

THESIS

A PILOT STUDY OF A MINDFULNESS-BASED GROUP PROGRAM IN ADOLESCENTS
AT RISK FOR EXCESS WEIGHT GAIN

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ABSTRACT

A PILOT STUDY OF A MINDFULNESS- BASED GROUP PROGRAM IN ADOLESCENTS AT-RISK FOR EXCESS WEIGHT GAIN

There is a cross-sectional and prospective association of depressive/anxiety symptoms with excess weight in adolescents. Theoretically, intervening to decrease mental health symptoms in adolescents at-risk for excess weight gain may offer a novel approach to also decrease the risk for excess weight gain. Mindfulness-based approaches show preliminary promise in adults with obesity and in some adolescent samples; yet feasibility and acceptability in adolescents at-risk for excess weight gain has not been determined. In this study, I examined the feasibility and acceptability of a 6-week mindfulness-based group program in adolescent girls and boys at-risk for excess weight gain, and I explored the effects of participation in a mindfulness-program on perceived stress, depression, anxiety, and body mass index (BMI) indices, as compared to a 6-week health education control group program. Participants were age 12-17 years old and determined to be at-risk for excess weight gain based upon above-average BMI percentile or a strong family history of overweight. Adolescents were assessed at baseline, 6-weeks/post-treatment, and a 6-month follow-up. Fifty-four adolescents were randomized to the mindfulness group program ($n=29$) or the health education control group ($n=25$). In the mindfulness group, participants were on average 13.97 years old, 66% non-Hispanic White, and 90% had overweight or obesity (BMI \geq 85th percentile). In the health education control group, participants were on average 14.49 years old, 72% non-Hispanic White and 84% had overweight or obesity. Feasibility and acceptability were measured by group attendance, homework

completion, and program acceptability ratings. Depression, anxiety symptoms, and perceived stress were measured by validated surveys. Adolescents' median session attendance was six out of six sessions in both the health education group and the mindfulness group. In the mindfulness group, homework completion averaged 63%. In the mindfulness group, 92% thought that the group addressed their concerns, and 100% would recommend the group to others like them. Adolescents randomized to the mindfulness group showed greater decreases in perceived stress at post-treatment than adolescents in the health education group. There were some within-condition changes in key variables, but no other significant between-condition effects at either post-treatment or 6-months follow-up were observed. In conclusion, a relatively brief mindfulness-based group program appears to be feasible and acceptable to adolescents at-risk for excess weight gain. A mindfulness-based training program may offer some acute psychological benefits, particularly in terms of perceived stress. Yet, further research is needed on mindfulness programs for adolescents at-risk for excess weight gain with longer follow-up periods, and also with adolescents with elevated depression and anxiety at baseline.

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Literature Review

Overview: Adolescent Obesity, Depression/Anxiety, and Mindfulness

Obesity in adolescents is highly prevalent, and it is related to serious acute and long-term detrimental health outcomes (May, Freedman, Sherry & Blanck, 2013; Ogden, Carroll, Kit & Flegal, 2012). The prevalence of depression and anxiety symptoms in adolescents also is high, particularly in teenagers at risk for excess weight gain (Neil & Christensen, 2009). Therefore, novel ways of jointly intervening to effectively address these health issues common to teenagers are necessary. Obesity and depression/anxiety are related. Depression and anxiety symptoms are more elevated in adolescents who have excess weight and obesity as compared to adolescents who are lean (Anderson et. al., 2007; Roberts & Duong, 2016), and further, may be important, potentially modifiable determinants of excessive weight gain in a considerable subset of youth (Rofey et al., 2009). The connection between depression/anxiety and excess weight gain in adolescents may offer an important opportunity for coordinated, targeted prevention efforts for both issues.

Obesity is a well-recognized major public health problem among all age groups (May, Freedman, Sherry & Blanck, 2013). There may be some signs of a slowing in the historical rise of obesity in certain demographic groups in the U.S. Unfortunately, adolescent obesity appears to continue to be on the rise (Ogden, Carroll, Kit & Flegal, 2012). Current standard-of-care intervention programs for weight management in adolescents focus on lifestyle changes to diet and exercise. These programs unfortunately are not very effective in the short-term, and long-term effectiveness is not well known (Al-Khudairy et al., 2017; Ho et al, 2012). Most adolescent participants in weight loss treatment interventions lose only a small percentage of excess body

weight. Another big challenge with existing intervention programs is that adolescents commonly gain weight back after programs end (Stice, Shaw & Marti, 2006). While these issues also occur in adult weight management interventions, adolescents with and at-risk for obesity appear to be an especially challenging group to intervene with (Alberga et. al., 2012). In a recent meta-analysis of 44 adolescent studies, weight management interventions that focused on a combination of diet and exercise had low evidence for significant or sustained effects on decreasing BMI (Al-Khudairy et al., 2017). Novel methods for prevention of excess weight gain in adolescents are in high need. By the term “prevention of excess weight gain,” I am referring to both preventing the onset of obesity as well as to preventing continued excess weight gain in youth who already have developed overweight and obesity.

One potential shortcoming of traditional lifestyle approaches to weight management is the assumption that “one size fits all” (Austin, Field, Wiecha, Peterson & Gortmaker, 2005). Such approaches typically do not address the comorbid mental health symptoms, including depression and anxiety, which are common in heavier youth (Anderson et al., 2007). Depression and anxiety symptoms may interfere with the success of making lifestyle changes (Neil & Christensen, 2009), and in and of themselves may contribute to excess weight gain in adolescents (Rofey et al., 2009). Therefore, interventions that address depression and anxiety symptoms in adolescents at risk for excess weight gain could potentially lead, simultaneously, to both mental health benefits and to prevention of excessive weight gain.

