Anxiety and loss of control eating in relation to adverse eating and weight-related factors, and metabolic syndrome (MetS)-related measures

by

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ABSTRACT

Anxiety and loss of control eating in relation to adverse eating and weight-related factors, and metabolic syndrome (MetS)-related measures

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Thesis directed by Marian Tanofsky-Kraff, PhD, Department of Medical & Clinical Psychology

Loss of control (LOC) eating is associated with, and predictive of, eating disorder psychopathology, gains in BMI, and adverse metabolic outcomes in youth. Some data suggest anxiety may exacerbate these associations and play an important role in the impact of LOC on these outcomes. As such, the interaction of anxiety and LOC eating as it relates to eating disorder psychopathology, disinhibited eating behaviors, BMIz, fat mass, and MetS-related measures in youth was examined. The Eating Disorder Examination was used to assess presence of LOC eating/past month and global eating pathology. Youth completed questionnaires assessing trait anxiety and disinhibited eating, including emotional eating and eating in the absence of hunger. BMI and MetS-related measures (triglycerides, LDL-cholesterol, HDL-cholesterol, glucose, insulin, insulin resistance) were measured after an overnight fast. Fat mass (kg) was assessed by air displacement plethysmography or dual energy x-ray absorptiometry. The interaction of LOC eating by anxiety was tested using MANCOVAs adjusting for age, sex, and race. Height (cm) and depression were included for the model of fat mass, and height, fat mass, and depression were included in analyses of disinhibited eating and MetS-related measures. Three-hundred-eighty-three non-treatment seeking youths (13.0±2.8y; 53% female; BMI*z*=.8±1.1; 23% with

LOC eating) were studied. The interaction of anxiety and LOC was significant such that, only in youth with LOC eating, anxiety was positively associated with fasting insulin (p=.02) and insulin resistance (p=.01). The interaction of anxiety and LOC eating was not significantly related to global eating pathology, eating in the absence of hunger, emotional eating, BMIz, fat mass, nor any other MetS-related measures (ps=ns). Data from the current study suggest anxiety may be associated with insulin and insulin resistance in non-treatment-seeking youth with LOC eating, although longitudinal studies are required to confirm directionality of these findings. Additional studies are needed to identify potential mechanisms linking these outcomes. These mechanisms, in turn, may inform interventions for those at greatest risk for adverse health outcomes.

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CHAPTER 1: INTRODUCTION

OVERVIEW

Reported loss of control (LOC) eating, a hallmark feature of binge eating disorder, is highly prevalent in children and adolescents (34; 88). LOC eating is associated with, and predictive of, disordered eating psychopathology (90), gains in body mass index (kg/m^2, BMI) (95), and adverse metabolic outcomes in youth (91). Despite these apparently adverse outcomes, however, LOC eating remits over time in roughly half of youth (90). Thus, it is necessary to determine moderating factors that may help to better explain the relationship between LOC eating and these adverse outcomes. Some data suggest that anxiety may exacerbate these associations and play an important role in the impact of LOC on adverse correlates and potentially outcomes (69; 92). This is not surprising, as anxiety and eating disorders are highly comorbid (8; 29; 38; 55; 84), and anxiety symptoms are also commonly reported by youth with overweight (7; 22; 59; 64). As such, it is possible the combination of LOC eating behaviors and anxiety in youth may interact to exacerbate adverse outcomes. Therefore, the interaction of LOC eating and anxiety as it relates to disordered eating psychopathology, disinhibited eating behaviors, BMI*z*, fat mass, and metabolic syndrome (MetS)-related measures in youth warrants examination.

At the outset of this thesis, a broad overview of the literature on eating disorders and obesity will lay the foundation for the importance of research in this area. LOC eating will be defined and the research focused on its' relationship with eating disorder psychopathology, disinhibited eating, obesity, and MetS-related measures will be delineated. Subsequently, a review of the research on the relationship between anxiety, LOC eating, and obesity will follow. Lastly, a theoretical approach, namely, affect theory, will be proposed to describe the

relationships among these variables. The review of the literature and the theoretical basis of affect theory will lay the framework for the current study, which aims to integrate prior research in the field and fill the gaps in the literature on adverse outcomes of LOC eating and anxiety in youth. Understanding how the combination of LOC eating and anxiety affects related psychological and physiological outcomes in youth may help to identify those at greatest risk for persistent LOC eating and adverse health outcomes. Ultimately, gaining a better understanding of these relationships can help to better inform interventions for youth with LOC eating.

EATING DISORDERS

Several categories of eating disorders are currently recognized by the DSM-5; anorexia nervosa, bulimia nervosa, and binge eating disorder, with 12-month prevalence rates of 0.4%, 1-1.5%, and 1-4%, respectively (2; 5; 38; 40). All of these disorders can involve binge eating, however, only for bulimia nervosa and binge eating disorder is binge eating the hallmark behavior. Binge eating is characterized by the consumption of a large amount of food and the experience of LOC over eating (5). The experience of LOC over eating is a key feature of binge eating disorder (5), and involves the inability to regulate what, how much, or for how long one is eating, regardless of the amount of food eaten (96; 100). LOC eating includes both eating episodes in which an objectively large amount of food is consumed and episodes during which the amount of food consumed may be less clearly considered large. Thus, LOC eating is the subjective experience of being unable to control what or how much one eats. Given most research shows no difference between objectively and subjectively large binge episodes for physical and psychological correlates (58; 71), researchers have argued that the experience of LOC eating is the more salient feature of binge eating, rather than the amount of food reportedly consumed (58; 71). Furthermore, given the challenges of assessing an objectively large amount

of food in children and adolescents with different nutritional needs throughout development (45; 72), LOC eating – regardless of episode size – is often considered in the pediatric literature (36; 51; 90).

LOC eating is common in childhood and adolescence. Prevalence of youth reporting LOC eating, with frequency ranging from at least once in the past month to one episode in the past year, is between 6-57 % (67; 72; 76; 77; 96). One survey study showed that 1.9% of girls and 0.8% of boys reported LOC eating behaviors at least monthly. This survey also showed the prevalence of LOC eating increased with stage of pubertal development and age for girls (20). LOC eating is more common in adolescence compared to childhood (26). Although the peak age of onset for binge eating disorder is between 16-20 years old (82), youth can report experiences of LOC eating as early as middle childhood (46).

The experience of infrequent LOC eating is particularly common among youth with overweight (34). Research suggests higher rates of LOC eating in overweight treatment-seeking adolescents, with estimates between 20-35% (28). In adolescence, LOC eating is more common in females than males (12; 48; 77), with rates typically occurring twice as frequently in adolescent girls compared to boys (1; 18). Further, LOC eating is associated with, and predictive of, disordered eating pathology (90), gains in BMI (kg/m^2) (95), and adverse metabolic outcomes in youth (91).

LOC EATING, EATING DISORDER PSYCHOPATHOLOGY, AND OTHER DISINHIBITED EATING BEHAVIORS

One's attitudes and behaviors surrounding food and eating are of critical importance to improve understanding of the pattern of weight trajectories in youth. The relationship between LOC eating, eating disorder psychopathology, and other disinhibited eating behaviors in youth is

well defined (19; 50; 83). Cross-sectionally, psychological correlates of LOC eating specific to eating disorders include cognitions such as body image disturbance and behaviors such as dietary restraint and emotional eating (3). Prospectively, children with persistent LOC eating experience significantly greater increases in eating disordered attitudes and depression over time compared to those without reported LOC eating (36; 90). Onset of LOC eating in childhood increases risk for more severe psychopathology, such as anxiety (90), more severe binge eating, use of multiple purging behaviors, and a full-threshold bulimia nervosa diagnosis later in life (11).

Disinhibited eating is an umbrella term for several behaviors that, similar to LOC eating, involve a lack of healthy restraint over eating (72). Examples of disinhibited eating include eating in the absence of hunger and emotional eating. Behaviorally, "eating in the absence of hunger" is a measure frequently used to capture individual differences in youths' caloric intake in the absence of hunger, or after consuming a meal (10). Youth who report eating in the absence of hunger frequently endorse LOC eating (87; 89), suggesting this may be a useful clinical outcome requiring further investigation. Eating in the absence of hunger has been associated with, but not predictive of, weight over time (74); thus, the behavior may play a role in risk for various obesity-related health outcomes.

Another facet of disinhibited eating is emotional eating, or the tendency to use food to regulate mood. Emotional eating has been shown to prospectively predict LOC eating at one-year follow-up in a sample of 8-13 year old youth across the weight spectrum (3). Along these lines, a systematic review showed that decreases in maladaptive emotion regulation strategies were associated with decreases in eating pathology following psychological intervention, lending support to the importance of emotion in disinhibited eating (75). This suggests difficulty managing intense emotions, such as anxiety, may be a particular challenge for youth that could

potentially exacerbate LOC eating. Taken together, disinhibited eating behaviors such as eating in the absence of hunger and emotional eating are important factors to consider in the relationship between LOC eating and psychological and physiological variables.

LOC EATING AND OBESITY

A clear and consistent relationship has been identified between LOC and obesity. LOC eating is robustly associated with high BMI and body fat mass (49; 95). This is highly relevant given approximately one-third of youth in the United States ages 2-19 years old have overweight or obesity, with rates of extreme obesity among youth around 6% (27; 53; 54). Pediatric overweight is predictive of adult obesity (99), as well as serious medical risks such as elevated blood pressure and dyslipidemia (21). LOC eating is highly prevalent among children and adolescents with overweight and obesity, with a recent meta-analysis estimate of 31% across studies (34). Over time, LOC eating has been associated with excessive weight gain (25; 77; 86; 94) and poses a higher medical risk and an increased likelihood of adult obesity (86). Given the serious medical and psychological consequences associated with obesity (14; 101), excess weight gain from LOC eating during childhood and adolescence is a major public health concern.

