THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF BIOBEHAVIORAL HEALTH

Sex Differences in Eating in Response to Stress: The Moderating Role of Disordered Eating Behaviors

HOPE IDICULLA
SPRING 2022

A thesis
submitted in partial fulfillment
of the requirements
for baccalaureate degrees
in Biobehavioral Health and Science
with honors in Biobehavioral Health

Reviewed and approved* by the following:

Lori A. Francis
Associate Professor of Biobehavioral health
Thesis Supervisor

Helen M. Kamens
Associate Professor of Biobehavioral health
Honors Adviser

* Electronic approvals are on file.

ABSTRACT

Background: Adolescent obesity, which has been described as an epidemic among youth in America, shows links to disordered eating behaviors. There is evidence of sex differences in adolescent obesity, but little research has been conducted on these sex differences and the role of disordered eating behaviors in adolescent stress eating, especially among multicultural, low socioeconomic status, and non-metropolitan communities. Further research is also needed to address the role of cortisol recovery and body mass index (BMI) status in adolescent stress eating. Examining sex differences in stress eating may provide new information to inform the development of interventions to prevent adolescent obesity.

Objectives: There were three main objectives of this paper: (1) to determine if there were sex differences in eating in response to stress, (2) to determine if sex differences in stress-related eating differed based on adolescents' disordered eating behaviors, and (3) to determine if there were sex differences in cortisol responding and BMI in adolescents who consume more in response to stress compared to those who do not.

Methods: Participants included 278 predominantly low-income and rural adolescents (mean age = 14.2 $\pm$ 0.6) and their parents. Families were seen for two, 2.5-hour visits (i.e., one low-stress visit, one high-stress visit) that were ~1 week apart, which varied based on youth exposure to a psychosocial stress task. Pre- and post-weight intake was measured from an ad-libitum meal served at both visits. Youth height and weight were measured by trained research assistants. Adolescents provided a self-report of their disordered eating behaviors, including restrained eating, emotional eating, and external eating.

Results: Adolescents did not consume significantly more kilocalories (kcals) on the high-stress visits than the low-stress visits. No significant sex differences were found in eating in response to stress for difference in kcal intake; however, boys exhibited greater consumption during the meal at each home visit (for both low- and high- stress days) than girls. There were no sex differences in eating in response to stress based on adolescents' disordered eating behaviors. There was a trend towards high-stress eating boys consuming greater kcals in response to stress than high-stress eating girls. Additionally, there was a trend in low-stress eating boys consuming fewer kcals in response to stress than low-stress eating girls. There was a trend towards girls who were high-stress eaters showing blunted cortisol recovery in response to stress. There was a trend towards boys who were low stress-eaters having lower BMI z-scores compared to girls who were low stress-eaters.

Conclusion: There were no major sex differences in stress-related eating in this sample of adolescents from rural, poor households. Future studies are needed to further assess sex differences in stress eating and disordered eating behaviors in order to inform interventions that address eating behaviors that may influence adolescent obesity.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

Thank you to all the amazing people in my life.

To Dr. Francis, thank you for your wonderful support and vital insight. I truly could not have done this project without your guidance.

To Dr. Kamens, thank you for your reliable communication and thoughtful revisions.

To my family, thank you for believing in me and giving me all the love in the world. I love you all so much.

To my friends, thank you for all the late-night study sessions. We did it!

Chapter 1

Introduction

Adolescent Obesity

Adolescent obesity has been described as an epidemic among youth in America (Sanyaolu, 2019), especially among multicultural, low-socioeconomic status (SES), and non-metropolitan communities (Caprio et al., 2008). Those belonging to non-Hispanic Black, Hispanic, American Indian, and Alaskan Native populations exhibit greater levels of obesity compared to non-Hispanic White and non-Hispanic Asian as of 2015-2016 (Hales et al., 2017). Additionally, youth from lower-income populations and those with parents with lower levels of education have been shown to have higher rates of obesity compared to those from higher-income families and those with parents with higher education levels (Ogden et al., 2018a). Moreover, trends in obesity show that youth from rural populations display higher rates of overweight and obesity compared to youth from urban populations (Johnson & Johnson, 2015).

Adolescent obesity has been shown to be associated with a multitude of negative physical health outcomes, including chronic diseases such as type 2 diabetes, metabolic risk factors, asthma, and dental health issues (Delamater et al., 2013). Additionally, various psychosocial comorbidities include internalizing and externalizing disorders (Trent et al., 2009; Bell et al., 2011; Eschenbeck et al., 2009; Fiese et al., 2009; Hillman et al., 2010; Gibson et al., 2008; Datar & Sturm, 2004; Anderson et al., 2006; Bell et al., 2007), attention-deficit hyperactivity disorder (Agranat-Meged et al., 2005; Kim et al., 2011), and sleep problems (Bayer et al., 2009; Nixon et al., 2008). Poor body image, social isolation, discrimination, and reduced quality of life may also be consequences of adolescent obesity (Delamater et al., 2013). Obesity in youth has been shown to have both short- and long-term negative health outcomes and more research is required to understand its potential causes and best approaches to prevention. Sex differences in obesity have also been seen as obesity has proven to be greater and increasing in boys (20.6% as of 2015-16) compared to girls (18.4%) in the U.S, as evidenced by a nationally representative study of obesity trends from 1999-2016 (Wang et al., 2020).

The development of obesity in adolescents can partially be explained using the energy balance equation. The energy balance equation is derived from Newton's first law of thermodynamics in which energy can neither be created nor destroyed (Hall et al., 2012). This is true for human biology in that energy consumed through food cannot be created nor destroyed but instead must be used or stored in the body. The energy balance equation determines the rate of change in body energy stores: energy balance = energy intake - energy expenditure. Thus, to gain weight, energy intake must be greater than energy expenditure. To lose weight, energy expenditure must be greater than energy intake. To maintain weight, energy in would be equivalent to energy out (Hall et al., 2012). For the purposes of this thesis, the energy intake side of the equation will be focused on with an emphasis on disordered eating behaviors. We hypothesized that disordered eating behavior impacts energy intake in ways that may lead to weight gain and eventual obesity.

Disordered Eating Behaviors in Adolescents

Disordered eating is a prevalent issue in the U.S., and among adolescents, body dissatisfaction and disordered eating are prevalent across all socioeconomic backgrounds (Larson et al., 2021). Disordered eating behaviors are linked with adolescent obesity (Braet et al., 2008;

Neumark-Sztainer et al., 2006) as well as other negative health outcomes such as malnutrition (in the case of restrictive disordered eating, such as dieting), and diabetes (in the case of overeating eating behaviors, such as binge eating) (Johnson et al., 2002; Kelly et al., 2005). Adolescent disordered eating behaviors are often a precursor to eating disorders, which have considerable morbidity and mortality rates (Neumark-Sztainer, 2011). Disordered eating is also prevalent among adolescents from diverse racial/ethnic backgrounds; however, large gender and racial/ethnic disparities exist. For example, disordered eating behaviors have been shown to be greater in girls, especially those from Hispanic and American Indian races (Croll et al., 2002). The intersectionality of belonging to a racial/ethnic minority and a gender minority may place girls of racial/ethnic identities at the most risk (Beccia et al., 2019). Disordered eating behaviors describe a wide range of different eating behaviors (Ackard, 2004), but for the purposes of this thesis, 4 dimensions of eating behaviors known to be potential risk factors for obesity will be reviewed: restrained, emotional, external, and stress-related eating.

Restrained Eating

Restrained eating is an eating behavior in which individuals cognitively suppress their energy intake, typically for weight control purposes (Fedoroff et al., 1997). Although it seems as though this eating behavior should be associated with lower levels of body mass index (BMI), results from studies have found that restrained eating is associated with a high BMI trajectory in early adolescence (Stice, 2001; Lluch et al., 2000; Rutters et al., 2011; Wardle et al., 1992). Additionally, studies have shown that restrained eating is associated with overweight and obesity in adolescents (Braet et al., 2008). Snoek et al. (2013) also found that in adolescents ages 13-15 years old, restrained eating was related to BMI, but only in early adolescence. Other studies in adolescents have suggested a bidirectional association between restrained eating and obesity in that BMI predicted restrained eating more than restrained eating predicted BMI (Snoek et al., 2008; Lawless et al., 2021). Moreover, other studies have shown that the relationship between restrained eating and obesity varies by population. In normal weight adult populations, a positive association was found between higher restrained eating and obesity (de Lauzon-Guillain et al., 2006; Lluch et al., 2000; Bellisle et al., 2004; Provencher et al., 2003), but in people with obesity, the opposite was true (Bellisle et al., 2004; Provencher et al., 2003; Cappelleri et al., 2009; Foster et al., 1998). These results may indicate that restrained eating is an obesogenic eating behavior in people with normal weights whereas it separates those who attempt to restrain eating behavior in people with obesity, in which overeating is common (Johnson et al., 2012). Overall, there is clear evidence of an association between restrained eating and obesity.

Some studies report that restrained eaters demonstrate self-control in food intake (van Koningsbruggen et al., 2013); however, restraint theory suggests that restrained eating leads to disinhibited eating behaviors and results in increased calorie intake (Johnson et al., 2012). For the purposes of this study, restraint theory is used to explain potential associations between restrained eating and obesity. Restraint theory originally evolved as a part of the Theory of Externality (Herman & Polivy, 1980). It was thought that chronic caloric restraint led to food deprivation, reduced internal cues, and thus, resulted in more sensitivity to external stimuli and overeating (Stroebe et al., 2008).

Emotional Eating

Emotional eating is a type of disinhibited eating behavior as it is influenced by factors other than hunger (Stunkard & Messick, 1985), and is defined as eating in response to negative emotions such as depression, sadness, stress, etc. as evidence shows that negative emotions have a greater impact on calorie consumption in high emotional eaters compared to positive emotions (van Strien et al., 2013; van Strien et al., 2016a). Emotional eating relates to the psychosomatic theory in which emotional eaters do not respond to internal cues of satiety, but to their emotions instead, especially with feelings of anxiety and stress (Kaplan & Kaplan, 1957).

Evidence shows that there are mixed results between emotional eating and obesity in adolescent studies. A systematic review by Limbers and Summers (2021) found that across 13 different studies (including both cross-sectional and longitudinal) of 12- to 19-year-old youths, most studies did not show a link between emotional eating and weight status; however, findings from other studies have provided evidence that emotional eating is indeed associated with higher weight status and BMI in adolescents (Shriver et al., 2019; van Strien et al., 2016a). van Strien (2018) suggests that emotional eating may emerge during adolescence, possibly due to the increase of estrogen during puberty (Klump, 2013; Klump et al., 2016). Further research is needed to examine the associations between emotional eating and BMI in adolescents.

External Eating

Schachter's Theory of Externality suggests that people with obesity are more sensitive to external stimuli, such as sight, smell, or appearance of palatable foods, and less responsive to internal cues of satiety, thus leading to overeating and weight gain (Schachter, 1971; Schachter

& Rodin, 1974). This phenomenon is referred to as external eating, which is another type of disinhibited eating due its influence by factors other than hunger (Stunkard & Messick, 1985). Many older studies have supported the link between external eating and obesity (Goldman et al., 1968; McArthur & Burstein, 1975; Nisbett, 1968; Ross, 1974; Schachter & Friedman, 1974; Schachter et al., 1968; Schachter & Gross, 1968; Tom & Rucker, 1975).

Moreover, more recent studies have linked external eating behavior to increased BMI. Braet et al. (2008) found that 38.4% of youth ages 7-13 who were overweight reported external eating. Additionally, another study found that children who were overweight scored higher in external eating and food responsiveness compared to normal-weight children (Jahnke & Warschburger, 2012). For adults, a seperate study found that men and women ages 35-55 who regained weight over a period of 2 years after losing it scored higher for external eating and other disordered eating behaviors compared to those who kept off the weight (Neumann et al., 2018). External eaters may have more difficulty losing weight in general for adults (Dohle et al., 2018) and youth ages 8-12 (Nederkoorn et al., 2007). While these studies focus on populations other than adolescents, it demonstrates the need for more research on adolescents to confirm the relationship between external eating and increased BMI.

Stress Eating

Stress is known to be linked with obesity through various interacting pathways, including cognitive (executive function and self-regulation), physiological (Hypothalamic-pituitary-adrenal axis), behavioral (eating, physical activity, and sleep), and others (Tomiyama, 2019). Stress has been linked to changes in eating behaviors; studies have shown that stress may lead to unhealthy eating behaviors through an indirect pathway in which stress results in deviations in normal, healthy behaviors (O'Connor et al., 2008). In rodent models, stress has been shown to have various effects on eating behaviors, from not eating at all to increasing food intake so much that they gain weight (Patterson & Abizaid, 2013). Dallman et al. (2003) proposed that people increase their consumption of comfort food while under stress to reduce the activity of the chronic stress-response network. For the purposes of this thesis, we hypothesized that stress may be associated with obesity in adolescents due to its effects on disordered eating behavior, namely eating in response to stress. Stress-related eating may be a maladaptive response to stress, and adolescents may use food to soothe themselves after a stressful experience. Previous studies have shown that comfort eating may help to decrease the negative affect resulting from stress, and may provide emotional relief (Klatzkin et al., 2019). Another study found that negative feelings of self-worth were associated with external eating while feelings of physical incompetence were associated with emotional eating (Braet & Van Strien, 1997). Differences in stress eating may be sex-related and evident in youth with other disordered eating behaviors.

Sex Differences in Disordered Eating Behaviors

There is evidence of sex differences in disordered eating behaviors among adolescent girls and boys. Prevalence of disordered eating behaviors is typically higher in females than males (Nagata et al., 2018). In preadolescent and adolescent girls, restrained eating was linked to a higher risk of developing obesity (Stice et al., 1999; Stice et al., 2005). With respect to emotional eating, Snoek et al. (2007) found no significant association between BMI and emotional eating in girls, but a negative correlation in boys. That is, boys with higher levels of emotional eating had lower BMIs. Additionally, in a study of patients ages 7-19 with extreme obesity in an obesity treatment program, significant sex differences were found in that boys with high external eating and low behavioral inhibition (a measure of self-control) lost the most weight in the program (Naets et al., 2020). Sex differences in the associations between disordered eating and obesity in youth warrants further research, especially in youth from rural, low-income populations (Hirsch et al., 2014) and those among racial/ethnic minority groups (Lincoln et al., 2014).

