



Mindfulness and laboratory eating behavior in adolescent girls at risk for type 2 diabetes

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ABSTRACT

Mindfulness-based intervention has become increasingly popular to address disinhibited eating in obesity and type 2 diabetes (T2D). Theoretically, present-moment attention promotes the ability to recognize and respond to internal hunger cues and to differentiate physiological hunger from other stimuli. Yet, there is limited research describing the relationship of mindfulness with disinhibited eating patterns in adolescents. In this study, we evaluated the relationship of dispositional mindfulness to laboratory eating in 107 adolescent (12–17 years) girls at risk for T2D. Adolescents reported dispositional mindfulness, were evaluated for recent loss-of-control-eating (LOC-eating) by interview, and participated in two successive, standardized laboratory test meals to assess eating when hungry as well as eating in the absence of hunger (EAH). Adolescents rated state appetite throughout the test meal paradigms. In analyses adjusting for body composition and other possible confounds, mindfulness was inversely related to caloric intake during the EAH paradigm. Mindfulness did not relate to energy intake when hungry. Instead, there was a significant interaction of reported LOC-eating by state hunger, such that girls with recent, reported LOC-eating and high state hunger consumed more calories when hungry, regardless of mindfulness. Findings suggest that in girls at risk for T2D, mindfulness may play a role in disinhibited eating. A propensity for LOC-eating may be most salient for overeating in a high hunger state.

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1. Introduction

Mindfulness refers to a non-judgmental state of purposeful awareness that brings attention to the present moment and allows for the recognition and consideration of internal and external experiences without the pressure to alter the moment or take immediate action (Kabat-Zinn, 1991). Mindfulness has dispositional or trait-like characteristics, but also may be learned and developed through training (Shapiro, Carlson, Astin, & Freedman, 2006). Mounting empirical evidence suggests that mindfulness promotes psychological and physical health through adaptive self-regulation,

such as improved emotion regulation and fostering healthy eating (Creswell, 2017). In adults, mindfulness-based interventions have gained popularity as a therapeutic modality to address disinhibited eating patterns that contribute to obesity and type 2 diabetes (T2D) (Godfrey, Gallo, & Afari, 2015; Godsey, 2013). However, there is limited information expressly describing the relationship of dispositional mindfulness to disinhibited eating in adolescents at risk for adverse weight and metabolic outcomes.

Disinhibited eating refers to a lack of self-regulation over food consumption, including behaviors such as eating in the absence of hunger (EAH) and loss-of-control-eating (LOC-eating) (Shomaker, Tanofsky-Kraff, & Yanovski, 2011). EAH is the intake of palatable food in the absence of physiological hunger, in response to emotional and/or external cues such as the availability of highly palatable food (Kral & Faith, 2007), and EAH is a common form of

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disinhibited eating in youth with overweight and obesity (Shomaker et al., 2011). Externality theory suggests that individuals prone to obesity are less sensitive to internal cues and highly sensitive to external cues to eat (Schachter & Rodin, 1974). In early studies, youth with obesity ate significantly more when presented with snacks (Costanzo & Woody, 1979) and were more influenced by external cues such as the availability or composition of food (Schachter & Rodin, 1974; Schachter, 1971) than youth who were lean. More recent studies also have demonstrated a positive cross-sectional association between EAH, as assessed by survey and test meal intake, with body mass index (BMI) in adolescents (Fisher et al., 2007; Shomaker et al., 2010).

Another prevalent form of disinhibited eating is LOC-eating, referring to perceived overeating accompanied by a subjective sense of not being able to control what or how much one is eating (American Psychiatric Association, 2013). The experience of LOC is frequently reported in adolescents with overweight and obesity (Tanofsky-Kraff, 2008; Tanofsky-Kraff et al., 2004; Vannucci et al., 2013) and in adolescents with obesity-related comorbidities including T2D (Wilfley et al., 2011). Youth who endorse LOC are more likely to gain excess weight and body fat over time (Field et al., 2012; Sonnevile et al., 2013; Tanofsky-Kraff et al., 2009) and to show a worsening in components of metabolic health that elevate T2D risk (Kelly et al., 2015; Tanofsky-Kraff et al., 2012).