LOC EATING AND METABOLIC SYNDROME-RELATED MEASURES

The relationship between LOC eating and excess body weight appears to extend to obesity-related health comorbidities, above and beyond the contribution of adiposity. Obesity is considered a primary contributor to MetS, defined as a cluster of adverse physiological health abnormalities including abdominal obesity as well as abnormal cholesterol, blood sugar, and triglyceride concentrations that increase one's risk for heart disease and type 2 diabetes (101). Cross-sectionally, youth reporting LOC eating episodes show greater dysfunction in components

of MetS such as higher systolic blood pressure and low-density lipoprotein cholesterol (LDL-C), above and beyond the contribution of adiposity (60). Prospectively, and importantly over and above initial body weight and gains over time, children with LOC eating are at a higher risk for the development of MetS components (70), such as worsening triglycerides and increased visceral adipose tissue (49; 85; 91). Thus, pediatric LOC eating not only puts youth at higher risk for development of obesity, but increases risk for comorbid obesity-related health problems as well. Relationships between LOC eating and markers of obesity-related health issues indicate youth with LOC may be at particular risk for adverse physiological outcomes. However, not all youth with LOC eating develop adverse health outcomes or become overweight. As a result, examining moderating factors that may put youth at higher risk is critical.

Taken together, the literature outlined thus far bolsters the potentially adverse nature of LOC eating. Research has supported the relationship between LOC eating and a number of pernicious outcomes, including eating disorder psychopathology, disinhibited eating behaviors, excess weight gain, and worsening MetS-related measures. However, despite these various adverse outcomes, LOC eating remits over time in roughly half of youth who report the behavior (90). As such, it is important to identify factors among youth for whom LOC eating does not remit that may increase risk of adverse outcomes. Well-supported theories in the eating disorders literature may help to explain factors that could contribute to persistent or worsening LOC eating over time.

AFFECT THEORY OF LOC EATING

Negative affect has been consistently associated with LOC eating across the age spectrum (30; 33). The relationship between LOC eating and negative affect is consistent with affect theory, which is commonly supported in the eating disorders literature. Affect theory proposes

that LOC eating may develop as a result of maladaptive coping with negative emotions (23; 32; 39), serving as a maladaptive attempt to escape from psychosocial stress or to reduce negative emotions (35; 63). In a feeding laboratory, pre-meal state negative affect was related to greater consumption of carbohydrates, dessert, and snack-type foods in youth at high risk for obesity and with reported LOC eating (62), which suggests negative affect may play a role in overeating and subsequent excess weight gain. Using naturalistic designs, ecological momentary assessment (EMA) studies have shown increases in negative affect serve as a momentary trigger to LOC eating episodes (33), supporting the notion of this behavior as a maladaptive response used to reduce negative affect in the moment (61). Research has supported affect theory both cross-sectionally (31; 70) and prospectively as a risk factor for development of LOC eating in youth (81).

Although there is significant support for affect theory throughout the literature, some studies have not found a relationship between negative affect and LOC eating. For example, in an EMA study examining state affect and LOC eating, negative affect did not significantly predict momentary LOC eating episodes directly (61). Similarly, another study using an EMA protocol did not find negative mood to trigger LOC eating episodes, although there was a link between cognitions about body image and subsequent LOC episodes (37). These inconsistencies in negative affect's role as a specific precursor to LOC eating may be due to an over-reporting bias in retrospective recall of mood for studies that did not utilize EMA methodology. However, Shank and colleagues made an important distinction in the affect theory literature, finding that pre-meal anxiety is the most salient negative mood state for palatable food intake among adolescent girls with LOC eating (69). As a result, it is possible some studies showing inconsistencies in affect theory may not have specifically looked at anxiety, which has been

shown to be more salient than other negative mood states (e.g. anger, confusion, depression, fatigue) in terms of food intake among girls with LOC eating (69).

LOC EATING, OBESITY, AND ANXIETY

The comorbidity between anxiety and LOC eating is well-defined in the literature (8; 29; 38; 55; 84), and as such, is a logical factor to consider as a contributor to adverse health outcomes. Moreover, adolescents with overweight at high risk for the development of eating disorders display elevated levels of anxiety and negative affect (20). Not surprisingly, this relationship extends to pediatric LOC eating. LOC and anxiety symptoms are closely related both cross-sectionally (28; 49) and prospectively (47; 90) in youth. LOC eating is associated with anxiety symptoms in both non-treatment seeking youth (32), and those pursuing weight management (28; 32). Notably, links between anxiety and LOC eating have been found above and beyond the contribution of excess body weight or fat. Moreover, the relationship between LOC eating and higher anxiety in youth persists regardless of eating episode size (71), lending further support to research finding LOC eating is the key feature of binge eating in youth, rather than the amount of food consumed.

Anxiety symptoms may also play a role in elevated BMI as well. Some data suggest that adolescent anxiety is associated with elevated BMI in both clinical (64) and community samples of youth (7). While anxiety alone is not a predictor of excessive weight gain in youth, a recent meta-analysis supports a significant positive relationship between weight status and anxiety in youth (14). This relationship was stronger for females than males, such that girls experienced higher levels of anxiety as weight status increased. Adolescent obesity has also been shown to predict later onset of anxiety disorder diagnosis in girls (6). The high correlation between internalizing behavioral problems, such as anxiety, and childhood obesity may be twofold in that

psychological distress may foster weight gain, and being overweight may contribute to social problems such as social withdrawal and isolation (59). Additionally, clinically significant anxiety among youth with overweight or obesity has been shown to be associated with greater body dissatisfaction and lower scores on health-related quality of life (44). Despite these data, few studies have directly explored the relationship between anxiety and adverse physiological outcomes related to excessive weight gain in general populations (65; 66) or in youth (57).

The high overlap between LOC eating and anxiety in youth, particularly among those with overweight, suggests a shared etiology. One potential reason for the overlap between eating disorders and anxiety may be shared underlying vulnerability factors, such as negative evaluation fears and stress surrounding social appearance (42; 43). Additionally, anxiety may play a key role in the effects of interpersonal psychotherapy, a targeted intervention for girls with overweight with LOC eating. In a randomized control trial of an intervention for prevention of excess weight gain, girls with high anxiety showed the greatest improvements in weight and adiposity three years after receiving interpersonal psychotherapy compared to standard of care treatment (92). Targeting psychological characteristics, such as anxiety, may be an important consideration in interventions designed for management of weight-related outcomes. Thus, these data suggest that exploring the relevance of the overlap between anxiety and LOC eating in relation to other psychological and physical comorbidities is warranted.

Together, these findings lend support to affect theory of disordered eating, suggesting negative affect contributes to LOC eating. Affect theory provides a potential framework to shed light on those with LOC eating at highest risk for overweight and adverse psychological and health outcomes. Given the salience of anxiety in relation to LOC eating (69), it may be that anxiety in particular exacerbates the severity of psychological and physiological components of

LOC eating, and thus results in increased risk for overweight, disinhibited eating, and adverse health outcomes.

THE PRESENT STUDY

Given the robust link between LOC eating and anxiety in youth, as well as the links between LOC eating and disordered and disinhibited eating and physiological markers of health, an exploration of the role that anxiety plays in the relationship between LOC eating and adverse health correlates is warranted. It is possible that the interaction of LOC eating and anxiety may identify those at greatest risk for exacerbated psychological and physiological health outcomes. Given the link between LOC eating and these outcome measures is well-established, the current study specifically examines how anxiety relates to disordered eating pathology, disinhibited eating, BMI*z*, fat mass, and MetS-related measures independently, and whether the interaction of anxiety and LOC eating is related to these variables in youth. It is hypothesized that anxiety will independently relate to the dependent variables, and that these relationships will be most robust among youth who report LOC eating (see Figure 1).

Aims and Hypotheses

Aim 1: Examine whether trait anxiety relates to disordered eating attitudes, eating in the absence of hunger, and emotional eating

Hypothesis 1: Trait anxiety will be independently related to disordered eating attitudes, eating in the absence of hunger, and emotional eating

Aim 2: Examine whether trait anxiety relates to BMI*z*, fat mass, and MetS-related measures

Hypothesis 2: Trait anxiety will be independently related to BMI*z*, fat mass, and MetS-related measures

Aim 3: Test whether anxiety moderates the relationship between LOC eating and disordered eating attitudes, eating in the absence of hunger, emotional eating, BMI*z*, fat mass, and MetS-related measures

Hypothesis 3: The relationship between trait anxiety and disordered eating attitudes, eating in the absence of hunger, emotional eating, BMI*z*, fat mass, and MetS-related measures will be most robust among youth with LOC eating, compared to youth without LOC eating

CHAPTER 2: METHODS

PARTICIPANTS AND RECRUITMENT

The study made use of a convenience sample drawn from non-treatment seeking, healthy youth in two studies conducted at the National Institutes of Health (NIH); the Children's Growth and Behavior Study (ClinicalTrials.gov ID: NCT02390765) and the Eating Behaviors in Children Study (ClinicalTrials.gov ID: NCT00320177). Both studies examined eating behaviors that promote pediatric overweight and obesity, and associated health comorbidities. Children ages 8-17 years old in generally good health were recruited for both of these studies. Participants were recruited through physicians' offices, local newspaper advertisements, and mailings to families in the greater Washington, DC metropolitan area.

PROCEDURES

Participants were interviewed to assess presence of LOC eating in the past month and global eating pathology, and completed questionnaires to measure trait anxiety and disinhibited eating behaviors. BMI*z*, triglycerides, low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C), glucose, and insulin were collected from blood samples after an overnight fast.