Sex differences in disordered eating behaviors may vary based on biopsychosocial differences between boys and girls. Keller et al. (2019) proposed a biopsychosocial model to describe sex differences in youth eating behavior and described a number of biological and psychosocial pathways linking eating behaviors to youth obesity, and how these pathways vary by sex. These potential factors will be discussed further in the next section.

Factors That May be Related to Sex Differences in Eating Behaviors in Adolescents

Biological Factors

Stress can influence health outcomes through a direct, biological pathway involving activation of the Hypothalamic-Pituitary-Adrenal (HPA) axis (Ulrich-Lai & Herman, 2009). The HPA-axis is responsible for releasing corticotropin releasing hormone (CRH), adrenal corticotropic hormone (ACTH), and cortisol during times of stress. (Jacobson & Sapolsky, 1991). However, chronic stress causes a constant production of cortisol, which may lead to a blunted cortisol response over time and HPA-axis dysregulation as it takes longer for cortisol levels to return to their baseline under chronic exposure to stress (Juster et al. 2010; McEwen

2000; Wingenfeld et al. 2009). This dysregulation may harm the body as the HPA-axis becomes more sensitive and may result in greater levels of cortisol during stress (McEwen & Gianaros, 2010), especially in late adolescence (15-17) in which youths display greater stress-induced cortisol levels compared to early adolescents (9-13) (Gunnar et al., 2009; Stroud et al., 2009). Higher levels of stress and a blunted cortisol response have been shown to be associated with higher BMIs and obesity in adolescents (Ruttle et al., 2013). Some evidence suggests that sex-specific susceptibility for chronic, non-communicable diseases, such as obesity, originates in childhood as a result of permanent alterations in the HPA-axis due to stress (Hanson & Gluckman, 2014). Moreover, there is evidence to show that sex differences exist in HPA-axis reactivity in adolescence (Van den Bergh & Van Calster, 2009; McCormick & Mathews, 2007; Lupien et al., 2009; Sondeijker et al., 2007). While little research exists on sex differences in disordered eating behaviors and HPA-axis in adolescents, evidence shows that cortisol levels in response to acute stress may be related to differences in disordered eating between adult women with restrained eating compared to those without (Paris et al., 2010). Adults and adolescents may be comparable in response to stress due to evidence that basal cortisol levels increase from childhood to adulthood (Gunnar & Vazquez, 2015). Sex differences can be seen in adolescent stress response as these levels increase consistently for girls but not boys (Schiefelbein & Susman, 2006). Additionally, adults and adolescent physiological response to stress in a lab setting have been shown to peak and demonstrate adult-like responses in mid-adolescence (14-15) (Gunnar et al., 2009; Sumter et al., 2010).

Psychosocial Factors

There are various psychosocial sex influences on adolescent's eating behaviors. Girls often demonstrate a greater dissatisfaction with their bodies at as young as 8 years old (Ricciardelli & McCabe, 2001; Williamson & Delin, 2001; Phares et al., 2004; Gustafson-Larson & Terry, 1992; Robinson et al., 2001; Collins, 1991; Thelen & Cormier, 1995) and have more thoughts surrounding their weight, including a desire to lose weight (Phares et al., 2004) and feelings of guilt regarding overeating (Gustafson-Larson & Terry, 1992). School-aged girls also report more dieting compared to boys their age (Elfhag et al., 2008). Overall, these various factors may explain differences in eating behaviors demonstrated by girls compared to boys.

Social norms and expectations surrounding food and young women may also contribute to the food-body association and the emphasis on an ideal body type. Boys are often expected to consume more food and consume for physical performance, whereas girls are expected to consume less food and consume healthier foods for appearance purposes (McKinley et al., 2005; Turner et al., 2013). While girls model more healthy behaviors (Hendy, 2002; Oliver & Thelen, 1996) such as greater behavioral self-regulation (Francis & Susman, 2009; Kochanska & Aksan, 2006), disordered eating may be more common in girls than boys as a result (Keller et al., 2019).

Summary and Objectives

As evidenced from the literature, adolescent obesity is a prevalent issue that is associated with disordered eating and is increasing more in boys compared to girls. Thus, the purpose of this thesis is to investigate sex differences among adolescents' biological responses to emotional, external, and restrained eating in response to stress, and to examine whether disordered eating and biological factors (cortisol regulation and BMI) are also related to these sex differences. The potential role of adolescents' restrained, emotional, and external eating on their caloric intake in response to a psychosocial stressor will be examined in this study. As shown in Figure 1, our conceptual model depicts sex and restrained eating, emotional eating, and external eating as moderators in the relationship between stress and stress eating. We hypothesized that disordered eating may potentially explain why stress eating may be higher in one sex versus the other. The results from this study may be used to design programs to prevent adolescent obesity. Implications for prevention will be discussed in Chapter 4.

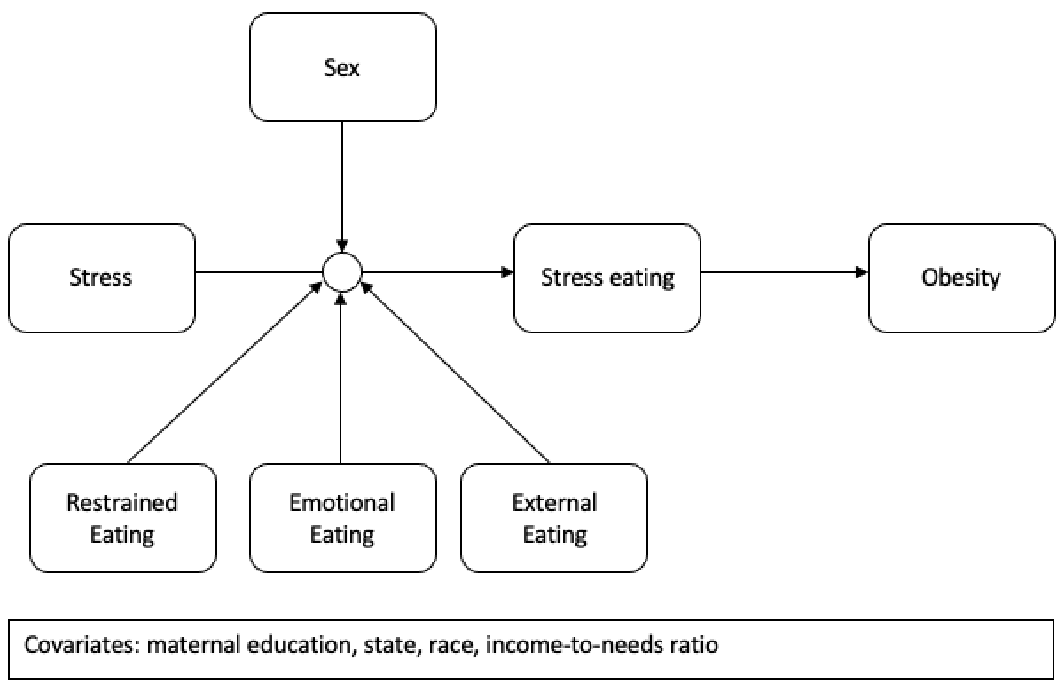

Figure 1. Conceptual Model

Research Question and Hypotheses

The 3 main objectives of this paper are to address the following research questions:

1. Are there sex differences in stress eating?
2. Do sex differences in stress eating differ based on adolescents disordered eating behaviors?
3. Are there differences in cortisol responding and BMI in adolescents who consume more in response to stress compared to those who do not?

We hypothesized that girls would be more likely to consume more calories in response to stress than boys. We also hypothesized that these sex differences in stress eating would be explained by greater disordered eating behaviors in girls, who will also have greater cortisol dysregulation and BMIs.

Chapter 2

Methods

Participants

Data were drawn from the Family Life Project (FLP) (Vernon-Feagans & Cox, 2013), a longitudinal, birth cohort study of predominantly poor youth and families residing in rural communities in the United States. Extensive details about study recruitment and data collection procedures are provided on the study web site (https://flp.fpg.unc.edu). Briefly, pregnant, English-speaking mothers residing in six poor rural counties in eastern North Carolina and Central Pennsylvania were recruited between 2003 and 2004 at the time that they gave birth; low-income families and Black families were oversampled. A total of 1,292 youths were followed from birth to 12 years of age. A subsample of 509 of the 1,292 (39.4%) participated in an ancillary research study (the Family Health Study (FHS)) that was designed to examine exposure to stress and its relation to obesity when youth were 14 years of age. Eligibility criteria for participation in the FHS ancillary study included living with both biological parents, the absence of severe food allergies or chronic medical problems affecting food intake, and the absence of dietary restrictions involving animal products; families were not recruited based on weight status or concern about adolescent weight. Descriptive statistics are provided in Table 7 in the Appendix. This study was approved by the Institutional Review Boards at the sponsoring universities for the North Carolina and Pennsylvania sites.

Design and Procedures

The FHS used a planned missingness design (Graham et al., 2006), with gold-standard measures of study construct collected objectively in one subsample of families through home visits (n=312), and subjective survey measures of the same constructs collected via web surveys in the home visit sample and in a smaller web-survey-only sample of (n=187) youth and their primary caregivers; primary caregivers will be referred to as “parent” from here on. Data collected in the home visit sample are the focus of this paper. Home visit families were seen for two 2.5-hour visits (i.e., one low-stress visit, one high-stress visit) that were ~1 week apart, which varied based on youth exposure to a psychosocial stress task. The order of the visit was not randomized. Before each home visit, families were contacted by phone to confirm the scheduled visit and to remind youth to refrain from eating or drinking anything other than water for at least 2 hours before the visit; the majority of youth were fasted for 4+ hours. Upon arrival to the home, parent and adolescent anthropometrics were measured by trained research assistants (RAs). Both parents and adolescents then completed a series of computer-based questionnaires and tasks over the course of ~1.5 hours. Next, adolescents and their immediate family members were given a standard meal and were seated together. Parents ($100) and youth ($25) received a gift card at the end of each home visit. Youth were excluded from the current analyses if they refused to participate (n=1), had food allergies or dietary limitations related to the foods served (n=7), were ill (e.g. rhinovirus) on the day of data collection (n=3), or had incomplete data (n=1). Additionally, at the home visit, one adolescent with an Autism Spectrum Disorder was discovered and removed from the dataset. This resulted in a final sample of 278 youth, referred to as “adolescents” from here on, and their parents.

Measures

Stress Regulation. Adolescents' reactivity to and recovery from a psychosocial set of stressors was assessed on the low- and high-stress visits in identical time increments (see Figure 3 in the Results section). Salivary cortisol changes were assessed twice at baseline (B1 and B2), immediately, 20 minutes, and 40 minutes following a 20-minute stress protocol (see Figure 2 for the timeline). On the low-stress visit, saliva was collected over the course of a number of questionnaires not thought to elicit stress (e.g., activity preferences) and executive function tasks that have been found to elicit low levels of arousal (e.g., delay discounting), based on unpublished pilot work completed before the study began. The first stress task was a **Star-Tracing Task**, which is a well-established cognitive stressor for youth (Matthews et al., 1987). This task required adolescents to trace a star for 3 minutes, with their non-dominant hand, while viewing the star's reflection in an adjacent mirror. This task has been shown to produce reliable responses to challenges, and performance on the task is linked to externalizing problems in youth (Keller & El-Sheikh, 2009; El-Sheikh et al., 2007). The second task was a 4-minute **Impossible Perfect Circle Task**, modified based on the Impossibly Perfect Circle Task from the Laboratory Temperament Assessment Battery (LAB-TAB, Goldsmith & Rothbart, 1996). In this task, adolescents were asked to try their best to draw a perfect circle. Throughout the task, the interviewer constantly stopped to interrupt the adolescent, examined the circle, and asked them to try again. The interviewer also pointed out imperfections in the circle. The third and final task is an adaptation of the **Block Design Test** originally developed by Kohs (1923). This task was designed to measure intelligence as well as visual-spatial and motor skills. Participants used red and white colored blocks to reproduce two dimensional, square geometric designs. Kohs blocks have given rise to a variety of tasks, all based on the same principle, including the Weschler

Intelligence Scale for Children (WISC-V) (Wechsler, 2014). For the current protocol, the task was modified by starting with relatively easy designs with generous completion times and then gradually increasing the design difficulty while decreasing the amount of time given to complete each design, which made it nearly impossible to complete the design. The RA also rushed the adolescent and counted down for the seconds remaining to add to the level of stress incurred during the task. Total task time with instructions averaged approximately 5 minutes.

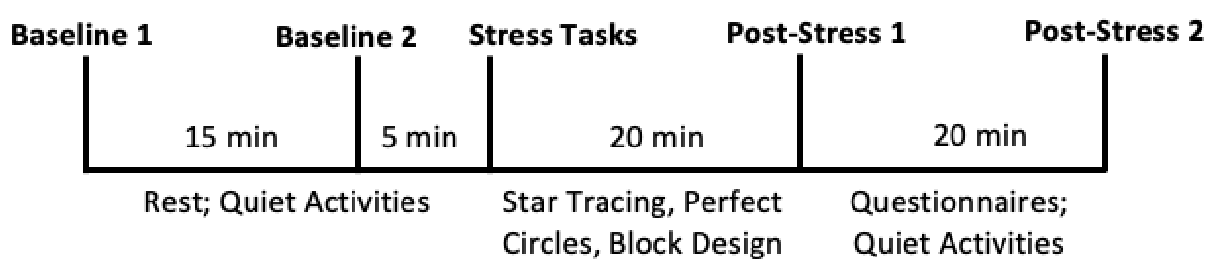

Figure 2. Stress Task Timeline

To improve saliva production and avoid sample contamination, adolescents were asked to quickly swish their mouths with water approximately 10 minutes before the start of the assessment. All samples were stored in a -80 degree freezer until they were shipped to Salimetrics, Inc. to be assayed using highly sensitive, commercially available assays (Salimetrics, LLC). The test requires only 25 µl of saliva (for singlet determinations) and has a range of sensitivity from 0.007 to 1.2 µg/dl, and average intra- and inter-assay coefficients of variation (CV) of 5.34% and 9.86%. The standard curve is highly reproducible; performance is robust for samples with ph ranging from 4.0 to 9.0 (Schwartz et al., 1998).

