Males	46 (65.7)
	Pubertal	71 (48.3)
	Females	56 (78.9)
	Males	15 (21.1)
	Unknown	6 (4.0)
Socioeconomic status	Low	38 (25.9)
	Middle	98 (66.7)
	High	11 (7.5)

Note. Because of rounding, not all percentages total 100.

Table 2
Means, standard deviations, and ranges of study variables (N = 147).

Variable	Mean (SD)	Range
Body mass index (kg/m2)	21.93 (5.01)	13.42–36.54
Waist circumference (cm.)	76.65 (5.28)	51.18–114.30
Cortisol (nmol/l)[a]	6.75 (6.75)	1.97–46.08
Depressive symptoms	11.14 (8.98)	0–37
Psychological stress	12.44 (54.90)	200–500

[a] $n = 144$.

When analyzed by age, sex, pubertal status, race/ethnicity, and SES, those who were overweight included 15 ten-year-olds, 10 eleven-year-olds, and one twelve-year-old. Those in the obese category included 22 ten-year-olds, 26 eleven-year-olds, and 11 twelve-year-olds. Seventeen girls and nine boys were overweight while 29 girls and 30 boys were obese. Based on pubertal status and overweight, 12 overweight participants were prepubertal while 14 were pubertal. Of those who were obese, 31 were prepubertal, 25 pubertal, and three unknown due to incomplete data. For overweight status, 20 were Caucasian, three African American, and three Hispanic. Thirty-eight Caucasian, 14 Hispanic, and 7 African American were obese. Of participants who were overweight, six children were in low SES, 20 in middle SES, and none high SES. In the obese category, 26 children were in low SES, 30 in middle SES, and three high SES.

Three children did not provide adequate saliva samples for testing of cortisol; thus, 144 total samples were included in the analysis of cortisol. Cortisol levels were within the normal limits of 1.69 to 12.81 nmol/l (Safarzadeh, Mostafavi, & Haghi, 2005) for approximately 91.7% ($n = 132$) of the group; however, 8.3% ($n = 12$) of the children had values that were >12.81 nmol/l.

Twenty-four (16.3%) of the participants reported mild to moderate depressive symptoms, while 23.1% ($n = 34$) indicated severe levels of depressive symptoms (Table 3). Of the normoweight ($n = 62$) children, 25% ($n = 16$) reported levels of depressive symptoms with 16.1% ($n = 10$) reporting mild or moderate levels and 9.7% ($n = 6$) reporting severe levels of depressive symptoms. Children in the overweight ($n = 26$) category reported depressive symptoms with 15.4% ($n = 4$) reporting mild to moderate symptoms and 34.6% ($n = 9$) indicating severe levels of depressive symptoms. Finally, of the 59 children in the obese category 49.1% ($n = 29$) reported depressive symptoms of which 16.9% ($n = 10$) were mild to moderate and 32.2% ($n = 19$) severe levels.

Of the 147 children, 46.3% ($n = 68$) had FBS scores higher than the mean value of 124.44 for the group. Of the 68 students who scored higher than the mean, 4.4% ($n = 3$) had BMI values between the 85th and 94th percentile, and 58.8% ($n = 40$) had BMI values at or above the 95th percentile.

A positive relationship between psychological stress and depressive symptoms was found ($r = 0.559$, $p < .001$), with those reporting higher psychological stress also having higher depressive symptoms. After controlling for puberty, sex, race/ethnicity, and SES, the independent variables depressive symptoms and psychological stress explained a significant amount of the variance in BMI scores $F(7, 139) = 4.49$, $p < .001$, ΔR^2 0.14. Depressive symptoms were significantly related to BMI ($\beta = 0.37$, $p < .001$); however, psychological stress did not relate to BMI (Table 4).

Table 3
Depressive symptoms and weight status (N = 147).

	Normoweight	Overweight	Obese	Total
Depressive symptoms	*n* (%)	*n* (%)	*n* (%)	*n*
None	46 (74.2)	13 (50)	30 (50.8)	89
Mild to moderate	10 (16.1)	4 (15.4)	10 (16.9)	24
Severe	6 (9.7)	9 (34.6)	19 (32.2)	34
Total, *n*	62	26	59	147

Table 4
Regression coefficients of control variables, psychological stress, and depressive symptoms on body mass (N = 147).