INTERVIEW AND QUESTIONNAIRES

Eating Disorder Examination (EDE)

The Eating Disorder Examination (EDE) adult (24) or child version (ChEDE) (13) was administered to categorize participants into those who endorsed LOC and to assess eating disorder psychopathology. Participants who endorsed at least one LOC eating episode within the past month were classified into the LOC eating group. Global eating disorder psychopathology was generated as the average of four EDE subscale scores; Restraint, Eating Concern, Shape Concern, and Weight Concern. The EDE has demonstrated excellent interrater reliability and good convergent and discriminant validity in youth (16; 95).

Training is required for administration of the EDE and ChEDE. Graduate students in clinical psychology and post-undergraduate research associates attended 15-20 hours of training workshops on the EDE and ChEDE. Workshops involved in-depth review of each question on the interview, listening to audiotape sample interviews, conducting practice interviews, and watching the trainer conduct interviews. Additionally, the trainer observed and co-rated an interview with each trainee. Training observation continued until at least 95% concordance between the trainer and trainee rating occurred. All interviews were audio-recorded and reviewed at weekly team meetings during data collection to ensure administration quality (95).

Anxiety

State-Trait Anxiety Inventory for Children (STAIC)

The State-Trait Anxiety Inventory for Children (STAIC) trait scale (79), a 20-item self-report measure of trait anxiety, was completed by study participants. Trait anxiety is defined as a personality trait capturing individual differences in the likelihood of experiencing anxiety across different situations (78). An example item from the trait anxiety subscale is "I worry too much,"

rated as “hardly ever,” “sometimes,” or “often.” Subscale scores range from 20 to 60. The STAIC has demonstrated good reliability and construct validity (56). The clinical cutoff for the STAIC is a score of 32. The scale is intended to capture continuous dimensions of trait anxiety, and higher scores indicate higher trait anxiety.

Disinhibited Eating

Eating in the Absence of Hunger Questionnaire for Children (EAH-C)

The Eating in the Absence of Hunger Questionnaire for Children and Adolescents (EAH-C) (89) is a 14-item self-report measure rated on a 5-point Likert scale ranging from 0 = “never” to 4 = “always.” This measure was designed to assess the frequency of precipitants to eating when one is not hungry or when sated in youth between the ages of 6-19 years old. The measure consists of three subscales: Negative Affect, External Eating, and Fatigue/Boredom. The EAH-C has shown good internal consistency, convergent validity, and temporal stability for all three subscales (89). Cronbach’s alpha was 0.88 in the current study.

Emotional Eating Scale – Children (EES-C)

The Emotional Eating Scale for Children (EES-C) (93) is a 25-item self-report measure designed to assess the urge to cope with negative affect by eating. The EES-C consists of three subscales: Anger/Anxiety/Frustration, Depression, and Unsettled. The EES-C has shown good internal consistency, discriminant and construct validity (93; 98). In the current study, Cronbach’s alpha was 0.95.

Body Composition

Height was measured in triplicate by a stadiometer. Fasting weight was measured by scale calibrated to the nearest 0.1 kg. BMI (kg/m^2) was calculated for all participants using the average across all three measurements and weight. Age and sex were included in calculations of

BMI*z* scores according to the Centers of Disease Control and Prevention growth standards (41). Fat mass (kg) was assessed by air displacement plethysmography (Bod Pod) or dual-energy x-ray absorptiometry (DXA), depending on the larger study. Measurements of adiposity were adjusted to ensure equivalence between the two assessment techniques by multiplying girls' Bod Pod fat percentage by 1.03 (52).

Metabolic Function

Triglycerides, cholesterol (HDL-C, LDL-C), glucose, and insulin were measured from fasting blood samples collected by trained nursing staff using a Hitachi 917 analyzer using reagents from Roche Diagnostics (Indianapolis, IN) per NIH guidelines. A Cobas FARA analyzer was utilized to directly measure HDL-C using reagents from Sigma chemical (St. Louis, MO). LDL-C was calculated using the formula: Total Cholesterol – HDL – (triglycerides / 5). Homeostatic model assessment of insulin resistance (HOMA-IR), a measure capturing insulin resistance, was calculated by multiplying fasting insulin (mU/L) by fasting glucose (mg/dL) and dividing by 405.

STATISTICAL ANALYSES

All statistical analyses were conducted using IBM SPSS Statistics 24. Data were screened for outliers, skew, and kurtosis. To minimize outliers' influence on characteristics of the distributions, extreme outliers were recoded to fall within 1.5 times the interquartile range below or above the 25^{th} or 75^{th} percentile (9). No more than 1% of the data comprising any variable was considered an outlier. EDE global score, fat mass (kg), triglycerides, insulin, and HOMA-IR did not achieve normality and were thus log transformed to meet the assumptions necessary for analyses. Group differences between demographic and anthropomorphic measures, such as race,

age, sex, and fat mass, were examined at baseline using chi square and analysis of variance (ANOVA) as appropriate.

Analysis of covariance (ANCOVA) models were utilized to compare differences between variables in BMI*z* and adiposity. Separate multiple analyses of covariance (MANCOVA) models were used to compare differences between variables in all eating-related factors of disordered and disinhibited eating, and MetS-related measures while protecting against familywise error rate and taking into account the correlation amongst these groups of variables. The interaction of LOC eating by anxiety for BMI*z* was tested using ANCOVA adjusting for depressive symptoms and race, as the metric already adjusts for age and sex. The model for fat mass was tested adjusting for depressive symptoms, age, sex, race, and height. Fat mass was included as a covariate in MANCOVA models used to test the differences in analyses of eating disorder pathology and disinhibited eating behaviors. Given the well-established links between insulin resistance and depressive symptoms (73), depressive symptoms were included as a covariate in MANCOVA models with MetS-related measures. Due to consistent data showing that both anxiety and LOC eating are more commonly endorsed by girls versus boys (1; 5), follow-up exploratory analyses were also conducted to test for sex differences in eating-related, weight-related, and MetS-related measures. Analyses to test for sex differences were achieved by splitting the file by sex and conducting ANCOVA or MANCOVA models as applicable, adjusting for relevant covariates.

CHAPTER 3: RESULTS

DESCRIPTIVE ANALYSES

Participants were 383 non-treatment-seeking youth (13.0±2.8 years old; 52.6% female; 52.3% Non-Hispanic White). The average BMI*z* was 0.8±1.1 and average fat mass (kg) was 18.5±15.4. Average trait anxiety in the sample was 30.3.

Twenty-three percent (*n*=86) of participants endorsed at least one LOC eating episode within the past month. Youth who reported LOC were significantly more likely to be female ($p<.01$), have higher BMI*z* ($p<.01$), and higher fat mass ($p<.01$) than youth without LOC eating. See Table 1 for sample characteristics based on LOC eating status. As expected and previously shown, youth with and without LOC eating differed on a number of eating-related (3; 87) and physical measures (91; 95).

ANXIETY AND DISORDERED EATING, DISINHIBITED EATING, BODY COMPOSITION AND METS-RELATED MEASURES

Adjusting for covariates, there was a significant positive main effect of anxiety with EDE global score ($p<.01$). Anxiety was also significantly associated with all EAH-C subscales, including Negative Affect ($p<.01$), External Eating ($p=.01$), and Fatigue/Boredom ($p=.01$), as well as all EES-C scales, including Anger/Anxiety/Frustration ($p<.01$), Depression ($p<.01$), and Unsettled ($p=.01$).

There were no significant main effects of anxiety with BMI*z* ($p=.32$), fat mass (kg) ($p=.98$), or any of the MetS-related measures, including triglycerides ($p=.13$) HDL-C ($p=.96$), LDL-C ($p=.60$), glucose ($p=.36$), insulin ($p=.21$), or HOMA-IR ($p=.19$).

Interaction between LOC eating and Anxiety, Disordered Eating, Disinhibited Eating, BMI*z*, and MetS-Related Variables

The interaction of anxiety and LOC eating was not significantly related to EDE global score (p=.53), eating in the absence of hunger subscales (ps>.13), or emotional eating subscales (ps>.51) (See Figures 2-8).

The interaction of anxiety and LOC eating was not significantly related to BMI*z* (p=.77) (See Figure 11) or fat mass (p=.93) (See Figure 12). In relation to MetS-related measures, the interaction of anxiety and LOC was significant such that, only among youth with LOC eating, higher anxiety was positively associated with higher fasting insulin (p=.02) (See Figure 9) and HOMA-IR (p=.01) (See Figure 10). The interaction of anxiety and LOC eating was not significantly related to any other component of MetS (triglycerides, LDL-C, HDL-C, glucose ps=ns) (See Figures 13-16).

Exploratory Analyses for Weight-related Factors by Sex

Of the 188 female and 178 male participants, 30% (n=56) of girls endorsed LOC eating, and 15% (n=27) of boys endorsed LOC eating. For eating-related factors (EDE global, EAH-C subscales, EES subscales), the interaction of LOC eating and anxiety was not significant for any eating-related measures among males (ps>.19) or females (ps>.12). In females, the interaction of LOC eating and anxiety was significant for BMI*z* (p=.05), such that only among females with LOC eating, higher anxiety was related to higher BMI*z* score, over and above the contribution of LOC eating or anxiety independently. This interaction was not significant among males (p=.22). The interaction of LOC eating and anxiety was not significant among males or females for fat mass (kg) (ps>.42). For MetS-related measures, the interaction of LOC eating and anxiety was not significant among females for any MetS-related measures (ps>.12). However, among males,

the interaction of LOC eating and anxiety was significant for LDL-cholesterol (p=.05), such that only among males with LOC eating, higher anxiety was associated with higher LDL-cholesterol levels. The interaction for other MetS-related measures (triglycerides, HDL-cholesterol, glucose, insulin, HOMA-IR) was not significant among males (ps>.06).

