Associations between eating behaviors, diet quality and body mass index among adolescents

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Abstract:

Objective: Some eating behaviors are associated with negative nutrition-related outcomes in adults, but research is lacking in adolescent samples. The current study examined whether dietary restraint moderates the relationship between disinhibition and weight outcomes and overall diet quality in a community sample of 16-year old adolescents. **Methods:** Participants were recruited from a longitudinal study examining self-regulation and cardiometabolic risk. Data for this cross-sectional study were collected from questionnaires and laboratory visits when participants were approximately 16 years old (n = 178). Disinhibition and restraint were assessed using two subscales of the Three-Factor Eating Questionnaire. Diet quality was determined using Healthy Eating Index-2010 (HEI-2010) scores that were calculated using dietary data from 24-h dietary recalls. Two separate hierarchical linear regression analyses tested whether restraint moderated the associations of disinhibition with BMI-for-age percentile and HEI-2010 scores. **Results:** After adjusting for covariates, restraint moderated the association between disinhibition and HEI-2010 scores ($\beta = -0.21$, $p = 0.03$). There was a main effect for disinhibition on BMI-for-age percentiles ($\beta = 0.58$, $p = 0.02$), but this relationship was not moderated by the level of restraint. **Conclusions:** The relationship between disinhibition and overall diet quality differed among adolescents according to level of dietary restraint. Although disinhibition independently predicted weight status, the level of restraint had no influence on this association. Future studies should examine restraint in relation to energy intake and weight concerns to better understand how it influences weight and dietary outcomes in this population.

Keywords: Adolescent | Diet quality | Healthy eating index | Obesity | Disinhibition | Restraint

Article:

1. Introduction

Adolescence is recognized as a critical time point for establishing lifelong health behaviors (CDC, 2018; Craigie, Lake, Kelly, Adamson, & Mathers, 2011; Healthy Behaviors in

Adolescence [Internet], 2016). The prevalence of obesity rises throughout adolescence and evidence suggests that individuals who are overweight during this period are at increased risk for tracking excessive adiposity into adulthood (Ogden, 2018; Simmonds, Llewellyn, Owen & Woolacott, 2016). Furthermore, many adolescents consume poor diets, failing to meet the minimum recommendations for fruits, vegetables, whole grains, and dairy products while exceeding the maximum recommended intakes of saturated fat and added sugars (Banfield, Liu, Davis, Chang, & Frazier-Wood, 2016; Cutler, Flood, Hannan, & Neumark-Sztainer, 2009; Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010). Healthy eating is one of the key factors that influence long-term obesity and other chronic disease risks, therefore a better understanding of the behaviors that influence dietary intake during adolescence is warranted (Popkin & Gordon-Larsen, 2004).

Healthy weight maintenance depends on balancing energy intake with energy expenditure over time (Das et al., 2017; Lutter & Nestler, 2009). Although basic energy balance is regulated through homeostatic signals to sustain life, humans also experience hedonic drivers of food intake, which influence the desire to obtain pleasure through eating (Lutter & Nestler, 2009). The current food environment in Western countries tends to promote hedonic aspects of eating via disproportionate access to palatable and energy-dense foods that have been linked to poor dietary outcomes and increased obesity risks (Caspi, Sorensen, Subramanian, & Kawachi, 2012; Gordon-Larsen, 2014; Miller, Reedy, Kirkpatrick, & Krebs-Smith, 2015). However, some individuals are able to maintain a healthy weight while others become overweight or obese (Birch & Davison, 2001; Mattes & Foster, 2014).