Coefficients[a]						
	Unstandardized coefficients		Standardized coefficients	t	P	Tol.
	B	Std. error	Beta			
Constant	0.44	0.42		1.06	.29	
Sex	0.35	0.19	0.16	1.87	.06	0.79
Prepubertal	−0.18	0.19	−0.09	−0.97	.33	0.76
SES (low)	−0.00	0.36	0.00	−0.01	.99	0.28
SES (mid)	−0.17	0.33	−0.08	−0.53	.60	0.29
Ethnicity	−0.05	0.18	0.02	−0.25	.80	0.96
CDI	0.05	0.01	0.37	3.91	<.001	0.66
FBS	0.00	0.00	0.03	0.37	.72	0.67

$F(7, 139) = 4.49$, $P < .001$.
CDI = Children's Depression Inventory; FBS = Feel Bad Scale.
Tol. = Tolerance statistic.
[a] Dependent variable: BMI. R Squared = 0.18 (Adjusted R Squared = 0.14).

After controlling for puberty, sex, race/ethnicity, and SES, the study variables (psychological stress and depressive symptoms) were added to the model to test for significant variance in central adiposity. The full model including the control variables, depressive symptoms, and psychological stress revealed a significant contribution of 24.9% to the amount of variance explained in central adiposity, $F(7, 139) = 7.93$, $p < .001$, ΔR^2 0.25. Depressive symptoms were found to contribute significantly to central adiposity ($\beta = 0.40$, $p < .001$), while psychological stress did not contribute significantly in the model (Table 5).

To address the third research question, simple linear regression models were used to determine whether, after puberty, sex, race/ethnicity, and SES were controlled, cortisol mediated the relationships between psychological stress and body mass and/or between depressive symptoms and body mass. The lack of relationships between psychological stress and cortisol, and between depressive symptoms and cortisol precluded the testing of cortisol for mediation among the study variables.

Discussion

The majority of the participants in this study were overweight or obese with more being obese than overweight. Children in the obese category in this study exceed that of those reported in the national NHANES study (18.4%) (Hales et al., 2018) but are similar to the estimated 50% in the southern region of states (Singh, Kogan, & van Dyck, 2010). The prevalence of overweight and obesity in children aged 10- to 17- years in the state where data were collected is estimated to be 35.5% (National Survey of Children's Health, 2016), which is lower than the percentage of 57.8% in our sample of children. Evidence suggests that low SES may be an associated factor with weight status, particularly overweight or obese (Rogers et al., 2015). In this sample, a majority of children were low to mid SES. Overweight or obese could be linked to SES; however, parents self-reported SES based on their occupation, and this information could not be substantiated and remains unclear.

Table 5
Regression coefficients of control variables, psychological stress, and depressive symptoms on central adiposity (N = 147).

Coefficients[a]						
	Unstandardized coefficients		Standardized coefficients	t	P	Tol.
	B	Std. Error	Beta			
Constant	25.35	1.89		13.42	<.001	
Sex	0.65	0.86	0.06	0.76	.45	0.79
Prepubertal	−0.63	0.86	−0.06	−0.74	.46	0.76
SES (low)	1.29	1.64	0.11	0.79	.43	0.28
SES (mid)	0.06	1.50	0.00	0.04	.97	0.29
Ethnicity	−0.07	0.82	−0.00	−0.08	.93	0.97
CDI	0.24	0.05	0.40	4.54	<.001	0.66
FBS	0.02	0.00	0.16	1.83	.07	0.67

$F(7, 139) = 7.93$, $P < .001$.
CDI = Children's Depression Inventory; FBS = Feel Bad Scale.
Tol. = Tolerance statistic.
[a] Dependent variable: Central Adiposity. R Squared = 0.26 (Adjusted R Squared = 0.25).

The WC mean in this group of children was above the national average. This finding differs from Xi and colleagues' report from national data that found children aged 6-to-11 years had an average WC of 65 cm (Xi et al., 2014). Approximately, 66 (44.8%) of children in this sample had WC values above the group mean. More girls in our study had WC above the 90th percentile than boys. These findings correspond with other investigators who found girls to have higher WC measurements than boys (Aeberli, Gut-Knabenhans, Kusche-Ammann, Molinari, & Zimmerman, 2011). Again, this might be the result of the number of children who were low SES, a factor found to influence overweight and obesity (Lee, Harris, & Lee, 2013; Rogers et al., 2015).