CHAPTER 4: DISCUSSION

SUMMARY

Using a validated interview, questionnaires, and objective methods to measure body composition and metabolic function, anxiety was found to be significantly related to global EDE pathology, all eating in the absence of hunger subscales, and all emotional eating subscales. The interaction of anxiety and LOC was significant such that, only in youth with LOC eating, anxiety was positively associated with fasting insulin and insulin resistance. The interaction of anxiety and LOC eating was not significantly related to global eating pathology, eating in the absence of hunger, emotional eating, BMIz, fat mass, nor any other MetS-related measures.

INTERPRETATION OF FINDINGS

Given the high comorbidity between anxiety and eating disorders (8; 29; 38; 55; 84), it is not surprising that anxiety was significantly related to all measures of disordered and disinhibited eating in this study, including global eating pathology, eating in the absence of hunger, and emotional eating. These findings are also in line with affect theory of disordered eating (35; 39), proposing that youth may turn to food as a maladaptive attempt to escape from or cope with negative emotions such as anxiety, given eating is often believed to provide comfort or distraction from negative emotions.

The findings that anxiety was not significantly related to adiposity was contrary to hypotheses. Although a recent meta-analysis supported a significant positive relationship

between weight status and anxiety in youth, the effect size was very small (r=.08), and the relationship was stronger for females than males (14). Given the small effect size of the relationship between anxiety and weight status in youth, it is possible that the mixed sample of males and females with a wide range of ages and weight statuses may have been too broad to capture the specific population that has a relationship between anxiety and weight status, and that having a sample with a larger number of adolescent females with overweight would have yielded significant findings. In fact, exploratory analyses showed a just significant interaction effect of LOC eating and anxiety on BMIz, such that among females, but not males, with LOC eating, higher anxiety was related to higher BMIz. It may be that anxiety is more relevant for weight-related outcomes in girls with LOC eating compared to boys. In fact, the dual pathway model of LOC eating posits that socio-cultural messages targeted at girls to promote pressure to be thin contribute to negative emotions, which in turn triggers LOC eating as a maladaptive attempt to escape from negative emotional distress (76; 80).

MetS-related variables were not significantly associated with anxiety in the current study, contrary to hypotheses. It may be that anxiety only impacts MetS-related variables through increased caloric intake of highly palatable foods, as shown among adolescent girls at a laboratory test meal (68). Given the present study measured baseline metabolic function after an overnight fast, instead of after youth consumed a laboratory test meal, the effect of anxiety on changes in metabolic function via increased palatable food intake may not have been captured. Interestingly, however, exploratory follow-up analyses showed a significant interaction of anxiety and LOC eating on LDL-cholesterol only among boys, but not among girls. While this finding just reached significance, was exploratory, and conducted after multiple tests, future

research might consider examining sex differences in the impact of anxiety on metabolic measures of health.

The interaction findings suggest anxiety may exacerbate LOC eating and its relation to insulin and insulin resistance. Although anxiety alone did not independently influence fasting insulin or insulin resistance in youth, it was associated with dysregulated metabolism when in conjunction with LOC eating. It is possible that those children who report both LOC eating and anxiety experience particularly high levels of distress that can cause chronic hypersecretion of stress hormones such as cortisol (65; 97) that may result in greater insulin resistance (15; 17). A possibility for the lack of significant findings for other components of MetS may be that full-syndrome binge eating disorder would have greater impact on metabolic characteristics as opposed to the subthreshold behaviors reported by children in the current study.

Given the connection between insulin and glucose in relation to excess weight and type 2 diabetes, it was surprising that the interaction of LOC eating and anxiety was not significantly related to glucose. However, the sample in the present study consisted of youth in generally good health, and exclusion criteria included any major medical illness. As such, youth with type 2 diabetes were excluded from the current study. It is possible, however, that youth with symptoms of prediabetes were captured in the current sample, which may reflect the results of the significant interaction on insulin and insulin resistance, but not glucose. Indeed, 4.7% of the current sample met criteria for pre-diabetes (4). It may be that pancreatic secretion of excess levels of insulin is effectively counteracting the increased glucose levels in the blood of the current sample. At present, the pancreas may be effectively maintaining glucose levels within a normal range by producing excess insulin. However, over time, the pancreas will fail to continue to produce enough insulin to manage high blood glucose levels, and insulin resistance will

develop, leading to excess glucose levels in the blood and development of type 2 diabetes. Examining the fluctuations in insulin and glucose levels in youth with LOC eating and high anxiety over time would be of interest, given the current study involved only a cross-sectional analysis. Indeed, the relationship observed between anxiety and LOC eating may be an early target for the development of diabetes.

STRENGTHS AND LIMITATIONS

Strengths of this study include a large, racially diverse sample of both males and females across a wide weight range. Recruitment of both boys and girls from racially and ethnically diverse backgrounds improves the generalizability of the current findings, as well as capturing a wide age and BMI*z* range. Importantly, we collected objective measures of metabolic function and body composition. The use of a clinical interview method to assess LOC eating is a strength given that it allows for more accurate assessment for disordered eating (95). Additionally, analyses controlled for adiposity and other potentially confounding variables, such as depression, race, age, sex, and height.

Study limitations include use of cross-sectional data, limiting ability to draw causal conclusions from the findings. Research has suggested the relationship between anxiety and excess weight may be twofold in that psychological distress may foster weight gain and being overweight may contribute to social problems (59), making the ability to draw causal links of particular importance. Additionally, waist circumference, a component of MetS, was not captured. The sample used in the present study was one of convenience and although the inclusion and exclusion criteria, questionnaires, interviews, and body composition measures were consistent, they were drawn from two separate NIH studies. Each study utilized a different method to measure fat mass, either air displacement plethysmography (Bod Pod) or dual-energy

x-ray absorptiometry (DXA). However, measures of fat mass were adjusted to ensure equivalence between the two assessment techniques (52) . Finally, youth in the LOC eating group had higher BMI*z*, fat mass, and consisted of more females than youth in the group without LOC eating. Although we adjusted for BMI*z*, fat mass, and sex in analyses, sex and weight matched groups of youth with and without LOC eating might have provided for a more robust analysis.

FUTURE DIRECTIONS

Future research should continue to explore the interactive effects of LOC eating and anxiety on eating and health-related outcomes. Longitudinal, prospective designs will clarify directionality in the relationship between anxiety, LOC eating, weight gain, and adverse eating and health-related outcomes. If prospective studies support the impact of anxiety on adverse outcomes in youth with LOC eating, anxiety may be an important screening target to identify risk for persistent LOC eating and associated chronic diseases. Additional studies are also needed to identify potential mechanisms linking anxiety, LOC eating, and MetS-related measures such as insulin and insulin resistance. This may involve examining MetS measures prior to and following a meal designed to simulate an LOC eating episode. Identifying these mechanisms may help to inform interventions for youth at greatest risk for adverse health outcomes such as type 2 diabetes or MetS. For example, treatment of underlying anxiety symptoms in youth with LOC eating at risk for adverse weight-related health outcomes may be a more effective treatment target than addressing LOC eating alone or behavioral weight-loss techniques. Specifically, at least one program that targeted negative affect through social functioning has been found to be effective for weight-related outcomes only among youth with social adjustment problems or anxiety (92). These findings lend support to social-anxiety models of LOC eating. Youth with

manifestations of anxiety may be identified as a particular phenotype for those who are prone to weight-related health issues. Findings from the current study provide important clinical implications for youth with LOC eating, potentially identifying those with high anxiety as a high-risk subgroup for particularly adverse health outcomes.

CONCLUSIONS

In conclusion, among youth with LOC eating, higher anxiety is associated with higher concentrations of insulin and higher insulin resistance. Further, exploratory analyses showed that only among females with LOC eating, higher anxiety was related to higher BMI*z* scores. While anxiety alone does not appear to directly impact weight or metabolic function in youth, when in conjunction with LOC eating, the interactive effects may be particularly deleterious. Indeed, if supported by prospective studies, anxiety may be a factor that can help identify youth who may be at risk for particularly adverse outcomes. Examination of the extent to which modifying anxiety is an effective intervention to reduce adverse weight-related health outcomes and potential development of chronic diseases, such as MetS or type 2 diabetes, is warranted.