Eating behaviors, including disinhibition and dietary restraint, appear to influence the variability of weight and diet-related outcomes among individuals (Bouhlal, McBride, Trivedi, Agurs-Collins, & Persky, 2017; French, Epstein, Jeffery, Blundell, & Wardle, 2012; Hays et al., 2002). While disinhibition refers to one's tendency to overeat palatable foods, or to eat in excess as a response to emotional or stressful situations (Bryant, King, & Blundell, 2008; French et al., 2012), dietary restraint is most often defined as one's conscious control or restriction of food intake, generally for the purpose of reducing or maintaining weight (Bond, McDowell, & Wilkinson, 2001; French et al., 2014; Hawks, Madanat, & Christley, 2008). The extant literature investigating the links between disinhibition, restraint and weight outcomes focuses largely on adults and/or clinical populations enrolled in obesity treatment programs (Bond et al., 2001; French et al., 2014). In these studies, a greater level of disinhibition is associated with a higher Body Mass Index (BMI) (Bryant et al., 2008; Hays et al., 2002; Williamson et al., 1995). The associations between restraint and weight outcomes (e.g. BMI) are less clear, and seemingly dependent on weight status and dieting history (Johnson, Wardle, & Griffith, 2002; Provencher, Drapeau, Tremblay, Després, & Lemieux, 2003; Williamson et al., 1995). Restraint has been shown, in some studies, to have a positive association with weight and BMI, but this association is not necessarily causal and might be due to the tendency of some overweight individuals to attempt to control weight (Provencher et al., 2003; Schaumberg, Anderson, Anderson, Reilly, & Gorrell, 2016). Further, evidence suggests that it is the interaction between these eating behaviors that predicts weight, and that dietary restraint might act to moderate the positive association between disinhibition and BMI (Hays et al., 2002; Lawson et al., 1995; Savage, Hoffman, & Birch, 2009; Williamson et al., 1995). For example, cross-sectional studies have shown that high levels of restraint reduce the effects of disinhibition on weight, such that

individuals with high disinhibition and high restraint weighed less than individuals with high disinhibition and low restraint (Lawson et al., 1995; Savage et al., 2009).

In terms of the influence of disinhibited or restrained eating on individuals' diet-related outcomes, research is scarce and the few existing studies focus on selected nutrients or food groups rather than general dietary pattern (Contento, Zybert, & Williams, 2005; Johnson, Pratt, & Wardle, 2005; Provencher et al., 2003). For instance, a high level of disinhibition has been associated with a greater intake of saturated fat, high-sugar and high-salt foods, sugar-sweetened beverages and unhealthy snacks (Contento et al., 2005; Leblanc et al., 2012). In contrast, higher dietary restraint has been correlated with lower intakes of total energy and dietary fat and a greater consumption of healthy foods, such as fruit and vegetables (Ard, Desmond, Allison, & Conway, 2006; Contento et al., 2005). Understanding how eating behaviors interact to influence overall diet quality rather than the consumption of individual nutrients or food groups is essential because improved overall diet quality plays a key role in the prevention of chronic disease (Camhi, Whitney Evans, Hayman, Lichtenstein, & Must, 2015).

Despite the well-recognized role of healthy eating early in life on long-term health outcomes, the research assessing diet and weight-related outcomes among adolescents is limited and has primarily focused on the influence of unhealthy weight-control practices, while largely neglecting the potential conjoint effects of disinhibition and dietary restraint on these important outcomes in non-clinical populations (Larson, Neumark-Sztainer, & Story, 2009; Neumark-Sztainer, Story, Perry, & Casey, 1999). Thus, the purpose of this study was to explore the associations between disinhibition and restraint in relation to BMI-for-age percentile and overall diet quality in a community sample of adolescents. Based on the existing literature largely limited to adults, we expected that: 1) disinhibition will independently predict BMI-for-age percentile and overall diet quality, 2) restraint will independently predict overall diet-quality, and 3) restraint will moderate the association between disinhibition and BMI-for-age percentile and overall diet quality in our sample of adolescents.