<u>Standardized, Ad-Libitum Meal</u>: Each family member participating in the meal was instructed to eat only from their own plate and not to share food with the target adolescent or eat off of their plate. The entrée and side foods were chosen during a scheduling phone call before

the home visit, and included the following choices: pizza (supreme, pepperoni, or cheese), salad (Caesar, southwest, or Asian), fruit side (mandarin orange cup or applesauce), and cookies (chocolate chip or oatmeal raisin). Total available meal calories ranged from 1090-1220 kilocalories (kcals), depending on the entrée chosen. Every effort was made to use the same brands/varieties across the length of the study; substitutions were noted and tracked. All foods were prepared and pre- and post-weighed in the home during the visit; each adolescent was served two slices of pizza, one and a half cups of salad, one fruit side, two cookies, and a bottle of water. Additional servings of each food were available. Foods (for the adolescent only) were pre- and post-weighed to the nearest .01 grams. Adolescents were flagged for a sensitivity analysis (see Design and Procedures section) if the following occurred during data collection: the pizza was substituted with a different brand (n=20), the pizza was partly burned (n=4), or a sibling ate off of the target adolescent's plate.

Dutch Eating Behavior Questionnaire for Children and Adolescents (DEBQ-C). The DEBQ-C is a 33-item measure designed to assess disordered eating behaviors and it consists of three subscales: the restrained eating scale, the emotional eating scale, and the external eating scale. Adolescents provided a self-report on this questionnaire. Response options ranged from 1 (never) to 5 (very often). 12 of the items also had a 0 (N/A) response option. Items 1 through 10 ask about eating less and restraining eating in response to concerns such as weight. Items 11 through 23 deal with eating in response to various emotions. Items 24 through 33 asks about external and environmental influences on the desire to eat. All three subscales and the total scale had good internal consistency and reliability with Cronbach's alpha ranging from 0.80 to 0.95, which is consistent with past studies (Hunot-Alexander et al., 2019).

Adolescent Body Mass Index (BMI). During the home visit, youth weight (nearest 0.01 kg) and height (nearest 0.01 cm) were measured in duplicate by trained RAs using standardized protocols. Centers for Disease Control and Prevention (CDC) growth charts were used to generate BMI indices and define non-overweight (BMI $<85^{th}$ percentile), overweight (BMI $\geq 85^{th}$ percentile), and 3 categories of obesity: class I obesity as $\geq 95^{th}$ BMI percentile, class II obesity (severe obesity) as $\geq 120\%$ of the 95^{th} BMI percentile, and class III (severe obesity) as $\geq 140\%$ of the 95^{th} percentile (Kuczmarski & Flegal, 2000).

Sociodemographics. At the 12-year home visit, parents reported on household sociodemographics, which included household income, maternal education, and state of residence. Maternal education was coded as 0 = high school diploma/GED or less, and 1= some college or more. Household income was determined based on any earner who resided in the home. Individuals were considered to be residents of the household if he/she spent 3+ nights/week in the youth's home. Income-to-needs ratio (INR) was calculated using the 2014 poverty threshold values (family income/poverty threshold), based on household size.

Statistical Analysis

All analyses were conducted using SAS version 9.4. All variables were assessed for normality. Descriptive statistics were generated for all variables. Natural logarithmic transformation was performed on cortisol data as recommended by Gordis et al. (2006). Cortisol regulation indices (reactivity and recovery) were created by dissecting the cortisol response curve; cortisol reactivity was calculated as changes in cortisol from baseline to 20 minutes post-stress. Cortisol recovery was calculated as changes in cortisol from 20 minutes post-stress to 40-

minute post-stress. Francis et al. (2013) showed that cortisol reactivity and recovery were related to dysregulated overeating in children ages 8 to 9 years when using this approach to dissecting the curve. In addition, area under the curve with respect to ground (AUC_g) and increase (AUC_i) was calculated using widely used formulas (Pruessner et al., 2003). AUC_g provides a measure of overall cortisol output for all measures, which AUC_i provides a measure of changes in cortisol output during the stress manipulation. Repeated measures ANOVA models were used to evaluate whether adolescents' consumption in response to the stress challenge increased between the low- and high-stress visits. All models were adjusted for adolescent race, state, maternal education, and income-to-needs ratio. Alpha levels were set to $p<.05$.

Chapter 3

Results

Descriptive Statistics

Table 7 in the Appendix provides descriptive information on the sample. The total sample consisted of 278 adolescents with complete data for both home visits, and their parents. Adolescents ranged in age from 13-16 years (mean = 14.2, SD ± 0.6 years); parent ages ranged from 29-60 years (mean = 40.5, SD ± 6.0 years) with 52.5% of mothers reporting education over 12 years and 47.5% less than or equal to 12 years. The majority of adolescents in the study were male (53.3%) and white (82.5%) while 27.5% were black. Overall, the average BMI percentile for adolescents was in the 72.9th percentile with a range from 2.8-99.8 (SD ± 27.3). The average body mass index z-score (BMIz) was 0.9 with a range from -1.9-2.9 (SD ± 1.1). 14.9% of adolescents were classified as overweight (BMI ≥ 85th percentile), 14.1% were obese (BMI ≥ 95th percentile), and 15.9% were severely obese (BMI≥120% of the 95th BMI percentile). The combined prevalence of youth with obesity (30.0%) was disproportionately high in our sample, compared to recent national prevalence rates for U.S. adolescents ages 12 to 19 years (Hales et al., 2018). However, the prevalence of obesity has also been found to be higher in rural youth (Davis et al., 2011; Jackson et al., 2005; Johnson & Johnson, 2015). The average INR was 2.0 ranging from 0.0-16.5 (SD ± 1.7). Approximately 38.8% of the sample was from North Carolina.

Manipulation Check: Cortisol Reactivity across Low- and High-Stress Conditions

Figure 3 displays the overall pattern of salivary cortisol reactivity and recovery on the low- and high-stress visits. As shown in Table 1, cortisol responses differed across the low- and high-stress visit. After adjusting for adolescent sex and race, AUC_g ($F(274) = 8.13$, $p= 0.004$), AUC_i ($F(274) = 21.44$, $p < 0.001$), and cortisol reactivity ($F(274) = 36.34$, $p < 0.001$) were higher on the high-stress visit than on the control day, demonstrating that the high-stress visit was more stressful than the low-stress visit. However, there were no differences in cortisol recovery scores ($F(277) = 1.53$, $p = 0.217$).

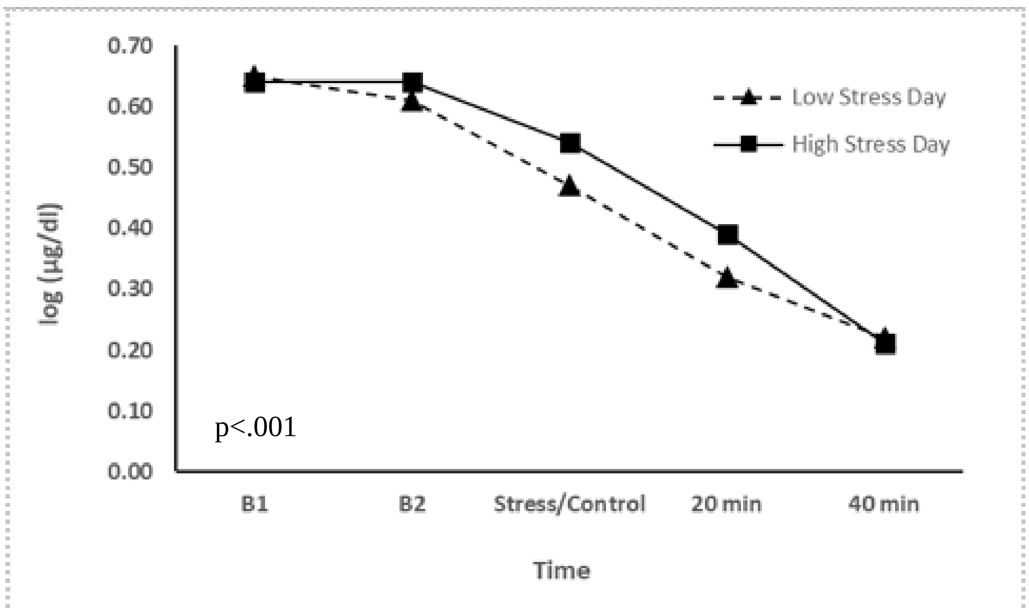

Figure 3. Cortisol Response on Stress and Control Days. B1=Baseline saliva measure 1, B2=Baseline saliva measure 2

Table 1. Mean (SE) differences in cortisol response on low- and high-stress visits, adjusted for adolescent sex and race

	Low-Stress Visit	High-Stress Visit	F statistic (DF), p-value
AUC_g	15.2 (1.1)	16.6 (1.1)	F(274) = 8.13, p= 0.004
AUC_i	-10.6 (0.5)	-8.9 (0.5)	F(274) = 21.44, p < 0.001
Cortisol Reactivity	0.11 (0.01)	0.17 (0.01)	F(274) = 36.34, p < 0.001
Cortisol Recovery	-0.43 (0.02)	-0.41 (0.02)	F(277) = 1.53, p = 0.217
Note: AUC_g = area under the curve with respect to ground, AUC_i = area under the curve with respect to increase			

Differences in Consumption Across Low- and High-Stress Visits

Next, differences in consumption during the meal on low- versus high-stress visits were examined. As shown in Table 2, adolescents did not consume significantly more kcals on high-stress visits than low-stress visits (F(198) = .55, p=.46).

Table 2. Mean (SE) differences in food intake on low- and high-stress visits, adjusted for adolescent sex and race

Consumption	Low-Stress Visit	High-Stress Visit	Adjusted p-value	F-Statistic
Kcal	957.62 (24.88)	940.38 (24.88)	.46	F(198) = .55
Note: kcal = kilocalories				

Sex Differences in Stress-Related Consumption During the Meal

Next, adolescent sex was examined as a moderator of the effect of stress on consumption during the meal. There were sex differences in kcal consumption at each visit in that boys exhibited greater consumption during the meal at each home visit (for both low- and high-stress visits) than girls (F(195) = 14.8, p<.001; results not shown). As shown in Table 3, there was no significant interaction of sex on the effect of stress on dinner consumption in kcals (F(197) = 1.03, p=.31), thus, there were no sex differences in the amount consumed in response to stress between visits. While boys did consume 5.5 kcals more on the stress day and girls consumed 41.7 kcals less, the boys' consumption was not significantly greater.

Table 3. Mean (SE) differences in dinner intake on low- and high-stress visits for boys and girls

	Boys		**Girls**			
	Low-Stress Visit	**High-Stress Visit**	**Low-Stress Visit**	**High-Stress Visit**	**F-Statistic**	**Day X Sex interaction p-value**
Kcal	1025.20 (34.27)	1030.74 (34.27)	890.86 (34.34)	849.18 (34.34)	F(197) = 1.03	.31

Sex Related Differences in Stress Eating Based on Disordered Eating Behaviors

As shown in Table 4, there were no significant effects for the interaction between day, sex, and disordered eating behavior. That is, none of the disordered eating behaviors were significantly associated with sex differences in eating in response to stress (see Figures 4-6). No differences were seen in restrained eating as a moderator (F(195) = 0.05, p=.82; Figure 4), no differences in emotional eating as a moderator (F(195) = 0.13, p=.72; Figure 5), and no differences in external eating as a moderator (F(194) = 0.67, p=.41; Figure 6).

Table 4. Mean (SE) differences in food intake by sex and disordered eating behavior

	Boys		Girls		F-Statistic	Day X Sex X Eating Behavior interaction p-value
	Low Restrained Eating	**High Restrained Eating**	**Low Restrained Eating**	**High Restrained Eating**		
Kcal (low-stress visit)	1000.03 (43.08)	1065.78 (53.6)	902.81 (56.73)	885.12 (42.79)	F(195) = 0.05	.82
Kcal (high-stress visit)	1010.56 (43.08)	1063.76 (53.6)	855 (56.73)	846.96 (42.79)		
	Low Emotional Eating	**High Emotional Eating**	**Low Emotional Eating**	**High Emotional Eating**		
Kcal (low-stress visit)	1007.29 (43.66)	1052 (52.94)	908.02 (58.73)	882.89 (42.54)	F(195) = 0.13	.72
Kcal (high-stress visit)	1010.77 (43.66)	1060.52 (52.94)	840.04 (58.73)	854.35 (42.54)		
	Low External Eating	**High External Eating**	**Low External Eating**	**High External Eating**		
Kcal (low-stress visit)	998.41 (45.75)	1066.6 (50.22)	910.72 (55.61)	880.05 (43.66)	F(194) = 0.67	.41
Kcal (high-stress visit)	1022.77 (45.75)	1051.29 (50.22)	844.76 (55.61)	852.93 (43.66)		
Note: kcal = kilocalories						

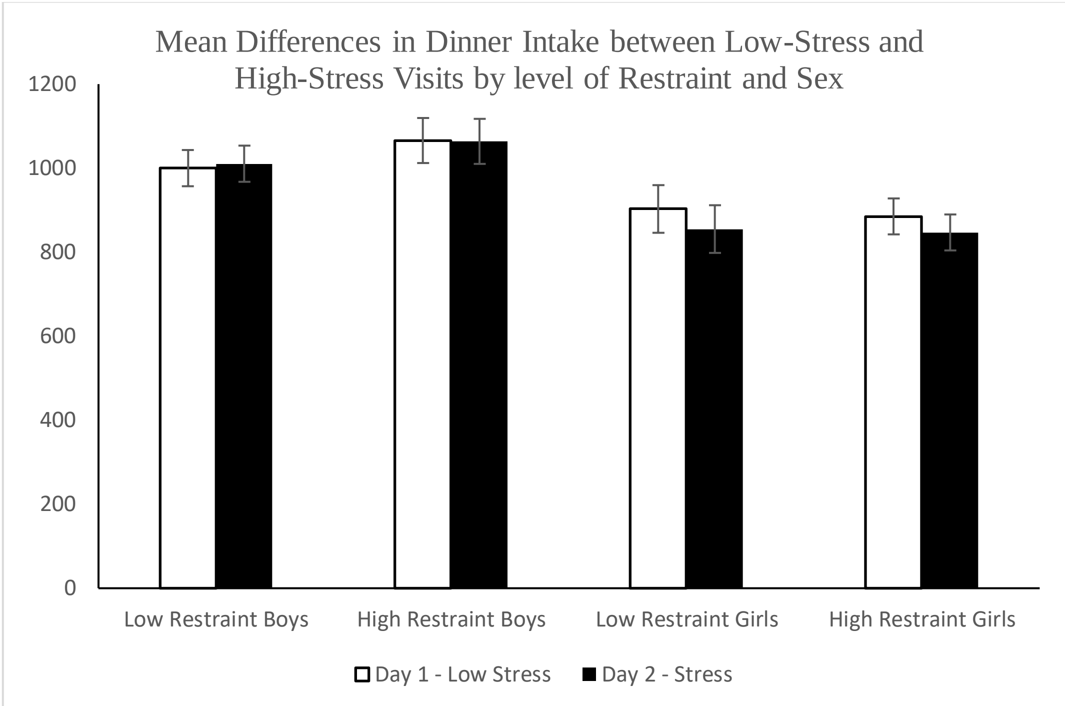

Figure 4. Mean Differences in Dinner Intake between Low-Stress and High-Stress Visits by Level of Restraint and Sex