In theory, mindfulness is anticipated to relate inversely to disinhibited eating because present-moment attention should promote an individual's ability to recognize and respond effectively to internal appetitive cues of hunger and satiety (Brown, Ryan, & Creswell, 2007). Moreover, attention to the present moment should support the differentiation between physiological hunger signals and other internal or external stimuli for eating, such as negative emotions or food availability (Brown et al., 2007; Olson & Emery, 2015). Nearly all existing studies characterizing the cross-sectional relationship of dispositional mindfulness with disinhibited eating have been conducted in adults. In healthy adult women, dispositional mindfulness was negatively related to a self-reported tendency to engage in disinhibited eating patterns, including eating in response to external food cues and negative affect (Lattimore, Fisher, & Malinowski, 2011). Likewise, in adults with T2D, mindfulness was inversely associated with self-reported eating in response to emotions or external cues (Tak et al., 2015). In other studies of non-clinical samples of adults using self-report surveys, dispositional mindfulness also has been inversely associated with reported eating in response to emotions (Pidgeon, Lacota, & Champion, 2013), disordered eating symptoms (Masuda, Price, & Lutzman, 2012), and fewer symptoms of disinhibited-type eating disorders such as bulimia nervosa (Lavender, Jardin, & Anderson, 2009). In a prior cross-sectional study of overweight and obese adolescent girls, dispositional mindfulness was related to a lower odds of reported binge-eating, less frequent reported-EAH in response to fatigue or boredom, and less reinforcing value of food (Pivarunas et al., 2015). Although existing data have primarily relied upon self-reports of disinhibited eating, one previous study of college students found that an experimental mindfulness induction led to greater enjoyment of eating paired with less energy intake from unhealthy "junk" foods in the laboratory (Arch et al., 2016). These preliminary findings support a relationship between dispositional mindfulness and eating behavior, yet more evidence in adolescents using objective measurement of food intake is needed.

Adolescence is an important age span for understanding the association between mindfulness and disinhibited eating, particularly in girls. This period is frequently marked by the emergence of and worsening of disinhibited eating (Neumark-Sztainer, Wall, Larson, Eisenberg, & Loth, 2011; Stice, Shaw, & Marti, 2006). Girls, as compared to boys, are also more likely to endorse disinhibited

eating behaviors in some studies (Ackard, Neumark-Sztainer, Story, & Perry, 2003; Neumark-Sztainer et al., 2011) and to have a greater risk for youth-onset T2D (Dabelea et al., 2014). Thus, understanding the relationship of mindfulness to disinhibited eating, especially in adolescent girls at high risk for T2D, has the potential to inform prevention efforts for T2D.

In the current study, we evaluated the association of mindfulness with laboratory eating behavior using two successive standardized, laboratory test meals that assess eating when hungry and EAH. Laboratory test meal studies avoid many of the confounding variables found within self-report, such as under-reporting (Goran, 1998; Lanctot, Klesges, Stockton, & Klesges, 2008; Tanofsky-Kraff, Haynos, Kotler, Yanovski, & Yanovski, 2007; Waling & Larsson, 2009). We anticipated that there would be an inverse relationship between mindfulness and EAH based on the notion that mindfulness encourages noticing, accepting, and differentiating among internal and external experiences (Brown et al., 2007), which may translate to an increased ability to self-regulate eating. Because mindfulness is related to reported LOC-eating patterns (Pivarunas et al., 2015), we sought to determine the relationship of mindfulness to EAH after accounting for LOC-eating, in order to ensure that any identified findings indicated a unique association of mindfulness with EAH. As a secondary objective, we explored the interaction of mindfulness and LOC in the prediction of laboratory eating behavior. Based on previous findings of other variables associated with eating and weight (Kelly et al., 2016; Shank et al., 2015; Stojek et al., 2017), we expected that reported LOC-eating status would exacerbate the inverse association of mindfulness with energy intake, such that being prone to uncontrolled eating in combination with less present-moment awareness would have the strongest effect on EAH. Finally, because attention (or lack of attention) to hunger cues is a key aspect of the conceptual model through which mindfulness regulates eating behavior (Brown et al., 2007; Schachter & Rodin, 1974), we adjusted for hunger state in all models and tested its interactions with mindfulness and LOC-eating.

2. Methods

2.1. Study sample

Participants in this cohort were healthy adolescent (12–17 years) girls recruited through the National Institutes of Health's clinical trials website, local community postings in libraries and supermarkets, direct mailings to area families, and through notices to school parents' listservs in Washington, DC and the greater metropolitan area. Recruitment materials targeted parents of adolescent girls who were concerned about their daughter being at risk for diabetes. All girls were determined to be at risk for T2D by having overweight or obesity (BMI \geq 85th percentile) and having one or more first- or second-degree relative with prediabetes, T2D, or gestational diabetes. Other criteria for study inclusion were mild to moderately elevated depressive symptoms defined as a total score \geq 16 on the Center for Epidemiologic Studies-Depression Scale (Radloff, 1977) and English-speaking. Exclusion criteria included current major depressive disorder or psychiatric symptoms requiring treatment; T2D (fasting glucose $>$ 126 mg/dL, 2-hour OGTT glucose $>$ 200 mg/dL); medication that could affect insulin resistance, body weight, or mood (such as antidepressants, stimulants, or insulin sensitizers); pregnancy; and current participation in weight loss or psychotherapy treatment programs. Adolescents provided written assent and their parents or guardians gave written consent for participation. The study was approved by the Institutional Review Board of the Eunice Kennedy Shriver National Institute of Child Health and Human Development. Adolescents

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