Table 1. Sample characteristics for LOC eating vs. No LOC groups

	Total (n = 383)	LOC+ (n = 86)	No LOC (n = 297)	p-value
Age (years)	13.0 ± 2.8	12.8 ± 2.9	13.1 ± 2.8	.34
Sex (female) (%)	52.6	68.6	46.8	<.01*
Race (Non-Hispanic White) (%)	52.3	54.7	52.2	.69
BMI*z* score	0.8 ± 1.1	1.2 ± 1.1	0.7 ± 1.1	<.01*
Fat Mass (kg)	18.5 ± 15.4	25.0 ± 18.0	17.2 ± 14.3	<.01*
EDE Global	0.5 ± 0.7	0.5 ± 1.0	0.3 ± 0.4	<.01*
EAH-C negaff	1.8 ± 1.2	1.8 ± .1	1.5 ± .1	<.01*
EAH-C external	1.9 ± 1.3	2.9 ± .1	2.5 ± .1	.01*
EAH-C fatigue	1.2 ± 1.1	2.2 ± .1	1.8 ± .1	<.01*
EES AAF	0.6 ± 0.7	0.9 ± 0.7	0.5 ± 0.7	<.01*
EES Depression	1.0 ± 0.9	1.3 ± 0.9	0.8 ± 0.8	<.01*
EES Unsettled	0.8 ± 0.8	1.0 ± 0.6	0.7 ± 0.8	.06
Triglycerides (mg/dL)	69.1 ± 33.0	74.7 ± 37.5	67.8 ± 31.7	.11
LDL-C (mg/dL)	93.3 ± 24.3	97.2 ± 26.7	92.4 ± 23.6	.13
HDL-C (mg/dL)	53.3 ± 12.7	52.7 ± 12.4	53.3 ± 12.7	.71
Glucose (mg/dL)	88.2 ± 6.7	87.4 ± 7.1	88.3 ± 6.5	.25
Insulin (mIU/mL)	12.0 ± 9.5	13.4 ± 9.9	11.7 ± 9.5	.16
HOMA-IR	2.7 ± 2.2	2.9 ± 2.2	2.6 ± 2.2	.25

Note: * Significant at $p < .05$. Abbreviations: LOC, loss of control; BMI, body mass index; EDE Global, Eating Disorder Examination global score; EAH-C negaff, Eating in the Absence of

Hunger-Child Negative Affect scale; EAH-C external, Eating in the Absence of Hunger-Child External Eating scale; EAH-C-fatigue, Eating in the Absence of Hunger-Child Fatigue/Boredom scale; EES AAF, Emotional Eating Scale – Anger/Anxiety/Frustration subscale; EES Depression, Emotional Eating Scale Depression subscale; EES Unsettled, Emotional Eating Scale Unsettled subscale; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; HOMA-IR, homeostatic model assessment insulin resistance

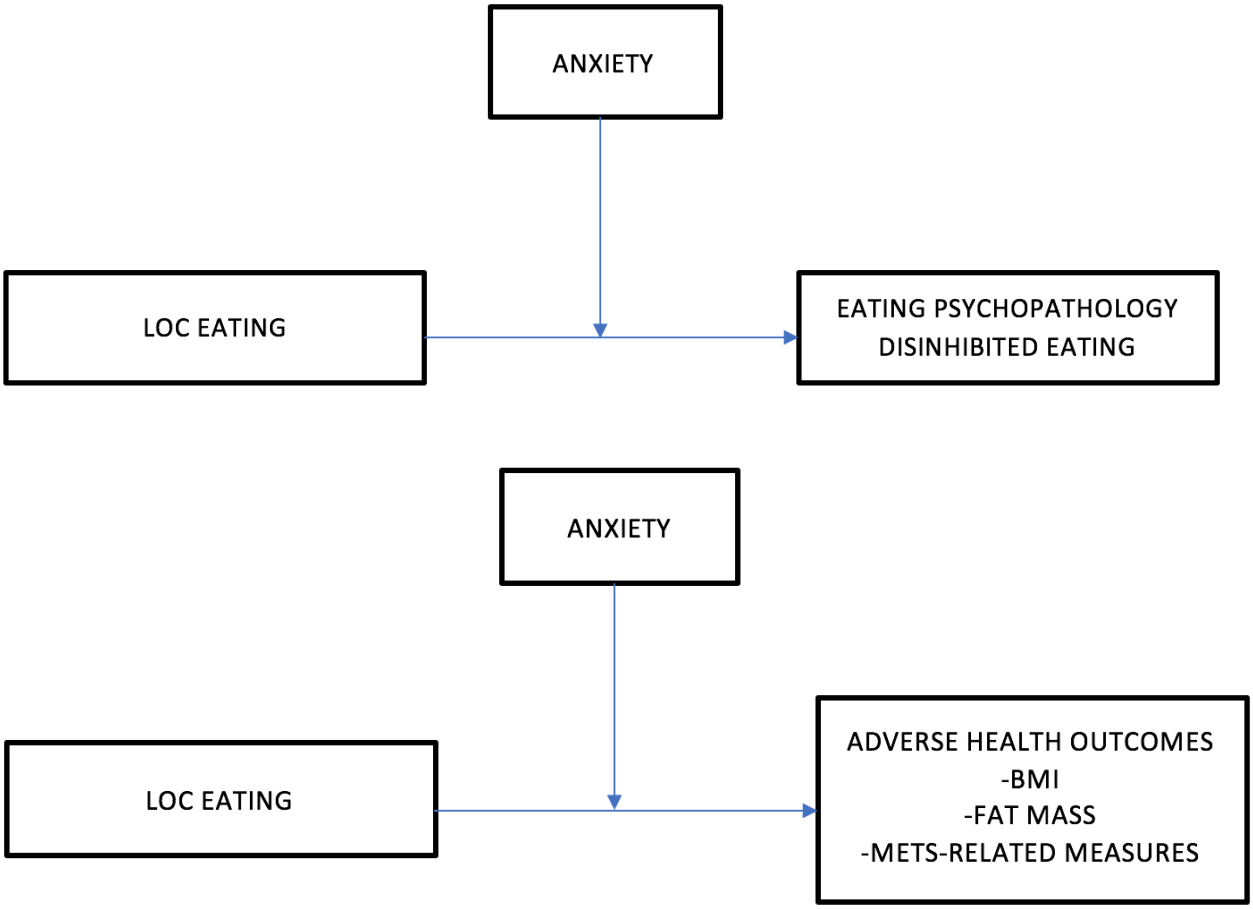

Figure 1. Conceptual model of the role of anxiety in the relationship between loss of control (LOC) eating, eating psychopathology, disinhibited eating, and adverse health outcomes.

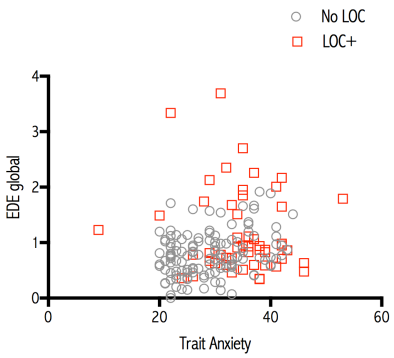

Figure 2. Non-significant interaction of anxiety and LOC eating on EDE global

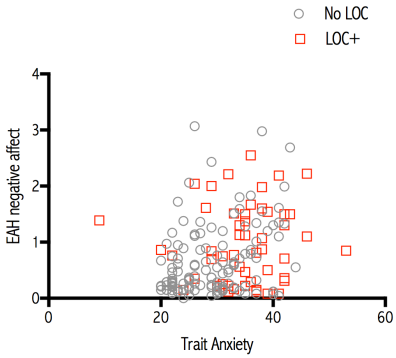

Figure 3. Non-significant interaction of anxiety and LOC eating on EAH-C negative affect

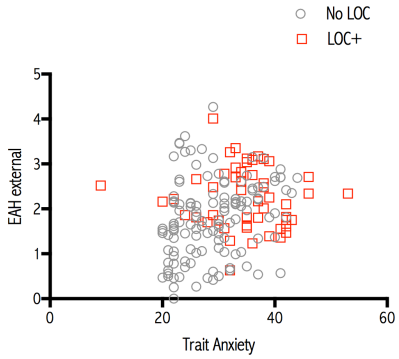

Figure 4. Non-significant interaction of anxiety and LOC eating on EAH-C external eating

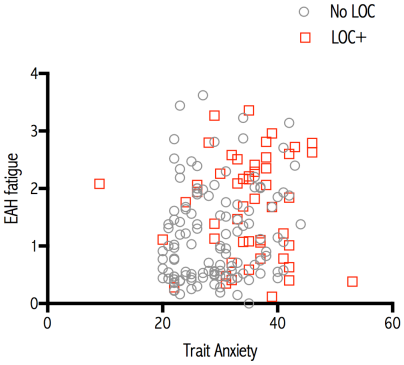

Figure 5. Non-significant interaction of anxiety and LOC eating on EAH-C fatigue/boredom

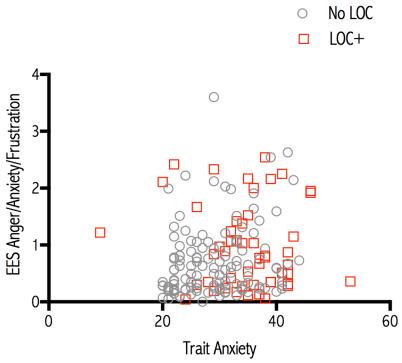

Figure 6. Non-significant interaction of anxiety and LOC eating on EES anger/anxiety/frustration

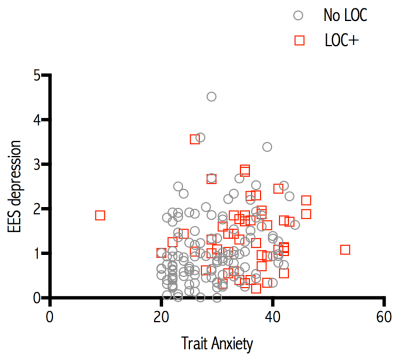

Figure 7. Non-significant interaction of anxiety and LOC eating on EES depression