2. Materials and methods

2.1. Participants and procedures

Cross-sectional data for the current study were collected from participants of the RIGHT Track Study, a longitudinal study assessing self-regulation and cardiometabolic risk. A complete description of the recruitment, screening procedures and participant characteristics is presented elsewhere (Wideman et al., 2016). Briefly, participants were recruited at age 2 through child daycare centers, the local Woman, Infant and Children (WIC) program, and the county health department in Greensboro, NC between 1994–1996. Participants in the original sample (n = 293) were representative of the surrounding community in terms of race and socioeconomic status (Wideman et al., 2016). Socioeconomic status (SES) was determined using the Hollingshead Index which measures social status of a child or adolescent based on the marital status, employment status, educational attainment, and occupational prestige of the parent (Hollingshead, 1975). Data for the current cross-sectional study were collected beginning in spring 2014 when participants were approximately 16 years old. Participants reported on health behaviors using online questionnaires. Other health data, including anthropometric

measurements, were collected in the lab by trained research assistants. Written consent from the adolescent and an accompanying parent were obtained prior to any data collection. Study procedures were reviewed and approved by the Institutional Review Board at the University of North Carolina Greensboro.

2.2. Study measures and variables

2.2.1. Eating behaviors

Participants reported on their current eating behaviors using the Three-Factor Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985), assessing disinhibition and cognitive restraint of eating. The disinhibition subscale of the TFEQ consists of 16-items which measure the individuals' tendency to overeat in response to external stimuli, such as high levels of emotion or presence of palatable foods (e.g. "Sometimes when I start eating, I just can't seem to stop") (Bryant et al., 2008; Stunkard & Messick, 1985). The restraint subscale of the TFEQ consists of 21 items that are associated with the intent to control food intake for weight management (e. g., "I deliberately take small helpings as a means of controlling my weight") (Stunkard & Messick, 1985). Responses were dichotomized and coded 0 or 1, with the exception of a single item from the restraint subscale (e.g. "On a scale of 0–5, where 0 means no restraint in eating and 5 means total restraint, which number would you give yourself") which was not collected in the original longitudinal study. Total scores for each subscale were calculated by summing respective responses, with higher scores indicating a greater level of the specific type of eating behavior. Crohnbach's alpha scores for the subscales of disinhibition and restraint were 0.77 and 0.81 respectively. A total of 178 participants provided complete data from the TEFQ at the 16-year visit.

2.2.2. Diet quality

Participants were asked to complete three 24-h dietary recalls (2 weekdays and 1 weekend day) immediately following their lab visit. Detailed procedures related to the dietary recalls in the RIGHT Track study can be found elsewhere (Wideman et al., 2016). The 24-h dietary recalls were collected by the Nutrition Obesity Research center (NORC) at the University of North Carolina Chapel Hill and analyzed using the Nutrition Data System for Research (NDSR) software. Dietary data from the available dietary recalls were averaged and the overall diet quality for each participant was determined using the Healthy Eating Index 2010 (HEI-2010) scoring system that was based on the official Dietary Guidelines for Americans that were current at the time of the study (Guenther et al., 2013; McGuire, 2010). From the reported intakes, 12 dietary component sub-scores were calculated and added together to create an overall diet quality score ranging from 0 to 100, with greater values indicating better adherence to the federal dietary guidelines (Guenther et al., 2013; McGuire, 2010). The total scores were then averaged to determine the overall diet quality score. Since the recommendations for food group amounts vary according to the individual's dietary energy intake, HEI-2010 scores are calculated based on intake of each component per 1000 kcal. The detailed procedures for calculating overall HEI-2010 scores are reported elsewhere (Guenther et al., 2013). In the current study, 148 participants provided dietary recalls at age 16: 137 completed 3 recalls, 6 completed 2 recalls and 5 participants completed 1 recall. There were no significant differences in the HEI score between

the participants who completed 3 versus 2 versus 1 dietary recall; thus, data from all participants who provided 1–3 dietary recalls were included in the final analyses.