A majority of children had cortisol values within normal range; however, 8.3% had cortisol values above the norm. In this sample, the cortisol values were not associated with elevated body mass or central adiposity. This finding contrasts with that of Chu et al. (2017), who found a positive relationship between cortisol and body composition in children. Because few studies exist with children, it is difficult to draw any conclusions about the relationships between cortisol and body mass or between cortisol and central adiposity. Chronic hyperstimulation of the hypothalamic-pituitary-adrenal (HPA) axis may be attributed to some dysregulation that leads to over- or under-secretion of cortisol; thus, a blunting effect of cortisol needs to be considered. This explanation of an altered HPA response pattern is plausible given the lack of elevations in our sample. Some researchers have noted that salivary cortisol levels were lower with altered HPA activity in children with elevated BMI compared to non-overweight children (Hillman, Dorn, Loucks, & Berga, 2012; Kjölhede, Gustafsson, Gustafsson, & Nelson, 2014). It is difficult to speculate because the associations between cortisol production and overweight and obesity have been understudied in children.

A positive relationship was found between psychological stress and depressive symptoms, and this finding is in line with those of other studies of adolescents (Braet, Vlierberghe, Vandevivere, Theuwis, & Bosmans, 2012; Mazurka, Wynne-Edwards, & Harkness, 2016). Because few investigators have noted the positive associations between depressive symptoms and psychological stress in school-age children, specifically children in our age grouping (Byrne, Olive, & Telford, 2016; Williamson, Birmaher, Dahl, & Ryan, 2005), determining consistency of these findings across studies may be a challenge.

Findings on the scores of the Feel Bad Scale reflected lower levels of stress. The mean score on the Feel Bad Scale for this sample was lower than that found by Lewis et al. (1984) with fifth and sixth grade children. Our findings are similar to recent studies that found relatively low perceived stress scores in children ($n = 30$) 7–12- year-olds with type I diabetes and in central nervous system cancer survivors ($n = 21$) ages 8–12 (Davis, 2017; Johnson, 2016). Given that the majority of the study participants' cortisol levels were within normal range, this finding coincides with scores on the Feel Bad Scale. The low perceived stress scores may be due to the Feel Bad Scale's lack of more relevant aspects (e.g., electronic communication, social media) that are associated with children's perception of stress (Kim, 2017).

Over 39% of participants indicated some level of depressive symptoms with the majority indicating severe levels. The percentage of children with severe levels of depressive symptoms corroborate findings of an earlier study of 510 (270 boys, 240 girls) aged 7–13 years in which 23% of children were noted to have elevated levels of depressive symptoms (McCabe, Ricciardelli, & Banfield, 2011). Not only did overweight

and obese children report depressive symptoms but normoweight children also reported depressive symptoms as well. In line with findings from a recent study, 478 school-age children reported depressive symptoms that ranged 20% to 50% during a seven-year period (Gudmundsen, Rhew, McCauley, Kim, & Stoep, 2018). These findings are of concern because depressive symptoms not addressed during childhood can lead to negative outcomes such as academic issues, impaired social relationships, and physical health problems (Horowitz & Garber, 2006).

Analyses addressing research question two indicated that depressive symptoms explained a significant amount of the variance in body mass and central adiposity when the control variables were in the full model. The finding is consistent with those of other researchers who found strong relationships between depressive symptoms and body size in children (Bahreinian et al., 2011; Cerniglia et al., 2018). In a study of 148 obese children, 7-to-10-years-old, researchers found significantly higher depressive symptoms in the obese group compared to a control of 273 healthy weight children (Esposito et al., 2014). It is plausible that overweight and obesity in children may lead to experiences of depressive symptoms. Without a longitudinal study examining these relationships over time, it is not possible to untangle the relationship.

Whereas depressive symptoms were significant in explaining both body mass and central adiposity, psychological stress was not significant. This, despite the fact that psychological stress was related to both BMI and WC. This finding differs from other investigations (Brumby et al., 2013; Roberts, Troop, Connan, Treasure, & Campbell, 2007) that noted the significant contribution of psychological stress between body weight and central adiposity in adults. Several studies found associations between psychological stress and increased WC in adolescents (Goldbacher, Matthews, & Salomon, 2005; Van Jaarsveld et al., 2009). It may be that psychological stress did not influence body mass or central adiposity because of low levels of perceived stress reported by the participants, confirmed by the mostly normal levels of cortisol. Or conceivably, psychological stress could influence depressive symptoms, and in turn, depressive symptoms could influence body mass and central adiposity. No studies at this time have examined depressive symptoms as a mediator among these relationships, and this would be interesting to consider in future studies.