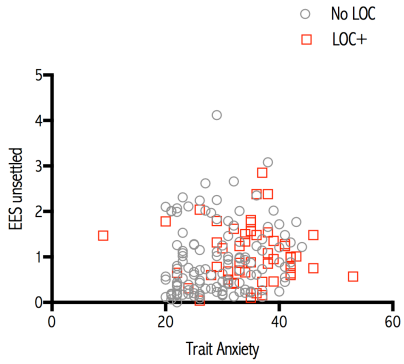

Figure 8. Non-significant interaction of anxiety and LOC eating on EES unsettled

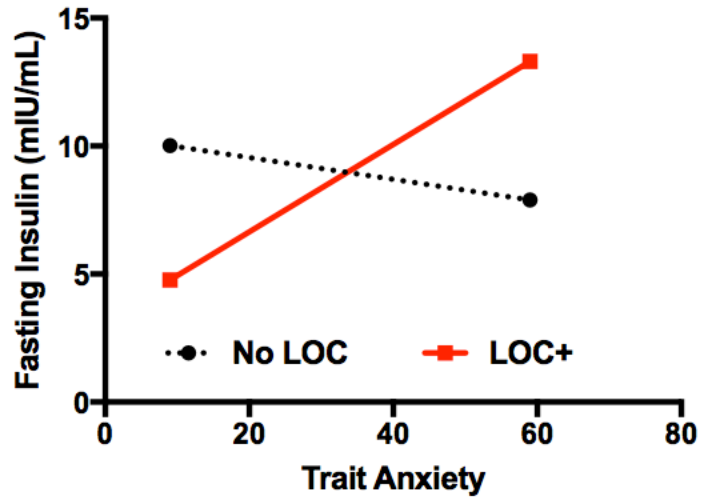

Figure 9. Significant interaction of anxiety and LOC eating on fasting insulin (mIU/mL)

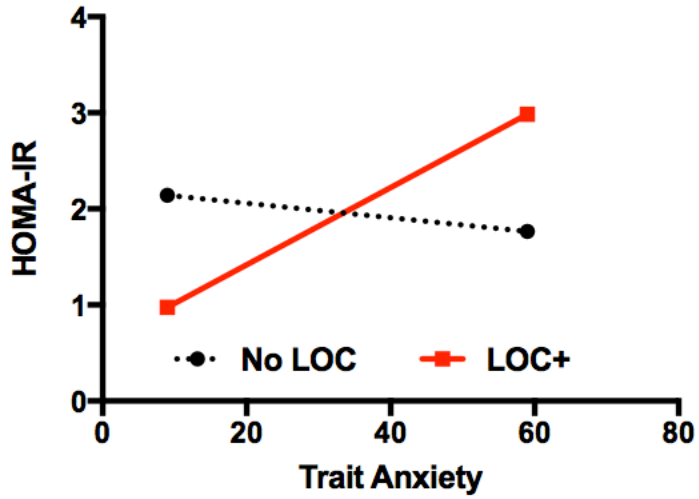

Figure 10. Significant interaction of anxiety and LOC eating on insulin resistance

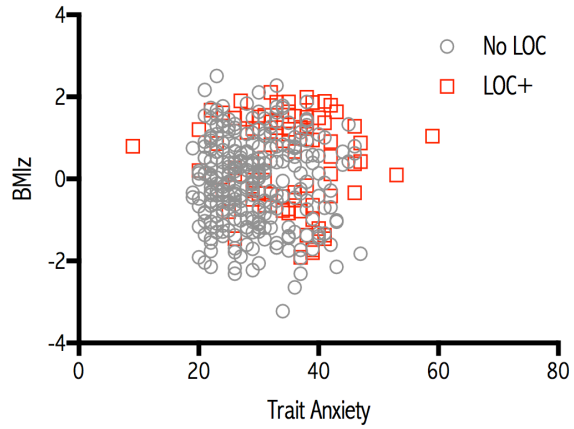

Figure 11. Non-significant interaction of anxiety and LOC eating on BMIz

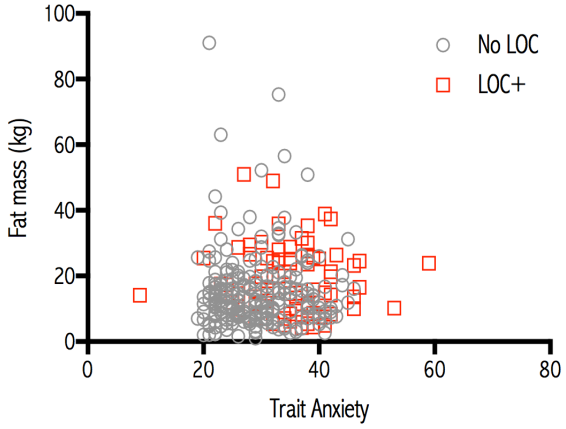

Figure 12. Non-significant interaction of anxiety and LOC eating on fat mass (kg)

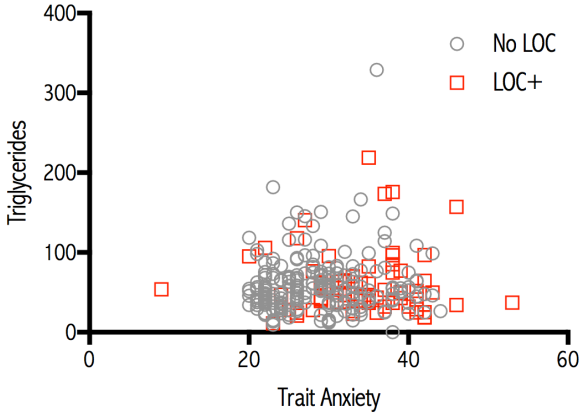

Figure 13. Non-significant interaction of anxiety and LOC eating on triglycerides

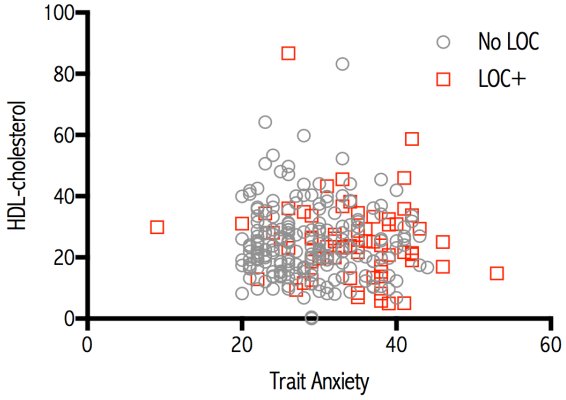

Figure 14. Non-significant interaction of anxiety and LOC eating on HDL-cholesterol

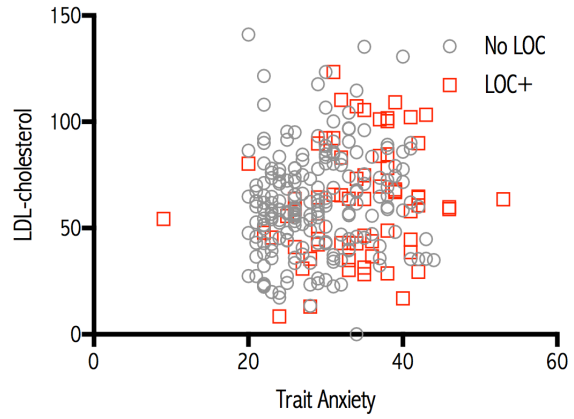

Figure 15. Non-significant interaction of anxiety and LOC eating on LDL-cholesterol

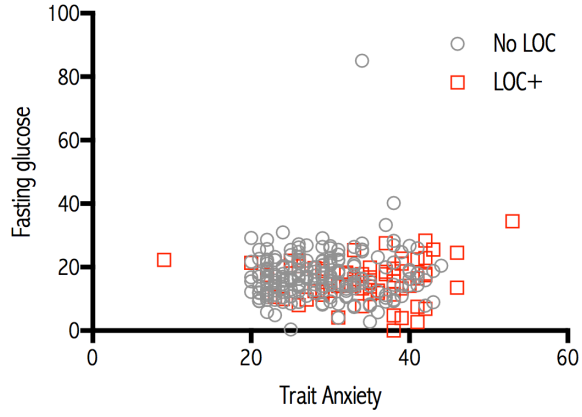

Figure 16. Non-significant interaction of anxiety and LOC eating on fasting glucose

REFERENCES

1. Ackard DM, Neumark-Sztainer D, Story M, Perry C. 2003. Overeating among adolescents: prevalence and associations with weight-related characteristics and psychological health. *Pediatrics* 111:67-74

2. Ágh T, Kovács G, Pawaskar M, Supina D, Inotai A, Vokó Z. 2015. Epidemiology, health-related quality of life and economic burden of binge eating disorder: a systematic literature review. *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity* 20:1-12

3. Allen KL, Byrne SM, La Puma M, McLean N, Davis EA. 2008. The onset and course of binge eating in 8-to 13-year-old healthy weight, overweight and obese children. *Eating Behaviors* 9:438-46

4. American Diabetes Association. 2014. Diagnosis and classification of diabetes mellitus. *Diabetes Care* 37:S81-S90

5. American Psychiatric Association [APA]. 2013. *Diagnostic and statistical manual of mental disorders (DSM-5®)*. American Psychiatric Pub

6. Anderson SE, Cohen P, Naumova EN, Jacques PF, Must A. 2007. Adolescent obesity and risk for subsequent major depressive disorder and anxiety disorder: prospective evidence. *Psychosomatic Medicine* 69:740-7

7. Anderson SE, Cohen P, Naumova EN, 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* 160:285-91

8. Aspen V, Weisman H, Vannucci A, Nafiz N, Gredysa D, et al. 2014. Psychiatric co-morbidity in women presenting across the continuum of disordered eating. *Eating behaviors* 15:686-93

9. Behrens JT. 1997. Principles and procedures of exploratory data analysis. *Psychological Methods* 2:131

10. Birch LL, Fisher JO, Davison KK. 2003. Learning to overeat: maternal use of restrictive feeding practices promotes girls' eating in the absence of hunger. *The American Journal of Clinical Nutrition* 78:215-20

11. Brewerton TD, Rance SJ, Dansky BS, O'Neil PM, Kilpatrick DG. 2014. A comparison of women with child-adolescent versus adult onset binge eating: Results from the National Women's Study. *International Journal of Eating Disorders* 47:836-43