2.2.3. Body mass index (BMI)

Participants' height and weight were measured using standard procedures by trained research assistants and used to calculate BMI (BMI = kg/m²) (Onyango, De Onis, & World Health Organization, 2008). Height was measured using a stadiometer (SECA, Chino CA) to the nearest 0.1 cm. Weight was measured using a medical scale to the nearest 0.1 kg (Detecto-Medic, Brooklyn NY). BMI-for-age percentile was determined for each participant using the CDC SAS program that calculates age- and gender-specific percentiles using the 2000 CDC growth charts (SAS Program, 2018). Since both a BMI z-score and a BMI-for-age percentile are adjusted for a child's age and gender, and a BMI z-score corresponds to a growth chart percentile by comparing it to a normal distribution table, the BMI-for-age percentile was chosen as the main outcome variable (Must & Anderson, 2006). Several participants with otherwise complete data had missing height and weight at the 16-y laboratory visit (n = 26); thus, missing BMI-for-age percentiles were imputed using the expectation/maximization likelihood treatment of missing data described by Schafer (1999). The imputation procedure consisted of modeling the available measurements from anthropometric data collected during the participant's laboratory visits at ages 4, 5, 7, 10, 15 and 17. The model's parameters were then used to define the data distribution from which to impute the missing BMI-for-age percentile values. To fully account for the data variability, and assuming that data were missing at random, ten sets were created in which all observed data were represented and missing data estimated, and the meaned values from the datasets were used in the analyses (Schafer, 1999).

2.3. Statistical analyses

Statistical analyses for the current study were conducted using SPSS 25.0 (25.0 SPSS Inc., Chicago, IL, 2017) and using SAS version 9.4 for the BMI-for-age percentile calculations (SAS Institute Inc., Cary, NC). Two separate hierarchical linear regression analyses were performed to test whether dietary restraint moderated the associations of disinhibition with weight (i.e., BMI-for-age percentile) and overall diet quality (i.e., HEI-2010 score). Continuous predictor variables, i.e. disinhibition and restraint, were first centered and an interaction term was created by multiplying the centered variables (Fryar, Carroll, & Ogden, 1960; Hayes & Andrew, 2013; Johnson & Fay, 1950). Covariates in the model with BMI-for-age percentile as the dependent variable included gender, race and SES. In the regression model with HEI-2010 score, covariates included gender, race, SES and BMI-for-age percentile. The interaction was probed using the Johnson-Neyman technique, available from the PROCESS macro version 3.1 for SPSS (Hayes & Andrew, 2013), which identified specific scores for dietary restraint where the relationship between disinhibition and the outcome variable transitioned to significance (Johnson & Fay, 1950). Statistical significance was set at a *p*-value of < 0.05.

3. Results

3.1. Descriptives

A total of 178 participants provided data for the main variables of interest and thus were included in the analyses for the current study. The sample's characteristics are presented in Table 1. Adolescents in the sample adhered poorly to the Dietary Guidelines, as indicated by the low mean diet quality score (Table 1). Pearson bivariate correlations between the main variables and covariates of the study are presented in Table 2.

Table 1. Sociodemographic, Anthropometric, and Dietary Characteristics of the Study Sample ($n = 178$).

	Descriptive Statistics	
Variable	Mean ± SD	*n* (%)
Age	16.6 ± 0.4	
Gender		
Female		103 (58)
Male		75 (42)
Race/Ethnicity[a, b]		
White		116 (65)
Non- White		62 (35)
SES[b]	43.6 ± 13.7	
BMI-for-age Percentile[c]	65.4 ± 25.6	
Weight Status Categories[d]		
Underweight		3 (2)
Healthy weight		125 (70)
Overweight		30 (17)
Obese		20 (11)
Disinhibition Score[e]	4.7 ± 2.8	
Restraint Score[e]	6.3 ± 4.1	
HEI-2010 Score[f]	49.1 ± 12.3	
Kcal[g]	1802 ± 656	

[a] Race included two categories based on the inclusion criteria of the larger study. [b] SES; socioeconomic status; 14 % of the sample had missing information on SES at 16y lab visit. Available SES from closest time point was used (age 10 for all but 3 cases). [c] 15 % of the sample had missing information for height and weight at 16y lab visit. [d] BMI-for-age percentile; body mass index-for-age percentile; cut offs developed by the CDC were used to categorize adolescents into weight categories: underweight = BMI <5 %; healthy weight = BMI 5th-84.99 %; overweight = BMI 85th-94.99 %; obese = BMI 95th-100 percentile. [e] Disinhibition scores ranging 0–16; restraint scores ranging 0–20. [f] HEI-2010; Healthy Eating Index; subjects with complete recalls (n = 148). [g] Kcal; kilocalories per day average from complete recalls (n = 148).