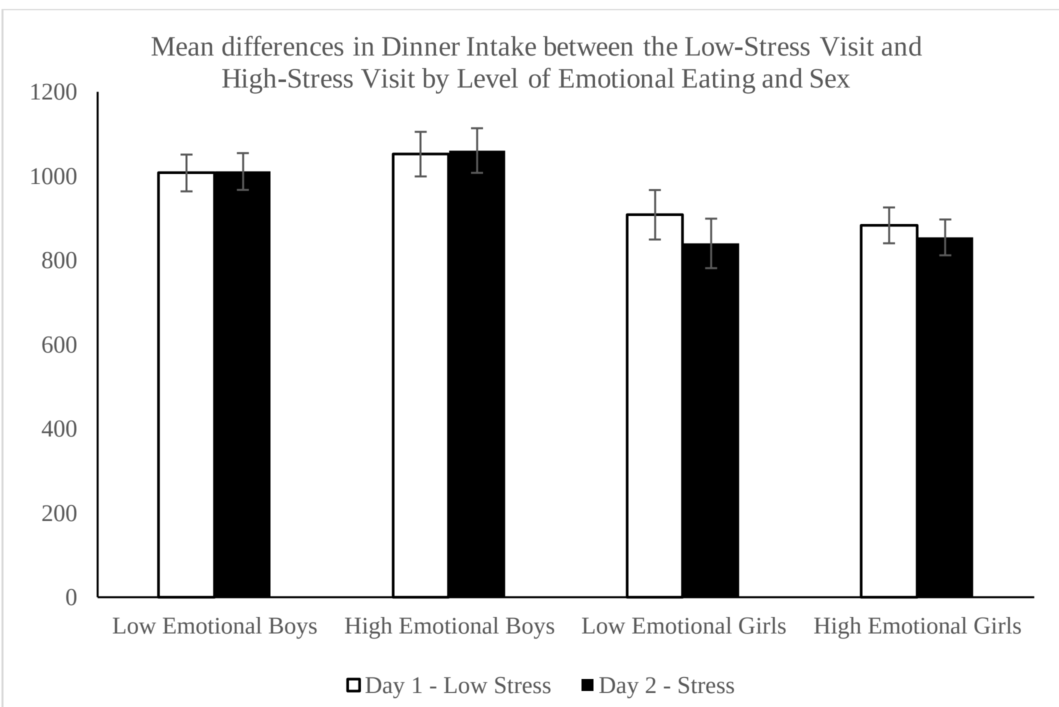

Figure 5. Mean differences in Dinner Intake between the No Stress Visit and Stress Visit by Level of Emotional Eating and Sex

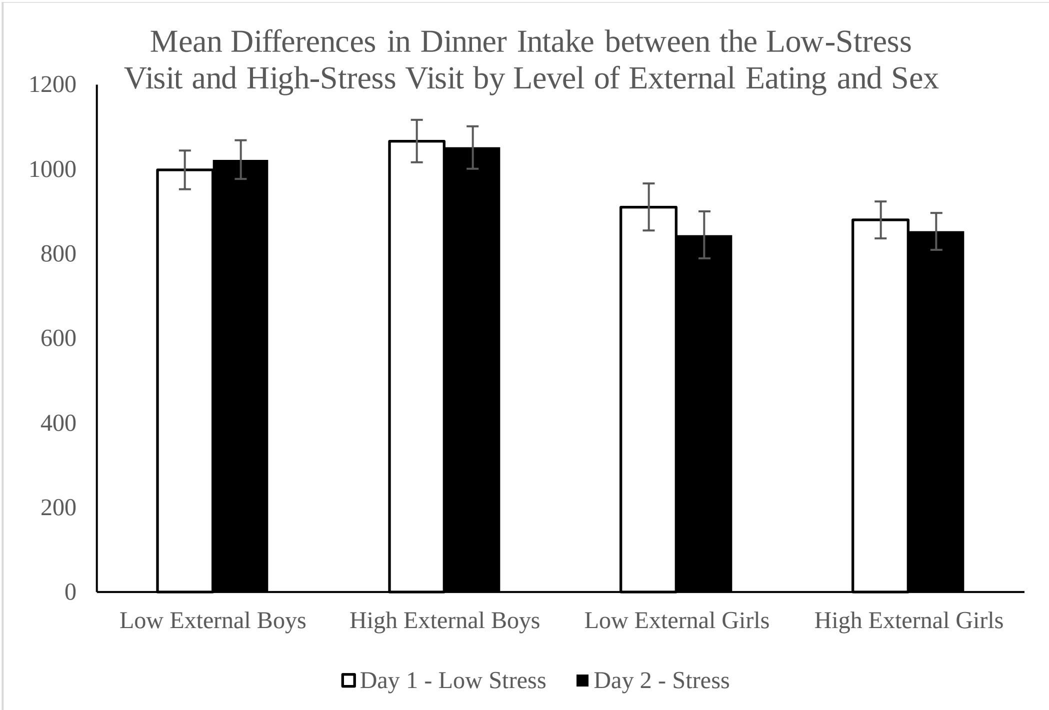

Figure 6. Mean Differences in Dinner Intake between the Low-Stress Visit and High-Stress Visit by Level of External Eating and Sex

Correlations Among Disordered Eating Behaviors, Consumption in Response to Stress, Adiposity, and Cortisol Responding in Adolescents

Given that there was no evidence of sex differences in eating in response to stress, nor were there associations with disordered eating, post-hoc analyses were conducted to better understand biobehavioral characteristics of stress eaters. Correlations among disordered eating behaviors, consumption in response to stress, BMIz, and cortisol responses were examined. First, adolescent weight status as a moderator of the stress effect on dinner intake was examined. As shown in Table 5, there was a positive correlation between BMIz and restrained eating for both girls ($r = .28$, $p<.01$) and boys ($r = .21$, $p\leq.05$). There was also a positive correlation between BMIz and emotional eating in girls ($r = .30$, $p<.01$) but not in boys. There was no association between BMIz and external eating for either boys or girls, or between BMIz and stress-related consumption (the difference in kcals consumed between the high- and low-stress visits). Moreover, BMI z-score was not significantly associated with cortisol reactivity or recovery in boys or girls.

Emotional and restrained eating were positively correlated in girls ($r = .36$, $p<.001$) and boys ($r = .29$, $p<.01$). Additionally, there was a positive association between external and restrained eating in girls ($r = .20$, $p \leq .05$) but not in boys. External eating was positively associated with emotional eating in both girls ($r = .57$, $p<.001$) and boys ($r = .44$, $p<.001$). Stress-related consumption was not significantly associated with any of the disordered eating behaviors (restrained, emotional, external) in girls or boys. However, cortisol reactivity was associated with stress-related consumption in boys ($r = .20$, $p \leq .05$) but not in girls; boys who exhibited greater increases in cortisol in response to stress consumed more during the high-stress visit than they consumed on the low-stress visit. Cortisol recovery was negatively correlated with cortisol reactivity in both girls ($r = -.56$, $p<.001$) and boys ($r = -.43$, $p<.001$); cortisol recovery was not associated with any other variable.

Table 5. Intercorrelations [1] between disordered eating behaviors, dinner kcal, BMIz, cortisol reactivity and cortisol recovery

	Restrained Eating	Emotional Eating	External Eating	Stress-Related Consumption	BMIz	Cortisol Reactivity
Emotional Eating	**.36*** .29**					
External Eating	**.20*** -.01	**.57***** .44***				
Stress-Related Consumption	**.02** .00	**.06** -.01	**.00** -.08			
BMIz	**.28**** .21*	**.30**** .05	**.05** -.10	**-.08** .04		
Cortisol Reactivity	**.09** -.15	**.01** -.00	**-.12** -.05	**-.08** .20*	**.06** -0.14	
Cortisol Recovery	**.02** .10	**-.10** .03	**-.02** .06	**.06** -.12	**.05** .09	**-.56***** -.43***

Note: [1]Adjusted for youth sex (0=boys, 1=girls), maternal education (years), household income-to-needs ratio (INR), and state of residence (0=Pennsylvania, 1=North Carolina). BMIz = body mass index z-score.
*$p \leq .05$, **$p < .01$, ***$p < .001$.
Correlation coefficients for girls appear in bold; estimate for boys are not in bold type.

Characteristics of Stress Eaters

The characteristics of adolescents who increased their intake in response to stress was examined, along with how they differed from adolescents who showed no change or decreases in intake. A dichotomous variable was created to indicate adolescents who were low- and high-stress eaters. High-stress eaters are defined as adolescents who increased their consumption during the meal on the high-stress visit compared to the low-stress visit, and low-stress eaters are adolescents who exhibited no change or reductions in consumption during the meal on the high-stress visit compared to the low-stress visit. Interactions with sex were examined for all relations.

Sex differences in consumption (kcals) in response to stress were examined for low- and high-stress eaters. As expected, high-stress eaters consumed significantly more kcals in response to stress than low-stress eaters ($F(198) = 248.58$, $p < .001$; results not shown) as seen in Figure 7; however, there was no interaction between stress eating and sex, meaning that there were no significant differences between how much either sex ate (whether they were low- or high- stress eaters) in response to stress ($F(198) = 3.28$, $p=.07$; Table 6). There was, however, a trend towards high-stress eating boys consuming greater kcals in response to stress than high-stress eating girls. Additionally, low-stress eating boys consumed fewer kcals in response to stress than low-stress eating girls. Regarding BMIz, there were no significant sex differences in BMIz between low- and high-stress eaters; however there was a trend toward low-stress eating boys having lower BMIz than low-stress eating girls ($F(198) = 2.67$, $p=.10$).

Lastly, sex differences in stress-induced cortisol responses for low- and high-stress eaters were examined. There were no significant sex differences in cortisol reactivity in low- and high-stress eaters ($F(188) = 2.52$, $p=.11$). Compared to girls who were low-stress eaters, there was a trend towards girls who were high-stress eaters showing poorer recovery following the stressor indicated by a greater increase in cortisol once the stressor ended ($F(187) = 3.12$, $p = .08$; Figure 8). No other differences with cortisol were noted.

Table 6. Mean (SE) differences in food intake on low- and high-stress visits for Cortisol Recovery Subgroups

	Boys		Girls			
	Low-stress Eaters	**High-stress Eaters**	**Low-stress Eaters**	**High-stress Eaters**	**Sex X Stress-Eating Interaction p-value**	**F-Statistic**
Stress Eating (Meal $Kcal_{diff}$)	-274.74 (38.12)	265.82[1] (31.30)	-227.05 (27.75)	196.64[2] (21.92)	.07	F(198) = 3.28
BMIz	0.49 (0.17)	0.90 (0.15)	1.04 (0.13)	0.86 (0.16)	0.10	F(198) = 2.67
Cortisol Reactivity (µg/dl)	-0.47 (0.07)	-0.27 (0.07)	-0.44 (0.06)	-0.50 (0.06)	0.11	F(188) = 2.52
Cortisol Recovery (µg/dl)	0.19 (0.04)	0.12 (0.05)	0.14 (0.05)	0.25 (0.04)	0.08	F(187) = 3.12

Meal $Kcal_{diff}$ = differences in consumption (kcals) between the high-stress and low-stress visits, BMIz = body mass index z-score

[1] High stress eating boys showed greater intake in response to stress than low stress eating boys (*p* < .001)

[2] High stress eating girls showed greater intake in response to stress than low stress eating boys (*p* < .001)