12. Britz B, Siegfried W, Ziegler A, Lamertz C, Herpertz-Dahlmann B, et al. 2000. Rates of psychiatric disorders in a clinical study group of adolescents with extreme obesity and in obese adolescents ascertained via a population based study. *International journal of obesity* 24:1707

13. Bryant-Waugh RJ, Cooper PJ, Taylor CL, Lask BD. 1996. The use of the eating disorder examination with children: A pilot study. *International Journal of Eating Disorders* 19:391-7

14. Burke NL, Storch EA. 2015. A meta-analysis of weight status and anxiety in children and adolescents. *Journal of Developmental & Behavioral Pediatrics* 36:133-45

15. Charmandari E, Kino T, Souvatzoglou E, Chrousos GP. 2003. Pediatric stress: hormonal mediators and human development. *Hormone Research in Paediatrics* 59:161-79

16. Christie D, Watkins B, Lask B. 2000. *Anorexia nervosa and related eating disorders in childhood and adolescence*. pp 105-125. East Essex, UK: Psychology Press

17. Chrousos G. 2000. The role of stress and the hypothalamic-pituitary-adrenal axis in the pathogenesis of the metabolic syndrome: Neuro-endocrine and target tissue-related causes. *International Journal of Obesity & Related Metabolic Disorders* 24

18. 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. *Journal of Adolescent Health* 31:166-75

19. Decaluwé V, Braet C. 2005. The cognitive behavioural model for eating disorders: A direct evaluation in children and adolescents with obesity. *Eating Behaviors* 6:211-20

20. Doyle AC, Grange D, Goldschmidt A, Wilfley DE. 2007. Psychosocial and physical impairment in overweight adolescents at high risk for eating disorders. *Obesity* 15:145-54

21. Ebbeling CB, Pawlak DB, Ludwig DS. 2002. Childhood obesity: public-health crisis, common sense cure. *Lancet* 360:473-82

22. Eddy KT, Tanofsky-Kraff M, Thompson-Brenner H, Herzog DB, Brown TA, Ludwig DS. 2007. Eating disorder pathology among overweight treatment-seeking youth: Clinical correlates and cross-sectional risk modeling. *Behaviour Research and Therapy* 45:2360-71

23. Elliott CA, Tanofsky-Kraff M, Shomaker LB, Columbo KM, Wolkoff LE, et al. 2010. An examination of the interpersonal model of loss of control eating in children and adolescents. *Behaviour Research and Therapy* 48:424-8

24. Fairburn CG, Cooper Z. 1993. The Eating Disorder Examination (12th edition). In *Binge eating: Nature, assessment, and treatment*., ed. CG Fairburn, GT Wilson:317-60. New York, NY, US: Guilford Press. Number of 317-60 pp.

25. Field AE, Austin S, Taylor C, Malspeis S, Rosner B, et al. 2003. Relation between dieting and weight change among preadolescents and adolescents. *Pediatrics* 112:900-6

26. Field AE, Camargo CA, Taylor CB, Berkey CS, Frazier AL, et al. 1999. Overweight, weight concerns, and bulimic behaviors among girls and boys. *Journal of the American Academy of Child & Adolescent Psychiatry* 38:754-60

27. Fryar CD, Carroll MD, Ogden CL. 2014. Prevalence of overweight and obesity among children and adolescents: United States, 1963-1965 through 2011-2012. *Atlanta, GA: National Center for Health Statistics*

28. Glasofer DR, Tanofsky-Kraff M, Eddy KT, Yanovski SZ, Theim KR, et al. 2007. Binge eating in overweight treatment-seeking adolescents. *Journal of Pediatric Psychology* 32:95-105

29. Godart NT, Flament MF, Curt F, Perdereau F, Lang F, et al. 2003. Anxiety disorders in subjects seeking treatment for eating disorders: a DSM-IV controlled study. *Psychiatry Research* 117:245-58

30. Goldschmidt AB, Aspen VP, Sinton MM, Tanofsky-Kraff M, Wilfley DE. 2008. Disordered eating attitudes and behaviors in overweight youth. *Obesity* 16:257-64

31. Goldschmidt AB, Jones M, Manwaring JL, Luce KH, Osborne MI, et al. 2008. The clinical significance of loss of control over eating in overweight adolescents. *International Journal of Eating Disorders* 41:153-8

32. Goossens L, Braet C, Van Vlierberghe L, Mels S. 2009. Loss of control over eating in overweight youngsters: the role of anxiety, depression and emotional eating. *European Eating Disorders Review* 17:68-78

33. Haedt-Matt AA, Keel PK. 2011. Revisiting the affect regulation model of binge eating: a meta-analysis of studies using ecological momentary assessment. *Psychological Bulletin* 137:660

34. He J, Cai Z, Fan X. 2016. Prevalence of binge and loss of control eating among children and adolescents with overweight and obesity: An exploratory meta-analysis. *International Journal of Eating Disorders*

35. Heatherton TF, Baumeister RF. 1991. Binge eating as escape from self-awareness. *Psychological Bulletin* 110:86

36. Hilbert A, Hartmann AS, Czaja J, Schoebi D. 2013. Natural course of preadolescent loss of control eating. *Journal of Abnormal Psychology* 122:684

37. Hilbert A, Rief W, Tuschen-Caffier B, de Zwaan M, Czaja J. 2009. Loss of control eating and psychological maintenance in children: An ecological momentary assessment study. *Behaviour Research and Therapy* 47:26-33

38. Hudson JI, Hiripi E, Pope HG, Kessler RC. 2007. The prevalence and correlates of eating disorders in the National Comorbidity Survey Replication. *Biological psychiatry* 61:348-58

39. Kenardy J, Arnow B, Agras WS. 1996. The aversiveness of specific emotional states associated with binge-eating in obese subjects. *Australian and New Zealand Journal of Psychiatry* 30:839-44

40. Kessler RC, Berglund PA, Chiu WT, Deitz AC, Hudson JI, et al. 2013. The prevalence and correlates of binge eating disorder in the World Health Organization World Mental Health Surveys. *Biological Psychiatry* 73:904-14

41. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, et al. 2002. 2000 CDC Growth Charts for the United States: methods and development. *Vital and health statistics. Series 11, Data from the national health survey*:1-190

42. Levinson CA, Rodebaugh TL. 2012. Social anxiety and eating disorder comorbidity: The role of negative social evaluation fears. *Eating behaviors* 13:27-35

43. Levinson CA, Rodebaugh TL. 2015. Negative social-evaluative fears produce social anxiety, food intake, and body dissatisfaction: evidence of similar mechanisms through different pathways. *Clinical Psychological Science* 3:744-57

44. Lim CS, Espil FM, Viana AG, Janicke DM. 2015. Associations Between Anxiety Symptoms and Child and Family Factors in Pediatric Obesity. *Journal of Developmental & Behavioral Pediatrics* 36:664-72

45. MacGuire S. 2010. Dietary Guidelines for Americans, 2010. ed. USDo Agriculture, USDoHaH Services. Washington, DC: US Government Printing Office

46. Matherne CE, Tanofsky-Kraff M, Altschul AM, Shank LM, Schvey NA, et al. 2015. A preliminary examination of loss of control eating disorder (LOC-ED) in middle childhood. *Eating behaviors* 18:57-61

47. Micali N, Solmi F, Horton NJ, Crosby RD, Eddy KT, et al. 2015. Adolescent eating disorders predict psychiatric, high-risk behaviors and weight outcomes in young adulthood. *Journal of the American Academy of Child & Adolescent Psychiatry* 54:652-9. e1

48. Mond J, Hall A, Bentley C, Harrison C, Gratwick‐Sarll K, Lewis V. 2014. Eating‐disordered behavior in adolescent boys: Eating disorder examination questionnaire norms. *International Journal of Eating Disorders* 47:335-41

49. Morgan CM, Yanovski SZ, Nguyen TT, McDuffie J, Sebring NG, et al. 2002. Loss of control over eating, adiposity, and psychopathology in overweight children. *International Journal of Eating Disorders* 31:430-41

50. Neumark-Sztainer D, Paxton SJ, Hannan PJ, Haines J, Story M. 2006. Does body satisfaction matter? Five-year longitudinal associations between body satisfaction and health behaviors in adolescent females and males. *Journal of Adolescent Health* 39:244-51

51. Neumark-Sztainer D, Wall M, Story M, Standish AR. 2012. Dieting and unhealthy weight control behaviors during adolescence: associations with 10-year changes in body mass index. *Journal of Adolescent Health* 50:80-6

52. Nicholson JC, McDuffie JR, Bonat SH, Russell DL, Boyce KA, et al. 2001. Estimation of body fatness by air displacement plethysmography in African American and white children. *Pediatric Research* 50:467-73

53. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. 2006. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA* 295:1549-55

54. Ogden CL, Carroll MD, Lawman HG, Fryar CD, Kruszon-Moran D, et al. 2016. Trends in Obesity Prevalence Among Children and Adolescents in the United States, 1988-1994 Through 2013-2014. *JAMA* 315:2292-9

55. Pallister E, Waller G. 2008. Anxiety in the eating disorders: understanding the overlap. *Clinical Psychology Review* 28:366-86

56. Papay JP, Hedl Jr JJ. 1978. Psychometric characteristics and norms for disadvantaged third and fourth grade children on the State-Trait Anxiety Inventory for Children. *Journal of Abnormal Child Psychology* 6:115-20

57. Pervanidou P, Chrousos GP. 2012. Metabolic consequences of stress during childhood and adolescence. *Metabolism* 61:611-9