Table 2. Bivariate Correlations Between Study Variables.

Variable	Gender	Race	SES	Restraint Score	Disinhibition Score	BMI-for-age %	HEI Score
Gender							
Race[a]	0.07						
SES[b]	−0.13	−0.32					
Restraint Score[c]	0.27**	−0.08	0.11				
Disinhibition Score[c]	0.08	−0.05	0.02	0.16*			
BMI-for-age %[d]	0.09	0.18*	−0.09	0.15*	0.18*		
HEI Score[e]	0.09	−0.21	0.18*	0.22**	0.01	−0.13	

* Significant at $p < 0.01$ level. ** Correlation is significant at the 0.05 level.
[a] Race included two categories based on the inclusion criteria of the larger study, white/non-white. [b] SES; socioeconomic status. [c] Disinhibition scores ranging 0–16; restraint scores ranging 0–20. [d] BMI-for-age %; Body mass index-for-age percentile; calculated using SAS program developed by CDC. [e] HEI; Healthy Eating Index; subjects with complete recalls (n = 148).

3.2. Regression analysis for BMI-for-age percentiles

Accounting for gender, race, and SES, the regression model was significant and explained 10 % of the variance in adolescents' BMI-for-age percentiles ($R^2 = 0.10$; $F = 3.13$; $p = 0.01$). There was a significant main effect of disinhibition on BMI-for-age percentiles, indicating that individuals with higher disinhibition also had greater BMI-for-age percentiles (Table 3). There was not a significant interaction effect between disinhibition and restraint on the outcome (Table 3).

Table 3. Results of Multiple Regression Analyses Predicting BMI-for-age Percentile from Disinhibition and Restraint Scores.

						95.0% CI	
Variables	**β**	**SE**	**Beta**	**t**	**Sig.**	**Lower**	**Upper**
Block 1: Control Variables							
Gender	0.48	3.98	0.01	0.12	0.90	−7.37	8.33
Race	10.23	4.14	0.19	2.47	0.01*	2.06	18.41
SES[a]	−0.07	0.15	−0.04	−0.49	0.63	−0.36	0.22
Block 2: Predictor							
Disinhibition Score	1.75	0.70	0.19	2.52	0.01*	0.38	3.12
Block 3: Moderator							
Restraint Score	0.94	0.48	0.15	1.96	0.05	−0.01	1.90
Block 4: Interaction Term							
Disinhibition X Restraint	−0.23	0.17	−0.10	−1.34	0.18	−0.57	0.11

* $p < 0.05$.
[a] SES; socioeconomic status.

Table 4. Results of Multiple Regression Analyses Predicting HEI-2010 Score from Disinhibition Score and Restraint Score.

|						95.0% CI	
Variables	**β**	**SE**	**Beta**	**t**	**Sig.**	**Lower**	**Upper**
Block 1: Control Variables							
Gender	1.58	2.08	0.06	0.76	0.45	−2.54	5.69
Race	−2.99	2.16	−0.12	−1.38	0.17	−7.27	1.28
SES[a]	0.11	0.07	0.12	1.47	0.14	−0.04	0.26
BMI-for-age Percentile[b]	−0.06	0.04	−0.14	−1.66	0.10	−0.14	0.01
Block 2: Predictor							
Disinhibition Score	0.20	0.36	0.05	0.56	0.58	−0.51	0.91
Block 3: Moderator							
Restraint Score	0.58	0.25	0.20	2.32	0.02*	0.09	1.07
Block 4: Interaction Term							
Disinhibition X Restraint	−0.21	0.09	−0.18	−2.24	0.03*	−0.39	−0.03

* $p < 0.05$.
[a] SES; socioeconomic status. [b] Body mass index-for-age percentile.