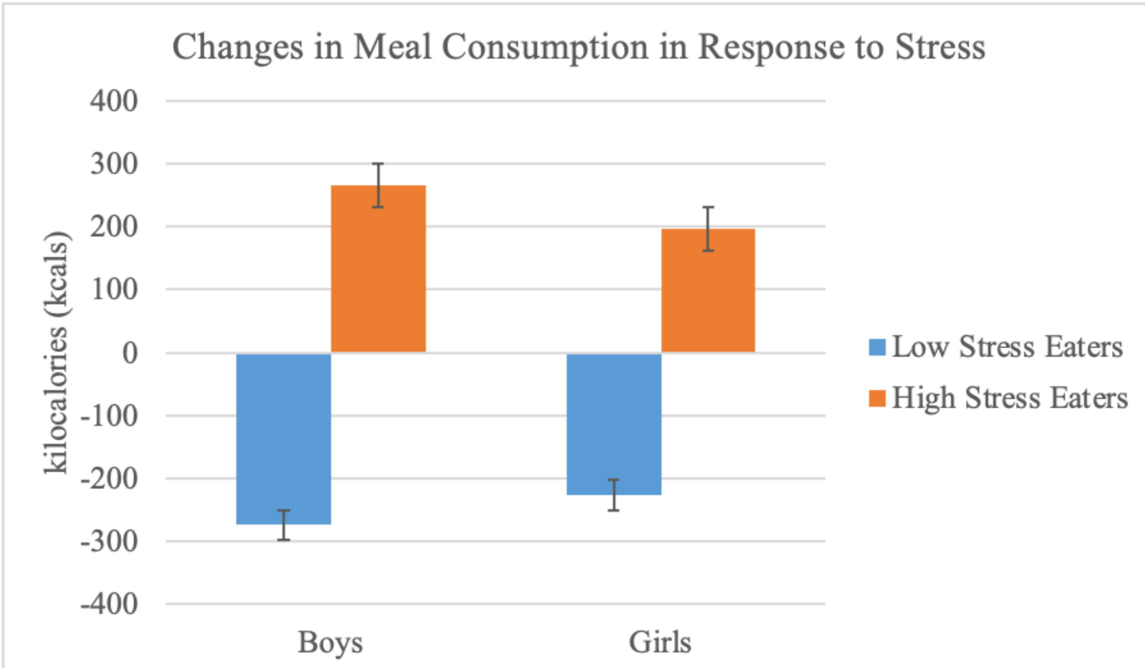

Figure 7. Changes in Meal Consumption in Response to Stress

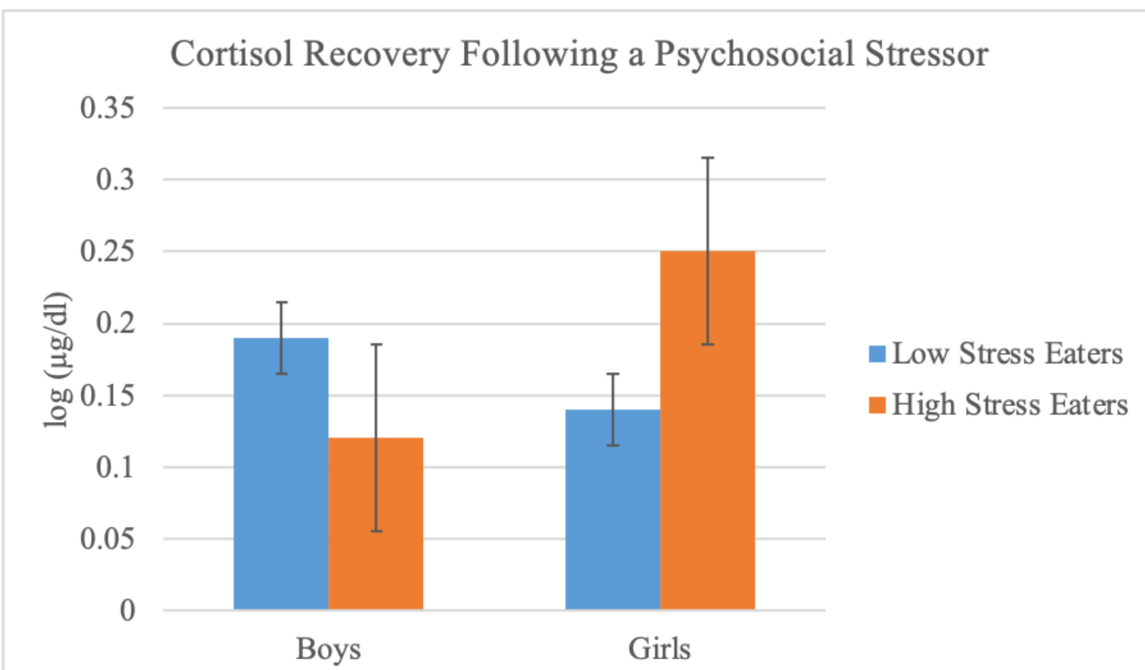

Figure 8. Cortisol Recovery Following a Psychosocial Stressor

Chapter 4

Discussion

The main objective of this paper was to determine if there were sex differences in eating in response to stress, or stress-induced eating. Overall, the findings from the study show that there was no evidence of eating in response to stress. Additionally, while there were no sex differences in the amount consumed in response to stress between visits, the results showed that there were sex differences in that boys exhibited greater consumption during the meal at each home visit (for both low- and high-stress visits) than girls. Additionally, this paper aimed to determine if disordered eating behaviors moderated the relationship between sex related differences in stress eating. The results showed that disordered eating behaviors (restrained, emotional, external) did not moderate the sex related differences in stress eating. The final objective of this paper was to determine if there were differences in cortisol responding or BMI in adolescents who consume more in response to stress compared to those who do not. While there was no main interaction between cortisol responding and sex, girls who were low-stress eaters showed lower levels of cortisol recovery (indexed by increases in cortisol following the stressor) than girls who were high-stress eaters. This indicates that girls who were high-stress eaters took a longer time to recover biologically following the stressor (Figure 8). Also, there were no significant differences in BMI z-scores in high-stress eaters; however, there was a trend in that low-stress-eating boys had lower BMI z-scores than low-stress-eating girls (Table 6).

We hypothesized that girls would consume more at dinner while under stress. This hypothesis was not supported; there were no sex differences in eating in response to stress. We also hypothesized that girls would exhibit more of these disordered eating behaviors with blunted cortisol responses and higher BMIs. These hypotheses were driven by the concept that disordered eating behaviors often correlate with higher levels of obesity (Braet et al., 2008; Neumark-Sztainer, 2006). Keller et al. (2019) described a biopsychosocial model of sex differences in the eating behavior of youth and suggest that the pressure placed on girls for external validation based on appearance may make them less susceptible to internal cues involving satiety, and thus, lead to higher risk for development of disordered eating behaviors that may lead to obesity. Moreover, changes in early adolescence involving social pressures for thinness and a slender body ideal may influence the development of eating disorders in girls (Levine et al., 1994). It is possible that a relationship between girls consuming more in response to stress and disordered eating behaviors was not seen as evidence indicates that adolescent girls may demonstrate more weight control behaviors in the presence of their friends, demonstrating that they change eating behaviors based on social influence (Higgs & Thomas, 2016). The girls in our study could have potentially been more sensitive to their eating behaviors while being watched by researchers.

Exposure to acute daily stressors has been associated with increased food intake in obese/overweight adolescents with disordered eating behaviors, which moderate the link between stress and food intake (Ajibewa et al., 2021). In adolescents, patterns of blunted cortisol were associated with higher BMIs and obesity (Ruttle et al., 2013). In 8- to 9-year-old boys and girls, cortisol AUCi was associated with higher levels of BMI and increased disinhibited eating in the absence of hunger, which indicated a potential link between biological stress regulation and children's eating behaviors (Francis et al., 2013). Thus, based on this evidence, we hypothesized that girls would show greater consumption in response to stress, and that they would exhibit more of a blunted cortisol response. Although the hypothesis on sex differences in eating in response to stress was not supported, the findings showed that girls who increased their consumption in response to stress also showed increases in cortisol during the recovery period after the stressor passed (an indicator of biological dysregulation). Although this association approached significance, this may suggest that stress regulation is associated with stress-related eating (a measure of eating regulation). A possible reason as to why this association only approached significance could be due to a power issue in which not enough participants were recruited for this study.

There is research to support that adult women who are high cortisol reactors (increased cortisol in response to stress) consume more calories following a psychosocial stressor compared to low cortisol reactors, which confirms that a psychophysiological response to stress may impact eating behaviors in adult women (Epel et al., 2001). Further research is needed to determine whether this relation holds true in adolescents, especially within adolescents from rural, poor populations. The present study also showed that boys who were low-stress eaters had lower BMI z-scores compared to girls who were low-stress eaters. This finding is counter to what has been shown in past literature, as one study found greater rates of overweight/obesity in stress eating boys compared to girls; however, it also found that stress-related eating behaviors were more common in girls than boys (Jääskeläinen et al., 2014). Moreover, Roy et al. (2021) found that the presence of overweight/obesity and stress was higher in adolescent males from urban areas. Few studies on eating behavior has been focused on rural, poor adolescents, and further research is needed to better understand factors that may influence stress eating in adolescents in this vulnerable population.

BMI differences in eating behaviors under stress were expected to emerge, as previous research shows food intake varies based on BMI. One study found that high cortisol reactivity in overweight adolescents was related to decreased calorie consumption after an acute stressor (Nagy et al., 2019). Boggiano et al. (2017) found that there were sex differences in hedonic eating patterns in that reward enhancement in girls was associated with increased BMI, anxiety-related, and depression-related eating while reward enhancement in boys was associated with anger/frustration-eating. Few sex differences related to BMI were found in the present study. More research is needed to determine whether relations among stress eating, BMI and cortisol responding vary by sex, particularly given the greater and increasing levels of obesity in boys compared to girls currently seen in the U.S. (Wang et al., 2020).

Limitations

There are several limitations to this study. Our sample was predominantly rural and poor, which limits our ability to generalize findings to non-rural, non-poor youth in the U.S. Adolescents in our sample had a disproportionately higher rate of obesity than the national rate for adolescents in the U.S. between 2015-2016 (Hales et al., 2018). Rates of obesity in youth have been shown to be higher in those from low-SES families (Rossen & Schoendorf, 2012), and in rural youth (Ogden et al., 2018b), which suggest that our sample may be representative of rural, poor youth in the U.S. The statistical power of this study was not enough to examine interactions by race, sex and weight status. It is possible that interesting interactions between sex and weight status may have been uncovered, however, the main interest of this study was on the role of eating behaviors as a moderator between stress and sex differences in food intake.

Additionally, parental influences on the relations examined were not addressed. A previous study has found evidence that parental stress may influence adolescent eating behaviors to be more obesogenic and stress-motivated (Dimitratos et al., 2022). Moreover, this paper did not address food insecurity, which may impact stress eating as indicated by evidence that early life experiences of low-SES, which predicts less food security and environmental safety, play a role in higher consumption of food despite energy need (Proffitt Leyva et al., 2020).

Conclusion

The purpose of this study was to determine if there were sex differences in stress eating, if disordered eating behaviors moderated the relationship between sex related differences in stress eating, and if there were differences in cortisol responding or BMI in adolescents who consume more in response to stress compared to those who do not. Overall, no sex differences were seen in stress eating and these were not modified by disordered eating behaviors; however, there were some trends in low- and high-stress eating boys' intake compared to low- and high-stress eating girls' intake. The results showed some evidence of poorer biological stress regulation in girls who were high stress eaters. Additionally, low-stress eating boys had lower BMI z-scores compared to low-stress eating girls, which provides some evidence of sex differences in stress-induced eating behaviors and BMI. Further studies are required to assess the issues of sex differences in obesity as well as create interventions to address disordered eating behaviors under stress to prevent obesity. Mindfulness-based interventions have shown some evidence of preventing worsening stress-eating behaviors and stabilizing weight for adolescents at risk for excess weight gain (Bernstein et al., 2021). However, more information is needed on factors related to stress eating in adolescent boys and girls, and which combination of factors may increase their risk for obesity.

Appendix A

Appendix Title

Tables

Table 7. Sample characteristics (n=278)

Characteristics	Mean (SD)	Range
Youth		
Age in years, mean (SD)	14.2 (0.6)	13.1 – 15.6
Sex, % female	46.7	
Race, % black	27.5	
BMI percentile	72.9 (27.3)	2.8 – 99.8
BMI z-score	0.9 (1.1)	-1.9 – 2.9
BMI classifications, %		
Overweight	14.9	
Obese	14.1	
Severely Obese	15.9	
Parent		
Maternal age in years, mean (SD)	40.5 (6.0)	28.9 – 59.8
Maternal education, %		
≤ 12 years	47.5	
> 12 years	52.5	
Household		
Income-to-needs ratio (INR)	2.0 (1.7)	0.0 – 16.5
North Carolina residence, %	38.8	

SD, standard deviation; %, percentage; BMI, body-mass-index.

Table 8. Descriptive Statistics for Restrained Eating Scale

Descriptive Statistics						
	N	**Mean**	**Std. Deviation**	**Sum**	**Minimum**	**Maximum**
Boys	104	1.62	0.68	168.70	1.00	3.70
Girls	96	2.00	0.85	191.80	1.00	4.40

Table 9. Descriptive Statistics for Emotional Eating Scale

Descriptive Statistics						
	N	**Mean**	**Std. Deviation**	**Sum**	**Minimum**	**Maximum**
Boys	104	1.49	0.67	154.54	1.00	3.69
Girls	96	1.87	0.86	179.54	1.00	5.00

Table 10. Descriptive Statistics for External Eating Scale

Descriptive Statistics						
	N	**Mean**	**Std. Deviation**	**Sum**	**Minimum**	**Maximum**
Boys	103	2.25	0.74	231.50	1.00	4.20
Girls	96	2.54	0.66	244.30	1.00	4.10

Table 11. Descriptive Statistics for TC BMI (FHS HV)

Descriptive Statistics						
	N	**Mean**	**Std. Deviation**	**Sum**	**Minimum**	**Maximum**
Boys	104	23.34	6.73	2427	16.07	50.55
Girls	96	25.07	6.73	2406	15.32	44.49

Table 12. Descriptive Statistics for Pct for BMI-for-age (FHS HV)

Descriptive Statistics						
	N	**Mean**	**Std. Deviation**	**Sum**	**Minimum**	**Maximum**
Boys	104	67.03	29.72	6971	5.16	99.85
Girls	96	75.59	23.25	7257	2.90	99.53

Table 13. Descriptive Statistics for Z-score for BMI-for-age (FHS HV)

Descriptive Statistics						
	N	**Mean**	**Std. Deviation**	**Sum**	**Minimum**	**Maximum**
Boys	104	0.70	1.15	72.90	-1.63	2.98
Girls	96	0.96	0.98	92.37	-1.90	2.60

Table 14. Descriptive Statistics for Total kcals consumed at dinner HV1

Descriptive Statistics						
	N	**Mean**	**Std. Deviation**	**Sum**	**Minimum**	**Maximum**
Boys	104	1050	369.89	109201	98.33	2134
Girls	96	902.82	252.97	86671	308.94	1358

Table 15. Descriptive Statistics for Total kcals consumed at dinner HV2

Descriptive Statistics						
	N	**Mean**	**Std. Deviation**	**Sum**	**Minimum**	**Maximum**
Boys	104	1056	390.32	109818	61.83	2046
Girls	96	861.14	287.08	82669	153.78	1564

BIBLIOGRAPHY

Ackard, D.M. (2004) Anorexia, bulimia, disordered eating, and obesity. In: Legato MJ (ed) *Principles of gender-specific medicine* (pp. 715–728). Elsevier Academic Press, California.