58. Pratt EM, Niego SH, Agras WS. 1998. Does the size of a binge matter? *International Journal of Eating Disorders* 24:307-12

59. Puder J, Munsch S. 2010. Psychological correlates of childhood obesity. *International Journal of Obesity* 34:S37-S43

60. Radin RM, Tanofsky-Kraff M, Shomaker LB, Kelly NR, Pickworth CK, et al. 2015. Metabolic characteristics of youth with loss of control eating. *Eating Behaviors* 19:86-9

61. Ranzenhofer LM, Engel SG, Crosby RD, Anderson M, Vannucci A, et al. 2014. Using ecological momentary assessment to examine interpersonal and affective predictors of loss of control eating in adolescent girls. *International Journal of Eating Disorders* 47:748-57

62. Ranzenhofer LM, Hannallah L, Field SE, Shomaker LB, Stephens M, et al. 2013. Pre-meal affective state and laboratory test meal intake in adolescent girls with loss of control eating. *Appetite* 68:30-7

63. Rieger E, Van Buren DJ, Bishop M, Tanofsky-Kraff M, Welch R, Wilfley DE. 2010. An eating disorder-specific model of interpersonal psychotherapy (IPT-ED): Causal pathways and treatment implications. *Clinical Psychology Review* 30:400-10

64. Rofey DL, Kolko RP, Iosif A-M, Silk JS, Bost JE, et al. 2009. A longitudinal study of childhood depression and anxiety in relation to weight gain. *Child Psychiatry and Human Development* 40:517-26

65. Rosmond R. 2005. Role of stress in the pathogenesis of the metabolic syndrome. *Psychoneuroendocrinology* 30:1-10

66. Rosmond R, Dallman MF, Björntorp P. 1998. Stress-related cortisol secretion in men: relationships with abdominal obesity and endocrine, metabolic and hemodynamic abnormalities. *The Journal of Clinical Endocrinology & Metabolism* 83:1853-9

67. Schlüter N, Schmidt R, Kittel R, Tetzlaff A, Hilbert A. 2015. Loss of control eating in adolescents from the community. *International Journal of Eating Disorders*

68. Shank LM, Crosby RD, Grammer AC, Shomaker LB, Vannucci A, et al. 2017. Examination of the Interpersonal Model of Loss of Control Eating in the Laboratory. *Comprehensive Psychiatry*

69. Shank LM, Crosby RD, Grammer AC, Shomaker LB, Vannucci A, et al. 2017. Examination of the interpersonal model of loss of control eating in the laboratory. *Comprehensive Psychiatry* 76:36-44

70. Shomaker LB, Tanofsky-Kraff M, Elliott C, Wolkoff LE, Columbo KM, et al. 2010. Salience of loss of control for pediatric binge episodes: does size really matter? *International Journal of Eating Disorders* 43:707-16

71. Shomaker LB, Tanofsky-Kraff M, Elliott C, Wolkoff LE, Columbo KM, et al. 2010. Salience of loss of control for pediatric binge episodes: does size really matter? *International Journal of Eating Disorders* 43:707-16

72. Shomaker LB, Tanofsky-Kraff M, Yanovski JA. 2011. Disinhibited eating and body weight in youth. In *Handbook of behavior, food and nutrition*:2183-200: Springer. Number of 2183-200 pp.

73. Shomaker LB, Tanofsky-Kraff M, Young-Hyman D, Han JC, Yanoff LB, et al. 2010. Psychological symptoms and insulin sensitivity in adolescents. *Pediatric Diabetes* 11:417-23

74. Shunk JA, Birch LL. 2004. Girls at risk for overweight at age 5 are at risk for dietary restraint, disinhibited overeating, weight concerns, and greater weight gain from 5 to 9 years. *Journal of the American Dietetic Association* 104:1120-6

75. Sloan E, Hall K, Moulding R, Bryce S, Mildred H, Staiger PK. 2017. Emotion regulation as a transdiagnostic treatment construct across anxiety, depression, substance, eating and borderline personality disorders: A systematic review. *Clinical Psychology Review*

76. Sonneville KR, Calzo JP, Horton NJ, Haines J, Austin SB, Field AE. 2012. Body satisfaction, weight gain and binge eating among overweight adolescent girls. *International Journal of Obesity* 36:944-9

77. Sonneville KR, Horton NJ, Micali N, Crosby RD, Swanson SA, et al. 2013. Longitudinal associations between binge eating and overeating and adverse outcomes among adolescents and young adults: does loss of control matter? *JAMA Pediatrics* 167:149-55

78. Spielberger CD. 1972. Anxiety as an emotional state. In *Anxiety: Current trends in theory and research*, ed. CD Spielberger, 1:22-49. San Diego, CA: Academic Press. Number of 22-49 pp.

79. Spielberger CD. 1973. *Manual for the State-trait Anxiety Inventory for Children*. Palo Alto: Consulting Psychologists Press

80. 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* 110:124

81. Stice E. 2002. Risk and maintenance factors for eating pathology: a meta-analytic review. *Psychological Bulletin* 128:825

82. Stice E, Marti CN, Rohde P. 2013. Prevalence, incidence, impairment, and course of the proposed DSM-5 eating disorder diagnoses in an 8-year prospective community study of young women. *Journal of Abnormal Psychology* 122:445

83. Stojek MM, Tanofsky-Kraff M, Shomaker LB, Kelly NR, Thompson KA, et al. 2016. Associations of adolescent emotional and loss of control eating with 1-year changes in disordered eating, weight, and adiposity. *International Journal of Eating Disorders*

84. Swinbourne JM, Touyz SW. 2007. The co-morbidity of eating disorders and anxiety disorders: A review. *European Eating Disorders Review* 15:253-74

85. Tanofsky-Kraff M. 2008. Binge eating among children and adolescents. In *Handbook of childhood and adolescent obesity*, ed. E Jelalian, R Steele:43-59. New York: Springer. Number of 43-59 pp.

86. Tanofsky-Kraff M, Cohen ML, Yanovski SZ, Cox C, Theim KR, et al. 2006. A prospective study of psychological predictors of body fat gain among children at high risk for adult obesity. *Pediatrics* 117:1203-9

87. Tanofsky-Kraff M, Goossens L, Eddy KT, Ringham R, Goldschmidt A, et al. 2007. A multisite investigation of binge eating behaviors in children and adolescents. *Journal of Consulting and Clinical Psychology* 75:901

88. Tanofsky-Kraff M, Marcus MD, Yanovski SZ, Yanovski JA. 2008. Loss of control eating disorder in children age 12 years and younger: proposed research criteria. *Eating behaviors* 9:360-5

89. Tanofsky-Kraff M, Ranzenhofer LM, Yanovski SZ, Schvey NA, Faith M, et al. 2008. Psychometric properties of a new questionnaire to assess eating in the absence of hunger in children and adolescents. *Appetite* 51:148-55

90. Tanofsky-Kraff M, Shomaker LB, Olsen C, Roza CA, Wolkoff LE, et al. 2011. A prospective study of pediatric loss of control eating and psychological outcomes. *Journal of Abnormal Psychology* 120:108-18

91. Tanofsky-Kraff M, Shomaker LB, Stern EA, Miller R, Sebring N, et al. 2012. Children's binge eating and development of metabolic syndrome. *International Journal of Obesity* 36:956-62

92. Tanofsky-Kraff M, Shomaker LB, Wilfley DE, Young JF, Sbrocco T, et al. 2017. Excess weight gain prevention in adolescents: Three-year outcome following a randomized controlled trial. *Journal of Consulting and Clinical Psychology* 85:218-27

93. Tanofsky-Kraff M, Theim KR, Yanovski SZ, Bassett AM, Burns NP, et al. 2007. Validation of the emotional eating scale adapted for use in children and adolescents (EES-C). *International Journal of Eating Disorders* 40:232-40

94. Tanofsky-Kraff M, Yanovski SZ, Schvey NA, Olsen CH, Gustafson J, Yanovski JA. 2009. A prospective study of loss of control eating for body weight gain in children at high risk for adult obesity. *International Journal of Eating Disorders* 42:26-30

95. Tanofsky-Kraff M, Yanovski SZ, Wilfley DE, Marmarosh C, Morgan CM, Yanovski JA. 2004. Eating-disordered behaviors, body fat, and psychopathology in overweight and normal-weight children. *Journal of Consulting and Clinical Psychology* 72:53-61

96. Tanofsky-Kraff M, Yanovski SZ, Yanovski JA. 2011. Loss of control over eating in children and adolescents. In *Developing an evidence-based classification of eating disorders: Scientific findings for DSM-5*, ed. R. H. Striegel-Moore, S. A. Wonderlich, B. T. Walsh, J. E. Mitchell:221-36. Washington, DC: American Psychiatric Association Press. Number of 221-36 pp.

97. Taylor AL, Fishman LM. 1988. Corticotropin-releasing hormone. *New England Journal of Medicine* 319:213-22

98. Vannucci A, Tanofsky-Kraff M, Shomaker LB, Ranzenhofer LM, Matheson BE, et al. 2012. Construct validity of the emotional eating scale adapted for children and adolescents. *International journal of obesity (2005)* 36:938

99. Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. 1997. Predicting obesity in young adulthood from childhood and parental obesity. *New England Journal of Medicine* 337:869-73

100. Wolfe BE, Baker CW, Smith AT, Kelly-Weeder S. 2009. Validity and utility of the current definition of binge eating. *International Journal of Eating Disorders* 42:674-86

101. Zimmet P, Alberti KGM, Kaufman F, Tajima N, Silink M, et al. 2007. The metabolic syndrome in children and adolescents–an IDF consensus report. *Pediatric Diabetes* 8:299-306