3.3. Regression analysis for diet quality

Accounting for gender, race, SES and BMI-for-age percentiles, the regression model explained 14 % of the variance in the diet quality score ($R^2 = 0.14$; $F = 3.38$; $p = 0.002$). The interaction effect between disinhibition and restraint in predicting diet quality was significant and explained a significant but small amount of variance beyond the main effect of disinhibition alone (R^2 change = 0.03, F^2 change = 5.04, $p = 0.03$), suggesting that the association between disinhibition and diet quality was influenced by adolescent's level of restraint (Table 4). The Johnson-Neyman technique showed that the moderating effect was significant when the mean restraint scores were

<−6.23 [(equivalent to a non-centered score of 0.6), 2.0 % of the restraint scores below this cutoff] and >7.80 [(equivalent to a non-centered score of 14.1), 5.4 % of restraint scores above this cutoff] (Fig. 1). The effect of restraint between these cutoff values was non-significant, suggesting that very high and very low levels of dietary restraint moderates the relationship between disinhibition and diet quality.
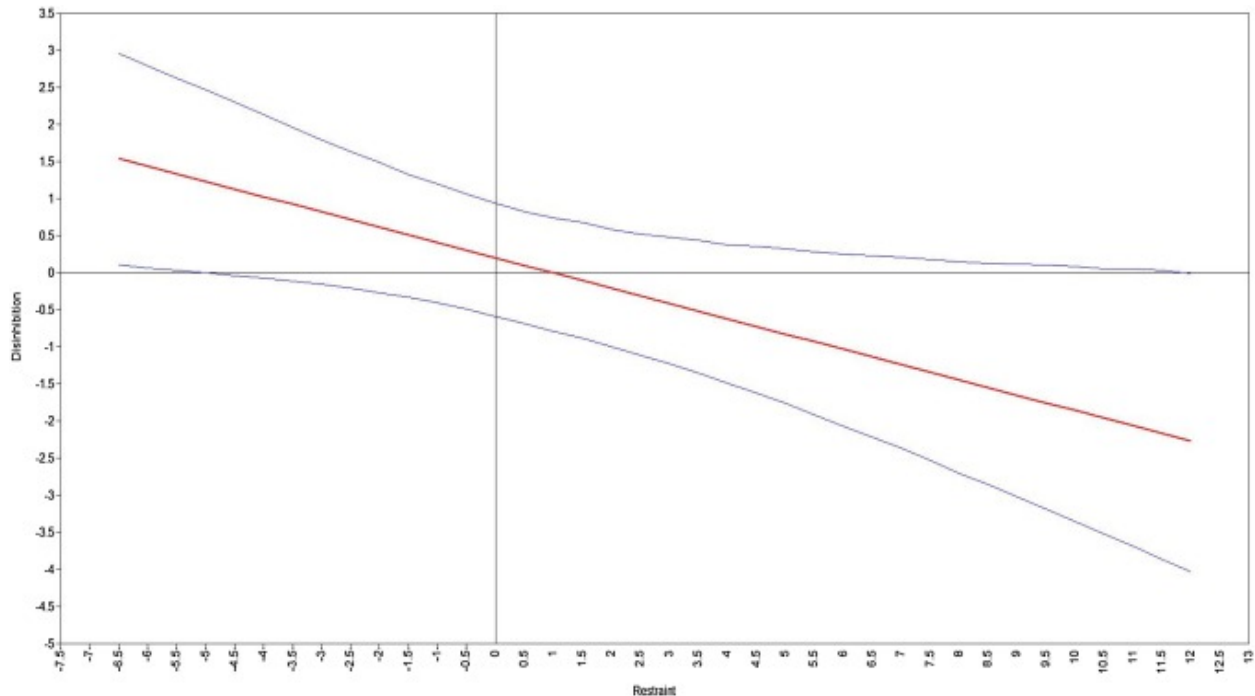
Figure 1. Conditional Effects of Disinhibition as a Function of Dietary Restraint on Overall Diet Quality.
The red line represents the regression line and the blue lines represent the 95 % confidence intervals. The x-axis represents observed values of restraint (centered) and the y-axis represents the association of disinhibition with diet quality (HEI-2010 scores).