Agranat-Meged, A. N., Deitcher, C., Goldzweig, G., Leibenson, L., Stein, M., & Galili-Weisstub, E. (2005). Childhood obesity and attention deficit/hyperactivity disorder: a newly described comorbidity in obese hospitalized children. *The International journal of eating disorders*, *37*(4), 357–359. https://doi.org/10.1002/eat.20096

Ajibewa, T. A., Robinson, L. E., Toledo-Corral, C., Miller, A. L., Sonneville, K. R., & Hasson, R. E. (2021). Acute Daily Stress, Daily Food Consumption, and the Moderating Effect of Disordered Eating among Adolescents with Overweight/Obesity. *Childhood obesity (Print)*, *17*(6), 391–399. https://doi.org/10.1089/chi.2021.0017

Anderson, S. E., Cohen, P., Naumova, E. N., & Must, A. (2006). Association of depression and anxiety disorders with weight change in a prospective community-based study of children followed up into adulthood. *Archives of pediatrics & adolescent medicine*, *160*(3), 285–291. https://doi.org/10.1001/archpedi.160.3.285

Bayer, O., Rosario, A. S., Wabitsch, M., & von Kries, R. (2009). Sleep duration and obesity in children: is the association dependent on age and choice of the outcome parameter?. *Sleep*, *32*(9), 1183–1189. https://doi.org/10.1093/sleep/32.9.1183

Beccia, A. L., Baek, J., Jesdale, W. M., Austin, S. B., Forrester, S., Curtin, C., & Lapane, K. L. (2019). Risk of disordered eating at the intersection of gender and racial/ethnic identity among U.S. high school students. *Eating behaviors*, *34*, 101299. https://doi.org/10.1016/j.eatbeh.2019.05.002

Bell, L. M., Byrne, S., Thompson, A., Ratnam, N., Blair, E., Bulsara, M., Jones, T. W., & Davis, E. A. (2007). Increasing body mass index z-score is continuously associated with complications of overweight in children, even in the healthy weight range. *The Journal of clinical endocrinology and metabolism*, *92*(2), 517–522. https://doi.org/10.1210/jc.2006-1714

Bell, L. M., Curran, J. A., Byrne, S., Roby, H., Suriano, K., Jones, T. W., & Davis, E. A. (2011). High incidence of obesity co-morbidities in young children: a cross-sectional study. *Journal of paediatrics and child health*, *47*(12), 911–917. https://doi.org/10.1111/j.1440-1754.2011.02102.x

Bellisle, F., Clément, K., Le Barzic, M., Le Gall, A., Guy-Grand, B., & Basdevant, A. (2004). The Eating Inventory and body adiposity from leanness to massive obesity: a study of 2509 adults. *Obesity research*, *12*(12), 2023–2030. https://doi.org/10.1038/oby.2004.253

Bernstein, R., Sanchez, N., Clark, E., Conte, I., Gulley, L. D., Legget, K. T., Cornier, M. A., Melby, C., Johnson, S. A., Lucas-Thompson, R., & Shomaker, L. B. (2021). Mindfulness-based intervention in adolescents at risk for excess weight gain: 1.5-year follow-up of pilot randomized controlled trial. *Eating behaviors*, *43*, 101580. https://doi.org/10.1016/j.eatbeh.2021.101580

Boggiano, M. M., Wenger, L. E., Burgess, E. E., Tatum, M. M., Sylvester, M. D., Morgan, P. R., & Morse, K. E. (2017). Eating tasty foods to cope, enhance reward, socialize or conform: What other psychological characteristics describe each of these motives?. *Journal of health psychology*, *22*(3), 280–289. https://doi.org/10.1177/1359105315600240

Braet, C., & Van Strien, T. (1997). Assessment of emotional, externally induced and restrained eating behaviour in nine to twelve-year-old obese and non-obese children. *Behaviour research and therapy*, *35*(9), 863–873. https://doi.org/10.1016/s0005-7967(97)00045-4

Braet, C., Claus, L., Goossens, L., Moens, E., Van Vlierberghe, L., & Soetens, B. (2008). Differences in eating style between overweight and normal-weight youngsters. *Journal of health psychology*, *13*(6), 733–743. https://doi.org/10.1177/1359105308093850

Cappelleri, J. C., Bushmakin, A. G., Gerber, R. A., Leidy, N. K., Sexton, C. C., Lowe, M. R., & Karlsson, J. (2009). Psychometric analysis of the Three-Factor Eating Questionnaire-R21: results from a large diverse sample of obese and non-obese participants. *International journal of obesity (2005)*, *33*(6), 611–620. https://doi.org/10.1038/ijo.2009.74

Caprio, S., Daniels, S. R., Drewnowski, A., Kaufman, F. R., Palinkas, L. A., Rosenbloom, A. L., & Schwimmer, J. B. (2008). Influence of race, ethnicity, and culture on childhood obesity: implications for prevention and treatment: a consensus statement of Shaping America's Health and the Obesity Society. *Diabetes care*, *31*(11), 2211–2221. https://doi.org/10.2337/dc08-9024

Collins M. E. (1991). Body figure perceptions and preferences among preadolescent children. *Int. J. Eat. Disord.*, *10*, 199–208. https://doi.org/10.1002/1098-108X(199103)10:2<199::AID-EAT2260100209>3.0.CO;2-D.

Croll, J., Neumark-Sztainer, D., Story, M., & Ireland, M. (2002). Prevalence and risk and protective factors related to disordered eating behaviors among adolescents: relationship to gender and ethnicity. *The Journal of adolescent health : official publication of the*

Society for Adolescent Medicine, *31*(2), 166–175. https://doi.org/10.1016/s1054-139x(02)00368-3

Dallman, M. F., Pecoraro, N., Akana, S. F., La Fleur, S. E., Gomez, F., Houshyar, H., Bell, M. E., Bhatnagar, S., Laugero, K. D., & Manalo, S. (2003). Chronic stress and obesity: a new view of "comfort food". *Proceedings of the National Academy of Sciences of the United States of America*, *100*(20), 11696–11701. https://doi.org/10.1073/pnas.1934666100

Datar, A., & Sturm, R. (2004). Childhood overweight and parent- and teacher-reported behavior problems: evidence from a prospective study of kindergartners. *Archives of pediatrics & adolescent medicine*, *158*(8), 804–810. https://doi.org/10.1001/archpedi.158.8.804

Davis, A. M., Bennett, K. J., Befort, C., & Nollen, N. (2011). Obesity and related health behaviors among urban and rural children in the United States: data from the National Health And Nutrition Examination Survey 2003-2004 and 2005-2006. *Journal of pediatric psychology*, *36*(6), 669–676. https://doi.org/10.1093/jpepsy/jsq117

de Lauzon-Guillain, B., Basdevant, A., Romon, M., Karlsson, J., Borys, J. M., Charles, M. A., & FLVS Study Group (2006). Is restrained eating a risk factor for weight gain in a general population?. *The American journal of clinical nutrition*, *83*(1), 132–138. https://doi.org/10.1093/ajcn/83.1.132

Delamater, A.M., Pulgaron, E.R., Daigre, O'Donohue, A., Benuto, L., Tolle, L., editors. (2013). *Adolescent health psychology.* New York, New York: Springer. Forthcoming.

Dimitratos, S. M., Swartz, J. R., Laugero, K. D. (2022). Pathways of parental influence on adolescent diet and obesity: a psychological stress–focused perspective. *Nutrition Reviews, 00*(0), 1–11. https://doi.org/10.1093/nutrit/nuac004.

Dohle, S., Diel, K., & Hofmann, W. (2018). Executive functions and the self-regulation of eating behavior: A review. *Appetite*, *124*, 4–9. https://doi.org/10.1016/j.appet.2017.05.041

El-Sheikh, M., Keller, P. S., & Erath, S. A. (2007). Marital conflict and risk for child maladjustment over time: skin conductance level reactivity as a vulnerability factor. *Journal of abnormal child psychology*, *35*(5), 715–727. https://doi.org/10.1007/s10802-007-9127-2

Elfhag, K., Tholin, S., & Rasmussen, F. (2008). Consumption of fruit, vegetables, sweets and soft drinks are associated with psychological dimensions of eating behaviour in parents and their 12-year-old children. *Public health nutrition*, *11*(9), 914–923. https://doi.org/10.1017/S1368980008002371

Epel, E., Lapidus, R., McEwen, B., & Brownell, K. (2001). Stress may add bite to appetite in women: a laboratory study of stress-induced cortisol and eating behavior. *Psychoneuroendocrinology*, *26*(1), 37–49. https://doi.org/10.1016/s0306-4530(00)00035-4

Eschenbeck, H., Kohlmann, C. W., Dudey, S., & Schurholz, T. (2009). Physician-diagnosed obesity in German 6- to 14-year-olds. Prevalence and comorbidity of internalising disorders, externalising disorders, and sleep disorders. *Obesity facts*, *2*(2), 67–73. https://doi.org/10.1159/000209987

Fedoroff, I. C., Polivy, J., & Herman, C. P. (1997). The effect of pre-exposure to food cues on the eating behavior of restrained and unrestrained eaters. *Appetite*, *28*(1), 33–47. https://doi.org/10.1006/appe.1996.0057

Fiese, B. H., Everhart, R. S., Wildenger, L. (2009). Wheezing, sleeping, and worrying: The hidden risks of asthma and obesity in school-age children. *Psychology in the Schools,* 46(8), 728-738. https://doi.org/10.1002/pits.20411

Foster, G. D., Wadden, T. A., Swain, R. M., Stunkard, A. J., Platte, P., & Vogt, R. A. (1998). The Eating Inventory in obese women: clinical correlates and relationship to weight loss. *International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity*, *22*(8), 778–785. https://doi.org/10.1038/sj.ijo.0800659

Francis, L. A., & Susman, E. J. (2009). Self-regulation and rapid weight gain in children from age 3 to 12 years. *Archives of pediatrics & adolescent medicine*, *163*(4), 297–302. https://doi.org/10.1001/archpediatrics.2008.579

Francis, L. A., Granger, D. A., & Susman, E. J. (2013). Adrenocortical regulation, eating in the absence of hunger and BMI in young children. *Appetite*, *64*, 32–38. https://doi.org/10.1016/j.appet.2012.11.008

Gibson, L. Y., Byrne, S. M., Blair, E., Davis, E. A., Jacoby, P., & Zubrick, S. R. (2008). Clustering of psychosocial symptoms in overweight children. *The Australian and New Zealand journal of psychiatry*, *42*(2), 118–125. https://doi.org/10.1080/00048670701787560

Goldman, R., Jaffa, M., & Schachter, S. (1968). Yom Kippur, air France, dormitory food, and the eating behavior of obese and normal persons. *Journal of personality and social psychology*, *10*(2), 117–123. https://doi.org/10.1037/h0026281

Goldsmith, H.H., & Rothbart, M.K. (1996). *The Laboratory Temperament Assessment Battery (Lab-TAB)* Personality Development Laboratory, Department of Psychology, University of Wisconsin; Madison, WI.

Gordis, E. B., Granger, D. A., Susman, E. J., & Trickett, P. K. (2006). Asymmetry between salivary cortisol and alpha-amylase reactivity to stress. Relation to aggressive behavior in adolescents. Psychoneuroendocrinology, 31, 976–987.

Graham, J. W., Taylor, B. J., Olchowski, A. E., & Cumsille, P. E. (2006). Planned missing data designs in psychological research. *Psychological methods*, *11*(4), 323–343. https://doi.org/10.1037/1082-989X.11.4.323

Gunnar, M.R., & Vazquez, D. (2015). Stress Neurobiology and Developmental Psychopathology. In *Developmental Neuroscience* (Vol. 2, pp. 533-577). John Wiley and Sons Ltd. https://doi.org/10.1002/9780470939390.ch13

Gunnar, M. R., Wewerka, S., Frenn, K., Long, J. D., & Griggs, C. (2009). Developmental changes in hypothalamus-pituitary-adrenal activity over the transition to adolescence: normative changes and associations with puberty. *Development and psychopathology*, *21*(1), 69–85. https://doi.org/10.1017/S0954579409000054

Gustafson-Larson, A. M., & Terry, R. D. (1992). Weight-related behaviors and concerns of fourth-grade children. *Journal of the American Dietetic Association*, *92*(7), 818–822.

Hales, C. M., Carroll, M. D., Fryar, C. D., & Ogden, C. L. (2017). Prevalence of Obesity Among Adults and Youth: United States, 2015-2016. *NCHS data brief*, (288), 1–8.

Hales, C. M., Fryar, C. D., Carroll, M. D., Freedman, D. S., & Ogden, C. L. (2018). Trends in Obesity and Severe Obesity Prevalence in US Youth and Adults by Sex and Age, 2007-2008 to 2015-2016. *JAMA*, *319*(16), 1723–1725. https://doi.org/10.1001/jama.2018.3060

Hall, K. D., Heymsfield, S. B., Kemnitz, J. W., Klein, S., Schoeller, D. A., & Speakman, J. R. (2012). Energy balance and its components: implications for body weight regulation. *The American journal of clinical nutrition*, *95*(4), 989–994. https://doi.org/10.3945/ajcn.112.036350

Hanson, M. A., & Gluckman, P. D. (2014). Early developmental conditioning of later health and disease: physiology or pathophysiology?. *Physiological reviews*, *94*(4), 1027–1076. https://doi.org/10.1152/physrev.00029.2013

Hendy H. M. (2002). Effectiveness of trained peer models to encourage food acceptance in preschool children. *Appetite*, *39*(3), 217–225. https://doi.org/10.1006/appe.2002.0510

Herman, C.P., & Polivy, J. (1980). Restrained eating. In A.J. Stunkard (Ed.), *Obesity* (pp. 208-225). Philadelphia, PA: Saunders.