Last, there were no significant relationships found between psychological stress and cortisol and between depressive symptoms and cortisol. This finding is inconsistent with other studies (Dockray et al., 2009; Francis, Granger, & Susman, 2013) who found that depressive symptoms were associated with increased cortisol and psychological stress linked to cortisol elevations in children (Donoho et al., 2011; Rao, Hammen, Ortiz, Chen, & Poland, 2008). Depressive problems were found to be related to higher cortisol in the morning in a general population of 1604 children aged 10–12 years (Dietrich et al., 2013). Alternatively, an earlier study found reduced cortisol responses to psychological challenges in young children (Luby et al., 2003). A possible explanation for the lack of significant relationships may be due to a diminished stress response that can occur with chronic stress; essentially, a blunting effect could exist. Ruttle et al. (2011) suggest that sustained high cortisol levels could normalize over time due to prolonged exposure to psychological factors, particularly stress in children. Some underlying mechanism may be at play; thus, a biobehavioral facet (e.g., stress-induced eating) that is linked to body mass and central adiposity may need to be considered for future study.

Limitations

Several limitations must be considered. The study was conducted in one school system in the southeastern U.S. Although African American and Hispanic children were represented in the study, the sample included a majority of Caucasian children, and the study was not powered to examine differences based on race/ethnicity or sex. Studies in other geographic locations may generate different results, which limits generalizability. Future studies need to include larger numbers of African American and Hispanic children to determine consistency of findings.

Because the study design was cross-sectional, and data were collected at one point in time, no causal relationships among the variables can be concluded. Thus, it is possible that the directions of psychological stress and depressive symptoms with body mass and central adiposity are reversed. Similar studies with larger, more diverse samples conducted over time may help to inform what underlying mechanism contribute to the development of increased body mass and central adiposity. Cortisol, a physiological measure of stress, was used to corroborate the psychological stress reported by participants. Based on the feasibility of repeated saliva specimen collection in a school setting, cortisol was measured by a single sample of saliva. Because a diurnal rhythm exists in healthy individuals, dysregulation in cortisol secretion could not be established with one sample. Therefore, measurement of cortisol at different times will need to be considered for future studies. In addition, psychological stress and depressive symptoms need to be studied over time to determine whether blunted cortisol effects or some dysregulation of the HPA axis is occurring.

Practice Implications

Given that the participants in this study reported psychological stress and depressive symptoms regardless of elevations in BMI and WC, it would be important to address such psychological issues in children beginning early in childhood. It is important to promote regular screening for depressive symptoms and psychological stress in children within primary prevention assessments by health care professionals. Although it may be beneficial to assign school nurses to assess depressive symptoms in the school setting, it may not be feasible to expect that every school will employ a full-time nurse to screen children or that the nurses would have time to perform screenings. Should evidence emerge that psychological stress or depressive symptoms lead to obesity in children, this may open new strategical approaches in reducing overweight and obesity. In addition, nurses can play an essential role in educating clinicians that both BMI and WC need to be included at child well visits. Incorporating body composition measurements such as BMI and WC may provide valuable monitoring of children over time and provides opportunities for early intervention in overweight and obese prevention.

Conclusions

Overweight and obesity as measured by BMI and WC were evident in the majority of children in this sample. This is of concern as obesity and overweight in children track to adulthood and are associated with chronic diseases such as diabetes, cardiovascular disease, and cancer. Further, more than one-third of children in this sample, no matter weight status, reported depressive symptoms, something not reported previously in the literature (Benson, Williams, & Novick, 2012). Depressive symptoms can impact academic achievement, interpersonal relationships, and potentially result in thoughts of self-harm or suicide and is a factor in the development of chronic diseases, such as cardiovascular disease. It is essential then to assess not only depressive symptoms but also overweight and obesity during this crucial developmental period. If depressive symptoms are noted, school nurses need to make referrals for further assessment and possible treatment.

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