4. Discussion

The main contribution of the current study is the examination of eating behaviors that may impact the BMI and diet quality of adolescents—a population with a high prevalence of unhealthy eating and obesity (Fryar et al., 1960; Ogden et al., 2016). It is well established that health behaviors track from adolescence into adulthood (Birch & Fisher, 1998), and, as seen in adult populations, dysregulated eating behaviors are associated with negative weight-related health outcomes (French et al., 2012; Neumark-Sztainer et al., 2006). Thus, it is critical to better understand the interactions of these eating behaviors to determine who might benefit most from particular intervention designs. The current study contributes to our current knowledge of disinhibition, restraint and their associations with weight and diet quality in a community sample of adolescents, as opposed to previous studies that have largely examined these eating behaviors in adults and/or overweight/obese individuals. Although further research with adolescents is still warranted, some findings presented here might be used when informing interventions for improving overall diet quality and/or weight outcomes in this population.

Higher levels of disinhibition were independently associated with higher BMI-for-age percentiles. This finding was expected and is consistent with findings from adult populations where disinhibition scores were positively associated with BMI and weight outcomes (Bellisle et al., 2004; Hays et al., 2002; Williamson et al., 1995). The proposed mechanism of this relationship is related to the vulnerability of disinhibited eaters to consume high-energy, high-fat, and high-sugar foods, resulting in a positive energy balance (Bryant et al., 2008; Contento et al., 2005; Leblanc et al., 2012). In contrast, dietary restraint alone, after controlling for gender, race, and SES, was not associated with BMI-for-age percentiles. A possible explanation for this finding is that the TFEQ measure of restraint does not differentiate between "perceived" and "physiological" restriction of food (Onyango et al., 2008); subsequently, some individuals might score high on dietary restraint, meaning they eat less than desired but still exceed their physiological energy needs leading to higher BMI. This might be especially true for individuals with a tendency to overeat palatable foods, and those who are more vulnerable to the influences of today's obesogenic food environments (Mattes & Foster, 2014; Neumark-Sztainer et al., 1999).

Some studies with adult samples suggest that restraint does not independently influence weight, but may attenuate the relationship between disinhibition and weight outcomes (Hays et al., 2002; Lawson et al., 1995; Savage et al., 2009; Williamson et al., 1995). Therefore, it was hypothesized that restraint would moderate the positive association between disinhibition and BMI-for-age percentile. In our adolescent sample, however, this interaction effect was not significant. It is important to note that the effect of restraint and disinhibition on weight outcomes is complex (Hays et al., 2002; Savage et al., 2009; Williamson et al., 1995) and that the interplay between eating behaviors may be influenced by other factors that were not captured in the study, such as adolescents' dieting status at the time of the study, body image, or weight concerns. For example, a study by Savage et al. (2009) examined associations between disinhibition, restraint and weight between dieters and non-dieters and found significant differences in the moderating ability of restraint on levels of disinhibition between groups by dieting status (Savage et al., 2009). Among non-dieters, higher disinhibition predicted higher weight to a greater extent when restraint was higher, whereas in dieters, higher disinhibition predicted higher weight when restraint was lower. Thus, additional factors related to weight control behaviors must be considered in future investigations of these associations.

With respect to dietary intake, scores for disinhibition were not independently associated with adolescents' diet quality, whereas dietary restraint alone was associated with improved diet quality. These findings appear to contradict results from previous studies which have linked higher disinhibition to less healthful food selection and increased restraint to a consumption of healthier foods (Contento et al., 2005; Lähteenmäki & Tuorila, 1995; Lindroos et al., 1997). These studies, however, tended to focus on a single food or nutrient and do not reflect a measure of overall diet quality and/or adherence to a healthy eating pattern (Guenther et al., 2013). It is possible that disinhibited eaters have enough variability in their diet composition that scores for diet quality are neither positively nor negatively affected. On the other hand, it is well established that adolescence is a unique developmental period, marked by physiological growth and changes to both behavioral and cognitive systems (Das et al., 2017). Food choices and food-related behaviors of adolescents are determined by a broad range of factors including parental and peer influence, time considerations, food availability, and convenience (Neumark-Sztainer et

al., 1999). Since personal factors are related to the initiation of behaviors among adolescents, they must be considered in greater depth when examining the relationship between eating behaviors and overall diet quality in future research.