Higgs, S., & Thomas, J. (2016). Social Influences on eating. *Current Opinion in Behavioral Sciences, 9*, 1-6. https://doi.org/10.1016/j.cobeha.2015.10.005

Hillman, J. B., Dorn, L. D., & Bin Huang (2010). Association of anxiety and depressive symptoms and adiposity among adolescent females, using dual energy X-ray absorptiometry. *Clinical pediatrics*, *49*(7), 671–677. https://doi.org/10.1177/0009922810363155

Hirsch, O., Kluckner, V. J., Brandt, S., Moss, A., Weck, M., Florath, I., Wabitsch, M., Hebebrand, J., Schimmelmann, B. G., & Christiansen, H. (2014). Restrained and external-emotional eating patterns in young overweight children-results of the Ulm Birth Cohort Study. *PloS one, 9*(8), e105303. https://doi.org/10.1371/journal.pone.0105303

Hunot-Alexander, C., Beeken, R. J., Goodman, W., Fildes, A., Croker, H., Llewellyn, C., & Steinsbekk, S. (2019). Confirmation of the Factor Structure and Reliability of the 'Adult

Eating Behavior Questionnaire' in an Adolescent Sample. *Frontiers in psychology*, *10*, 1991. https://doi.org/10.3389/fpsyg.2019.01991

Jääskeläinen, A., Nevanperä, N., Remes, J., Rahkonen, F., Järvelin, M. R., & Laitinen, J. (2014). Stress-related eating, obesity and associated behavioural traits in adolescents: a prospective population-based cohort study. *BMC public health*, *14*, 321. https://doi.org/10.1186/1471-2458-14-321

Jackson, J. E., Doescher, M. P., Jerant, A. F., & Hart, L. G. (2005). A national study of obesity prevalence and trends by type of rural county. *The Journal of rural health: official journal of the American Rural Health Association and the National Rural Health Care Association*, *21*(2), 140–148. https://doi.org/10.1111/j.1748-0361.2005.tb00074.x

Jacobson, L., & Sapolsky, R. (1991). The role of the hippocampus in feedback regulation of the hypothalamic-pituitary-adrenocortical axis. *Endocrine reviews*, *12*(2), 118–134. https://doi.org/10.1210/edrv-12-2-118

Jahnke, D. L., & Warschburger, P. A. (2008). Familial transmission of eating behaviors in preschool-aged children. *Obesity (Silver Spring, Md.)*, *16*(8), 1821–1825. https://doi.org/10.1038/oby.2008.255

Johnson, F., Pratt, M., & Wardle, J. (2012). Dietary restraint and self-regulation in eating behavior. *International journal of obesity (2005)*, *36*(5), 665–674. https://doi.org/10.1038/ijo.2011.156

Johnson, J. A., 3rd, & Johnson, A. M. (2015). Urban-rural differences in childhood and adolescent obesity in the United States: a systematic review and meta-analysis. *Childhood obesity (Print)*, *11*(3), 233–241. https://doi.org/10.1089/chi.2014.0085

Johnson, J. G., Cohen, P., Kasen, S., & Brook, J. S. (2002). Childhood adversities associated with risk for eating disorders or weight problems during adolescence or early adulthood. *The American journal of psychiatry*, *159*(3), 394–400. https://doi.org/10.1176/appi.ajp.159.3.394

Juster, R. P., McEwen, B. S., & Lupien, S. J. (2010). Allostatic load biomarkers of chronic stress and impact on health and cognition. *Neuroscience and biobehavioral reviews*, *35*(1), 2–16. https://doi.org/10.1016/j.neubiorev.2009.10.02

Kaplan, H. I., & Kaplan, H. S. (1957). The psychosomatic concept of obesity. *Journal of Nervous and Mental Disease*, *125,* 181–201.

Keller, K. L., Kling, S., Fuchs, B., Pearce, A. L., Reigh, N. A., Masterson, T., & Hickok, K. (2019). A Biopsychosocial Model of Sex Differences in Children's Eating Behaviors. *Nutrients*, *11*(3), 682. https://doi.org/10.3390/nu11030682

Keller, P. S., & El-Sheikh, M. (2009). Salivary alpha-amylase as a longitudinal predictor of children's externalizing symptoms: respiratory sinus arrhythmia as a moderator of effects. *Psychoneuroendocrinology*, *34*(5), 633–643. https://doi.org/10.1016/j.psyneuen.2008.12.016

Kelly, S. D., Howe, C. J., Hendler, J. P., & Lipman, T. H. (2005). Disordered eating behaviors in youth with type 1 diabetes. *The Diabetes educator*, *31*(4), 572–583. https://doi.org/10.1177/0145721705279049

Kim, J., Mutyala, B., Agiovlasitis, S., & Fernhall, B. (2011). Health behaviors and obesity among US children with attention deficit hyperactivity disorder by gender and medication use. *Preventive medicine*, *52*(3-4), 218–222. https://doi.org/10.1016/j.ypmed.2011.01.003

Klatzkin, R. R., Dasani, R., Warren, M., Cattaneo, C., Nadel, T., Nikodem, C., & Kissileff, H. R. (2019). Negative affect is associated with increased stress-eating for women with high perceived life stress. *Physiology & behavior*, *210*, 112639. https://doi.org/10.1016/j.physbeh.2019.112639

Klump K. L. (2013). Puberty as a critical risk period for eating disorders: a review of human and animal studies. *Hormones and behavior*, *64*(2), 399–410. https://doi.org/10.1016/j.yhbeh.2013.02.019

Klump, K. L., O'Connor, S. M., Hildebrandt, B. A., Keel, P. K., Neale, M., Sisk, C. L., Boker, S., & Burt, S. A. (2016). Differential Effects of Estrogen and Progesterone on Genetic and Environmental Risk for Emotional Eating in Women. *Clinical psychological science: a journal of the Association for Psychological Science*, *4*(5), 895–908. https://doi.org/10.1177/2167702616641637

Kochanska, G., & Aksan, N. (2006). Children's conscience and self-regulation. *Journal of personality*, *74*(6), 1587–1617. https://doi.org/10.1111/j.1467-6494.2006.00421.x

Kohs, S. C. (1923). *Intelligence measurement: A psychological and statistical study based upon the block-design tests*. New York: MacMillan Co.

Kuczmarski, R. J., & Flegal, K. M. (2000). Criteria for definition of overweight in transition: background and recommendations for the United States. *The American journal of clinical nutrition*, *72*(5), 1074–1081. https://doi.org/10.1093/ajcn/72.5.1074

Larson, N., Loth, K. A., Eisenberg, M. E., Hazzard, V. M., & Neumark-Sztainer, D. (2021). Body dissatisfaction and disordered eating are prevalent problems among U.S. young people from diverse socioeconomic backgrounds: Findings from the EAT 2010-2018 study. *Eating behaviors*, *42*, 101535. https://doi.org/10.1016/j.eatbeh.2021.101535

Lawless, M., Shriver, L. H., Hubbs-Tait, L., Topham, G. L., Swindle, T., & Harrist, A. W. (2021). Bidirectional Associations between Restrained Eating and Body Mass Index in Middle Childhood. *Nutrients*, *13*(5), 1485. https://doi.org/10.3390/nu13051485

Levine, M. P., Smolak, L., Moodey, A. F., Shuman, M. D., & Hessen, L. D. (1994). Normative developmental challenges and dieting and eating disturbances in middle school girls. *The International journal of eating disorders*, *15*(1), 11–20. https://doi.org/10.1002/1098-108x(199401)15:1<11::aid-eat2260150103>3.0.co;2-q

Limbers, C. A., & Summers, E. (2021). Emotional Eating and Weight Status in Adolescents: A Systematic Review. *International journal of environmental research and public health*, *18*(3), 991. https://doi.org/10.3390/ijerph18030991

Lincoln, K. D., Abdou, C. M., & Lloyd, D. (2014). Race and socioeconomic differences in obesity and depression among Black and non-Hispanic White Americans. *Journal of health care for the poor and underserved*, *25*(1), 257–275. https://doi.org/10.1353/hpu.2014.0038

Lluch, A., Herbeth, B., Méjean, L., & Siest, G. (2000). Dietary intakes, eating style and overweight in the Stanislas Family Study. *International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity*, *24*(11), 1493–1499. https://doi.org/10.1038/sj.ijo.0801425

Lupien, S. J., McEwen, B. S., Gunnar, M. R., & Heim, C. (2009). Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nature reviews. Neuroscience*, *10*(6), 434–445. https://doi.org/10.1038/nrn2639

Matthews, K. A., Rakaczky, C.J., Stoney, C.M., & Manuck, S.B. (1987). Are Cardiovascular-Responses to Behavioral Stressors a Stable Individual Difference Variable in Childhood. *Psychophysiology, 24*(4), 464-473.

McArthur, L. Z., & Burstein, B. (1975). Field dependent eating and perception as a function of weight and sex. *Journal of personality, 43*(3), 402–420. https://doi.org/10.1111/j.1467-6494.1975.tb00713.x

McCormick, C. M., & Mathews, I. Z. (2007). HPA function in adolescence: role of sex hormones in its regulation and the enduring consequences of exposure to stressors. *Pharmacology, biochemistry, and behavior, 86*(2), 220–233. https://doi.org/10.1016/j.pbb.2006.07.012

McEwen B. S. (2000). Allostasis and allostatic load: implications for neuropsychopharmacology. *Neuropsychopharmacology : official publication of the American College of Neuropsychopharmacology, 22*(2), 108–124. https://doi.org/10.1016/S0893-133X(99)00129-3

McEwen, B. S., & Gianaros, P. J. (2010). Central role of the brain in stress and adaptation: links to socioeconomic status, health, and disease. *Annals of the New York Academy of Sciences, 1186*, 190–222. https://doi.org/10.1111/j.1749-6632.2009.05331.x

McKinley, M. C., Lowis, C., Robson, P. J., Wallace, J. M., Morrissey, M., Moran, A., & Livingstone, M. B. (2005). It's good to talk: children's views on food and nutrition. *European journal of clinical nutrition, 59*(4), 542–551. https://doi.org/10.1038/sj.ejcn.1602113

Naets, T., Vervoort, L., Tanghe, A., De Guchtenaere, A., & Braet, C. (2020). Maladaptive Eating in Children and Adolescents With Obesity: Scrutinizing Differences in Inhibition. *Frontiers in psychiatry*, *11*, 309. https://doi.org/10.3389/fpsyt.2020.00309

Nagata, J. M., Garber, A. K., Tabler, J. L., Murray, S. B., & Bibbins-Domingo, K. (2018). Prevalence and Correlates of Disordered Eating Behaviors Among Young Adults with Overweight or Obesity. *Journal of general internal medicine*, *33*(8), 1337–1343. https://doi.org/10.1007/s11606-018-4465-z

Nagy, M. R., Gill, A., Adams, T., Gerras, J., Mazin, L., Leung, C., & Hasson, R. E. (2019). Stress-Induced Suppression of Food Intake in Overweight and Obese Adolescents. *Psychosomatic medicine*, *81*(9), 814–820. https://doi.org/10.1097/PSY.0000000000000732

Nederkoorn, C., Jansen, E., Mulkens, S., & Jansen, A. (2007). Impulsivity predicts treatment outcome in obese children. *Behaviour research and therapy*, *45*(5), 1071–1075. https://doi.org/10.1016/j.brat.2006.05.009

Neumann, M., Holzapfel, C., Müller, A., Hilbert, A., Crosby, R. D., & de Zwaan, M. (2018). Features and Trajectories of Eating Behavior in Weight-Loss Maintenance: Results from the German Weight Control Registry. *Obesity (Silver Spring, Md.)*, *26*(9), 1501–1508. https://doi.org/10.1002/oby.22270

Neumark-Sztainer, D., Wall, M., Guo, J., Story, M., Haines, J., & Eisenberg, M. (2006). Obesity, disordered eating, and eating disorders in a longitudinal study of adolescents: how do dieters fare 5 years later?. *Journal of the American Dietetic Association*, *106*(4), 559–568. https://doi.org/10.1016/j.jada.2006.01.003

Neumark-Sztainer, D., Wall, M., Larson, N. I., Eisenberg, M. E., & Loth, K. (2011). Dieting and disordered eating behaviors from adolescence to young adulthood: findings from a 10-year longitudinal study. *Journal of the American Dietetic Association*, *111*(7), 1004–1011. https://doi.org/10.1016/j.jada.2011.04.012

Nisbett R. E. (1968). Taste, deprivation, and weight determinants of eating behavior. *Journal of personality and social psychology*, *10*(2), 107–116. https://doi.org/10.1037/h0026283

Nixon, G. M., Thompson, J. M., Han, D. Y., Becroft, D. M., Clark, P. M., Robinson, E., Waldie, K. E., Wild, C. J., Black, P. N., & Mitchell, E. A. (2008). Short sleep duration in middle childhood: risk factors and consequences. *Sleep*, *31*(1), 71–78. https://doi.org/10.1093/sleep/31.1.71

O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology, 27*(1, Suppl), S20–S31. https://doi.org/10.1037/0278-6133.27.1.S20

Ogden, C. L., Carroll, M. D., Fakhouri, T. H., Hales, C. M., Fryar, C. D., Li, X., & Freedman, D. S. (2018a). Prevalence of Obesity Among Youths by Household Income and Education Level of Head of Household - United States 2011-2014. *MMWR. Morbidity and mortality weekly report*, *67*(6), 186–189. https://doi.org/10.15585/mmwr.mm6706a3

Ogden, C. L., Fryar, C. D., Hales, C. M., Carroll, M. D., Aoki, Y., & Freedman, D. S. (2018b). Differences in Obesity Prevalence by Demographics and Urbanization in US Children and Adolescents, 2013-2016. *JAMA, 319*(23), 2410–2418. https://doi.org/10.1001/jama.2018.5158

Oliver, K.K., & Thelen, M.H. (1996). Children's perceptions of peer influence on eating concerns. *Behav. Ther., 27*, 25–39. https://doi.org/10.1016/S0005-7894(96)80033-5

Paris, J. J., Franco, C., Sodano, R., Freidenberg, B., Gordis, E., Anderson, D. A., Forsyth, J. P., Wulfert, E., & Frye, C. A. (2010). Sex differences in salivary cortisol in response to acute stressors among healthy participants, in recreational or pathological gamblers, and in those with posttraumatic stress disorder. *Hormones and behavior*, *57*(1), 35–45. https://doi.org/10.1016/j.yhbeh.2009.06.003

Patterson, Z. R., & Abizaid, A. (2013). Stress induced obesity: lessons from rodent models of stress. *Frontiers in neuroscience*, *7*, 130. https://doi.org/10.3389/fnins.2013.00130

Phares, V., Steinberg, A.R., & Thompson, J.K. (2004). Gender Differences in Peer and Parental Influences: Body Image Disturbance, Self-Worth, and Psychological Functioning in Preadolescent Children. *J. Youth Adolesc.*, *33*, 421–429. https://doi.org/10.1023/B:JOYO.0000037634.18749.20.

Proffitt Leyva, R. P., Mengelkoch, S., Gassen, J., Ellis, B. J., Russell, E. M., & Hill, S. E. (2020). Low socioeconomic status and eating in the absence of hunger in children aged 3-14. *Appetite*, *154*, 104755. https://doi.org/10.1016/j.appet.2020.104755

Provencher, V., Drapeau, V., Tremblay, A., Després, J. P., & Lemieux, S. (2003). Eating behaviors and indexes of body composition in men and women from the Québec family study. *Obesity research*, *11*(6), 783–792. https://doi.org/10.1038/oby.2003.109

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. Psychoneuroendocrinology, 28, 916–931.

Ricciardelli, L. A., & McCabe, M. P. (2001). Children's body image concerns and eating disturbance: a review of the literature. *Clinical psychology review*, *21*(3), 325–344. https://doi.org/10.1016/s0272-7358(99)00051-3

Robinson, T. N., Chang, J. Y., Haydel, K. F., & Killen, J. D. (2001). Overweight concerns and body dissatisfaction among third-grade children: the impacts of ethnicity and socioeconomic status. *The Journal of pediatrics*, *138*(2), 181–187. https://doi.org/10.1067/mpd.2001.110526

Ross, L. (1974). Effects of manipulating salience of food upon consumption by obese and normal eaters. In S. Schachter & J. Rodin (Eds.), *Obese humans and rats* (pp. 43-52). Potomac, MD: Erlbaum.