One particular factor that has been related to diet quality is dieting efforts, which we did not account for in the current study. In previous studies among adolescents, unhealthy weight control behaviors, like skipping meals, were associated with lower intakes of fruits, vegetables and key micronutrients, whereas moderate weight-control behaviors, like replacing sugar-sweetened beverage with water, were associated with increased consumption of fruits and vegetables (Larson et al., 2009; Story, Neumark-Sztainer, Sherwood, Stang, & Murray, 1998). Since our study focused on a broader construct of restraint only, future research should investigate specific subscales of restraint that influence food choices among adolescents.

The association between disinhibition and diet quality differed according to the level of adolescents' dietary restraint. At very high levels of restraint, adolescents with low disinhibition had higher scores for overall diet quality, whereas at very low levels of restraint, adolescents with low disinhibition had lowered diet quality scores. This suggests that higher levels of dietary restraint might be necessary to positively influence overall diet quality, even among individuals with low disinhibition. It is possible that individuals with low disinhibition are less sensitive to food cues and cravings (Nansel et al., 2016). Therefore, at high levels of restraint, these individuals are more likely to demonstrate improved diet quality whereas at low levels of restraint, a lack of cognitive control of eating results in low diet quality (Nansel et al., 2016). On the other hand, for a majority of adolescents, the level of restraint did not impact the hedonic aspects of eating to moderate overall diet quality. This is not surprising given the poor diet quality scores in the sample. Given the abundant access to palatable foods in the current so-called obesogenic society, it is possible that the tendency toward eating opportunistically in such an environment overwhelms the ability to cognitively control food intake (Caspi et al., 2012; Mattes & Foster, 2014). It is also possible that restraint scores did not reflect long-term behavior, but rather inconsistent periods of dietary restriction which might then be followed by periods of disinhibition (Schaumberg et al., 2016). This is in line with previous studies which found the level of disinhibition to be the best predictor of overall food consumption (Van Strien, Cleven, & Schippers, 2000; Westenhoefer, Broeckmann, Münch, & Pudel, 1994). However, the relationship between eating behaviors, such as restraint and disinhibition, with overall diet quality among adolescents needs to be explored further in future research.

This study had several strengths and limitations. One of the strengths was that data were collected during a time point when individuals were beginning to formulate behaviors that reflect personal choices. Therefore, findings from these analyses provide valuable insights into dysregulated eating patterns and their associations with health outcomes during this transitional period. Another strength was that overall diet quality, rather than individual foods or food groups, was estimated using three 24-h dietary recalls and utilizing a multi-pass method that enhances the accuracy of food recall among individuals (Casey, Goolsby, Lensing, Perloff, & Bogle, 1999). Several limitations of the study must be also noted. Due to the cross-sectional design, we were not able to determine causal relationships between eating behaviors and weight outcomes or diet-quality. In addition, the sample was limited to a subset of adolescents originally involved in the RIGHT Track study at 2 years old so was not representative of 16-year-old

adolescents in the U.S. Since the original enrollment, there has been some attrition due to relocation and loss to follow-up. Thus, there is a potential for bias in the current sample as those who have remained in the study may have intrinsic reason for doing so (Wideman et al., 2016). Finally, the assessment of eating behaviors was conducted using the TFEQ, which is a self-reported questionnaire and therefore cannot capture actual behaviors of adolescents in food-related situations and may have increased reporting bias during the study.

5. Conclusions

The present study suggests that the association of disinhibition with diet quality is moderated by dietary restraint but only at very high and very low levels of this eating behavior. For the majority of adolescents in our sample, the effects of restraint did not impact the relationship between disinhibition and diet quality. Dietary restraint did not moderate the association between disinhibition and BMI-for-age percentiles. Overall, the research presented here suggests that additional factors likely influence the association between eating behaviors and nutrition-related outcomes among adolescents. Future research should examine these potential factors in larger samples of adolescents to advance our current understanding of how eating behaviors function in relation to diet quality and BMI during this period of transition.

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