Rossen, L. M., & Schoendorf, K. C. (2012). Measuring health disparities: trends in racial-ethnic and socioeconomic disparities in obesity among 2- to 18-year old youth in the United States, 2001-2010. *Ann Epidemiol.*, *22*(10), 698-704.

Roy, S. K., Jahan, K., Alam, N., Rois, R., Ferdaus, A., Israt, S., & Karim, M. R. (2021). Perceived stress, eating behavior, and overweight and obesity among urban adolescents. *Journal of health, population, and nutrition*, *40*(1), 54. https://doi.org/10.1186/s41043-021-00279-2

Rutters, F., Nieuwenhuizen, A. G., Bouwman, F., Mariman, E., & Westerterp-Plantenga, M. S. (2011). Associations between a single nucleotide polymorphism of the FTO Gene (rs9939609) and obesity-related characteristics over time during puberty in a Dutch children cohort. *The Journal of clinical endocrinology and metabolism*, *96*(6), E939–E942. https://doi.org/10.1210/jc.2010-2413

Ruttle, P. L., Javaras, K. N., Klein, M. H., Armstrong, J. M., Burk, L. R., & Essex, M. J. (2013). Concurrent and longitudinal associations between diurnal cortisol and body mass index across adolescence. *The Journal of adolescent health : official publication of the Society* *for Adolescent Medicine*, *52*(6), 731–737. https://doi.org/10.1016/j.jadohealth.2012.11.013

Sanyaolu, A., Okorie, C., Qi, X., Locke, J., & Rehman, S. (2019). Childhood and Adolescent Obesity in the United States: A Public Health Concern. *Global pediatric health*, *6*, 2333794X19891305. https://doi.org/10.1177/2333794X19891305

Schachter, S. (1971). Some extraordinary facts about obese humans and rats. *American Psychologist*, *26*(2), 129–144. https://doi.org/10.1037/h0030817

Schachter, S., & Friedman, L.N. (1974). The effects of work and cue prominence on eating behavior in S. Schachter & J. Rodin (Eds.). *Obese humans and rats* (pp. 11-14). Potomac, MD: Erlbaum.

Schachter, S., & Gross, L. P. (1968). Manipulated time and eating behavior. *Journal of personality and social psychology*, *10*(2), 98–106. https://doi.org/10.1037/h0026285

Schachter, S., & Rodin, J. (1974). *Obese humans and rats.* Lawrence Erlbaum.

Schachter, S., Goldman, R., & Gordon, A. (1968). Effects of fear, food deprivation, and obesity on eating. *Journal of personality and social psychology*, *10*(2), 91–97. https://doi.org/10.1037/h0026284

Schiefelbein, V. L., & Susman, E. J. (2006). Cortisol Levels and Longitudinal Cortisol Change as Predictors of Anxiety in Adolescents. *The Journal of Early Adolescence*, *26*(4), 397–413. https://doi.org/10.1177/0272431606291943

Schwartz, E. B., Granger, D. A., Susman, E. J., Gunnar, M. R., & Laird, B. (1998). Assessing salivary cortisol in studies of child development. *Child development*, *69*(6), 1503–1513.

Shriver, L. H., Dollar, J. M., Lawless, M., Calkins, S. D., Keane, S. P., Shanahan, L., & Wideman, L. (2019). Longitudinal Associations between Emotion Regulation and

Adiposity in Late Adolescence: Indirect Effects through Eating Behaviors. *Nutrients*, *11*(3), 517. https://doi.org/10.3390/nu11030517

Snoek, H. M., Engels, R. C., van Strien, T., & Otten, R. (2013). Emotional, external and restrained eating behaviour and BMI trajectories in adolescence. *Appetite*, *67*, 81–87. https://doi.org/10.1016/j.appet.2013.03.014

Snoek, H. M., van Strien, T., Janssens, J. M. A. M., & Engels, R. C. M. E. (2008). Restrained eating and BMI: A longitudinal study among adolescents. *Health Psychology*, *27*(6), 753–759. https://doi.org/10.1037/0278-6133.27.6.753

Snoek, H. M., van Strien, T., Janssens, J. M., & Engels, R. C. (2007). Emotional, external, restrained eating and overweight in Dutch adolescents. *Scandinavian journal of psychology*, *48*(1), 23–32. https://doi.org/10.1111/j.1467-9450.2006.00568.x

Sondeijker, F. E., Ferdinand, R. F., Oldehinkel, A. J., Veenstra, R., Tiemeier, H., Ormel, J., & Verhulst, F. C. (2007). Disruptive behaviors and HPA-axis activity in young adolescent boys and girls from the general population. *Journal of psychiatric research*, *41*(7), 570–578. https://doi.org/10.1016/j.jpsychires.2006.04.002

Stice E. (2001). A prospective test of the dual-pathway model of bulimic pathology: mediating effects of dieting and negative affect. *Journal of abnormal psychology*, *110*(1), 124–135. https://doi.org/10.1037//0021-843x.110.1.124

Stice, E., Cameron, R. P., Killen, J. D., Hayward, C., & Taylor, C. B. (1999). Naturalistic weight-reduction efforts prospectively predict growth in relative weight and onset of obesity among female adolescents. *Journal of consulting and clinical psychology*, *67*(6), 967–974. https://doi.org/10.1037//0022-006x.67.6.967

Stice, E., Presnell, K., Shaw, H., & Rohde, P. (2005). Psychological and behavioral risk factors for obesity onset in adolescent girls: a prospective study. *Journal of consulting and clinical psychology*, *73*(2), 195–202. https://doi.org/10.1037/0022-006X.73.2.195

Stroebe, W., Papies, E.K. and Aarts, H. (2008), From Homeostatic to Hedonic Theories of Eating: Self-Regulatory Failure in Food-Rich Environments. Applied Psychology, 57: 172-193. https://doi.org/10.1111/j.1464-0597.2008.00360.x

Stroud, L. R., Foster, E., Papandonatos, G. D., Handwerger, K., Granger, D. A., Kivlighan, K. T., & Niaura, R. (2009). Stress response and the adolescent transition: performance versus peer rejection stressors. *Development and psychopathology*, *21*(1), 47–68. https://doi.org/10.1017/S0954579409000042

Stunkard, A. J., & Messick, S. (1985). The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of psychosomatic research*, *29*(1), 71–83. https://doi.org/10.1016/0022-3999(85)90010-8

Sumter, S. R., Bokhorst, C. L., Miers, A. C., Van Pelt, J., & Westenberg, P. M. (2010). Age and puberty differences in stress responses during a public speaking task: do adolescents grow more sensitive to social evaluation?. *Psychoneuroendocrinology*, *35*(10), 1510–1516. https://doi.org/10.1016/j.psyneuen.2010.05.004

Thelen, M.H., & Cormier, J.F. (1995). Desire to be thinner and weight control among children and their parents. *Behav. Ther.*, *26*, 85–99. https://doi.org/10.1016/S0005-7894(05)80084-X

Tom, G., & Rucker, M. (1975). Fat, full, and happy: effects of food deprivation, external cues, and obesity on preference ratings, comsumption, and buying intentions. *Journal of* *personality and social psychology*, *32*(5), 761–766. https://doi.org/10.1037//0022-3514.32.5.761

Tomiyama A. J. (2019). Stress and Obesity. *Annual review of psychology*, *70*, 703–718. https://doi.org/10.1146/annurev-psych-010418-102936

Trent, M., Jennings, J. M., Waterfield, G., Lyman, L. M., & Thomas, H. (2009). Finding targets for obesity intervention in urban communities: school-based health centers and the interface with affected youth. *Journal of urban health : bulletin of the New York Academy of Medicine*, *86*(4), 571–583. https://doi.org/10.1007/s11524-009-9355-6

Turner K., Jeffries A., Beaton S., Ferguson S., Craig J. (2013). Gendered identity negotiations through food consumption. *Young Consum.*, *14*, 280–288. https://doi.org/10.1108/YC-02-2013-00342

Ulrich-Lai, Y. M., & Herman, J. P. (2009). Neural regulation of endocrine and autonomic stress responses. *Nature reviews. Neuroscience*, *10*(6), 397–409. https://doi.org/10.1038/nrn2647

Van den Bergh, B. R., & Van Calster, B. (2009). Diurnal cortisol profiles and evening cortisol in post-pubertal adolescents scoring high on the Children's Depression Inventory. *Psychoneuroendocrinology*, *34*(5), 791–794. https://doi.org/10.1016/j.psyneuen.2008.12.008

van Koningsbruggen, G. M., Stroebe, W., & Aarts, H. (2013). Successful restrained eating and trait impulsiveness. *Appetite*, *60*(1), 81–84. https://doi.org/10.1016/j.appet.2012.09.016

van Strien T. (2018). Causes of Emotional Eating and Matched Treatment of Obesity. *Current diabetes reports*, *18*(6), 35. https://doi.org/10.1007/s11892-018-1000-x van Strien, T., Cebolla, A., Etchemendy, E., Gutiérrez-Maldonado, J., Ferrer-García, M., Botella, C., & Baños, R. (2013). Emotional eating and food intake after sadness and joy. *Appetite*, *66*, 20–25. https://doi.org/10.1016/j.appet.2013.02.016

van Strien, T., Donker, M. H., & Ouwens, M. A. (2016a). Is desire to eat in response to positive emotions an 'obese' eating style: Is Kummerspeck for some people a misnomer?. *Appetite*, *100*, 225–235. https://doi.org/10.1016/j.appet.2016.02.035

van Strien, T., Konttinen, H., Homberg, J. R., Engels, R. C., & Winkens, L. H. (2016b). Emotional eating as a mediator between depression and weight gain. *Appetite*, *100*, 216–224. https://doi.org/10.1016/j.appet.2016.02.034

Vernon-Feagans, L., Cox, M., & FLF Key Investigators (2013). The Family Life Project: an epidemiological and developmental study of young children living in poor rural communities. *Monographs of the Society for Research in Child Development*, *78*(5), 1–vii. https://doi.org/10.1111/mono.12046

Wang, Y., Beydoun, M. A., Min, J., Xue, H., Kaminsky, L. A., & Cheskin, L. J. (2020). Has the prevalence of overweight, obesity and central obesity levelled off in the United States? Trends, patterns, disparities, and future projections for the obesity epidemic. *International journal of epidemiology*, *49*(3), 810–823. https://doi.org/10.1093/ije/dyz273

Wardle, J., Marsland, L., Sheikh, Y., Quinn, M., Fedoroff, I., & Ogden, J. (1992). Eating style and eating behaviour in adolescents. *Appetite*, *18*(3), 167–183. https://doi.org/10.1016/0195-6663(92)90195-c

Wechsler, D. (2014). Wechsler intelligence scale for children (5th ed). Bloomington, MN: Pearson.

Williamson, S., & Delin, C. (2001). Young children's figural selections: accuracy of reporting and body size dissatisfaction. *The International journal of eating disorders*, *29*(1), 80–84. https://doi.org/10.1002/1098-108x(200101)29:1<80::aid-eat13>3.0.co;2-o

Wingenfeld, K., Schulz, M., Damkroeger, A., Rose, M., & Driessen, M. (2009). Elevated diurnal salivary cortisol in nurses is associated with burnout but not with vital exhaustion. *Psychoneuroendocrinology*, *34*(8), 1144–1151. https://doi.org/10.1016/j.psyneuen.2009.02.015

ACADEMIC VITA

EDUCATION https://www.linkedin.com/in/hope-idiculla/

The Pennsylvania State University **University Park, PA**
Schreyer Honors College ***Graduation Anticipated: May 2022***
College of Health and Human Development; Eberly College of Science **Dean's List Fall (x7) 2018-present**
Majors: Biobehavioral Health**,** Bachelor of Science; Science, Bachelor of Science
Minor: Diversity and Inclusion with focus on Health and Identity

EXTRACURRICULAR & VOLUNTEER ACTIVITY

Penn State University Ambulance Services (PSUAS) Feb 2021 – Present
Volunteer EMT-B
- Served over 350 hours caring for patient health needs in emergency situations
- Accomplished various medical trainings on duty to enhance health needs of patients

Organic Chemistry I and II with Dr. Katherine Masters May 2020 – Dec 2021
Learning Assistant - 4 semesters
- Assisted students in conceptualizing challenging content during classes
- Fostered critical thinking and guidance to help student understanding during weekly office hours

Remote Area Medical (RAM) Aug 2021 – Present
Volunteer
- Served uninsured community members with free medical care on mobile clinic service trip to Belmont, NY
- Assisted doctors with taking vitals and dentists with free dental procedures

Penn State Alternative Breaks (PSAB) Aug 2019 – Present
Site Leader, Public Relations Chair
- Directed 4 social justice events on topics including healthcare access, COVID-19, and environmentalism
- Led weekend Baltimore service trip to work with those fighting food insecurity (2X)
- Publicized local volunteer opportunities and social justice event information through social media accounts

Springfield Hospital COVID-19 Vaccine Clinic June 2021 – July 2021
Volunteer
- Registered and directed over 200 patients to receive Pfizer COVID-19 vaccine dose

Global Medical Brigades Aug 2019 – Present
GB Local Initiatives Chair, GMB Social Media and Alt. Fundraiser Chair
- Collaborated virtually with Honduran communities to study medical clinics and healthcare system
- Coordinated local humanitarian opportunities including 6 Red Cross blood drives with over 100 donors
- Prepared for Panama Spring 2020 medical brigade for international aid – cancelled due to pandemic

SIGNATURE PROJECTS

Schreyer Honors Thesis with Dr. Lori Francis June 2021 – April 2022
Author
- Completed Honors thesis on sex differences in adolescent eating in response to stress

Kanvas for Kids in Schreyer Aug 2019 – Present
Founder and President
- Orchestrated creative canvas painting event for students to destress during midterms
- Planned to donate uplifting paintings to children in Hershey Hospital – postponed due to COVID-19

TECHICAL SKILLS AND CERTIFICATIONS

Nationally Registered Emergency Medical Technician (EMT), CPR, AED Certified Aug 2020 - Present
AED National Professions Honor Society May 2020 – Present