Mindfulness-based training is gaining traction in adolescents for its potential benefits in increasing essential self-regulatory skills that play a critical role in dealing with negative emotions such as depressed affect, managing anxiety and stress, and engaging in health behaviors relevant to weight gain (Jordan, Wang & Donatoni, 2014). Theoretically,

mindfulness-based interventions have been posited to enhance coping skills for dealing with stressors, and consequently, decrease symptoms of depression and anxiety, which in turn, potentially lessen excess weight gain as adolescents grow. Yet, much of what we know about the link between mindfulness and obesity is through studies with adults. To what extent mindfulness-based programming is feasible and acceptable to adolescents at risk for excess weight gain is not clear. There is also a lack of randomized controlled trials studying the efficacy of mindfulness-based training in adolescents generally and on weight outcomes particularly. Therefore, the purpose of this study was to conduct a randomized controlled pilot trial with the following aims: (1) determine the feasibility and acceptability of mindfulness-based group program in adolescents at risk for excess weight gain and (2) estimate the efficacy of a mindfulness-based group program for (2a) decreasing depression and anxiety symptoms and (2b) lessening excess weight gain in adolescents determined to be at risk for excess weight gain.

In the following sections of the introduction and background, I provide further detail on existing interventions focused on excess weight gain prevention and weight management in adolescence and challenges of these programs. Next, I review depression and anxiety in adolescence and the connection between these symptoms and obesity. I then review current literature on mindfulness in adolescence and the growing body of literature on mindfulness interventions to address obesity in adulthood. Finally, I wrap up the introduction with a rationale for the current study, aims, and hypotheses.

Current Interventions to Address Excess Weight Gain in Adolescents

Traditional interventions to address excess weight gain focus on teaching adolescents to eat healthier and to increase physical activity. Many existing excess weight gain prevention programs have been implemented in schools (Austin, Field, Wiecha, Peterson & Gortmaker,

2005). School-based interventions have typically been used because of advantages of more easily reaching adolescents, who spend a considerable amount of time at school and also eat one or two meals at school five days per week. However, unfortunately these programs are highly inconsistent in terms of the effects on weight outcomes and do not typically show long-term effects. Adolescents are likely to revert to unhealthy eating habits and sedentary behaviors shortly after programs end (Khambalia, Dickinson, Hardy, Gill & Baur, 2011). One likely explanation is that a “one size fits all” approach to excess weight gain prevention fails to address the heterogeneity of factors that drive excess weight gain and interventions that work for adolescents who have obesity (Field, Camargo, & Ogino, 2013). In particular, the reasons that adolescents overeat are varied, as is the control that they perceive that they have over their health behavior (Field, Camargo, & Ogino, 2013).

One overlooked factor that may differentiate a subgroup of teens at risk for excess weight gain is internalizing symptoms of depression and anxiety. Depression and anxiety commonly overlap (Neil & Christensen, 2009), are highly prevalent in adolescents (Corrieri et al. 2014), and may underlie excess weight gain through mechanisms such as overeating in an effort to cope with emotional distress (Ranzenhofer et al., 2013). Most lifestyle-focused programs for excess weight gain prevention do not address these underlying psychological symptoms. Likewise, traditional lifestyle-based interventions may lack sufficient content on self-regulation skills, which are important for stress management, emotion regulation, and health behaviors including emotionally-induced overeating patterns.

Depressive and Anxiety Disorders in Adolescence

The onset of major depressive disorder, a full-syndrome clinical disorder in the Diagnostic and Statistical Manual for Mental Disorders, Fifth Edition (DSM-5; American

Psychiatric Association, 2013), typically occurs during the adolescent years, with 20% of adolescent females developing major depressive disorder at some point during adolescence (Lewinsohn, Rohde & Seeley, 1998; Rohde et al, 2013). Females have a higher occurrence of reporting clinically elevated depression symptoms than males, with approximately a 2:1 ratio (Birmaher et al. 1996; Corrieri et al. 2014; Saluja, et al. 2004). Depression is one of the most common reasons for adolescents' use of mental health services, yet symptoms often go unnoticed and untreated (Wu et al., 1999). The high occurrence and detrimental outcomes of depressive disorders in adolescence make preventative intervention vitally important; adolescents who are clinically depressed are at risk for self-harm and suicide (Fergusson & Woodward, 2002). Adolescents with major depressive disorder suffer from significant impairment in important life domains, including social relationships, academic achievement, and physical health (Fergusson & Woodward, 2002). They are also more likely to engage in substance use than their peers who are not suffering from depression (Johnson, Burke, Brinkman & Wade, 2016; Merry et al., 2012). Major depressive disorder in adolescence, particularly when untreated, heightens the risk of having recurrent episodes of depression in adulthood (Birmaher et al. 1996; Corrieri et al. 2014).

Depressive disorders frequently co-occur with anxiety disorders (Corrieri et al, 2014; Neil & Christensen, 2009). Adolescence is a sensitive time period for anxiety disorders. Anywhere from 6% to 31% of adolescents experience a full-syndrome DSM-5 anxiety disorder by the age of 18 years (Corrieri et al., 2014; Merikangas et al., 2010; Woodward & Fergusson, 2001). The onset of most anxiety disorders is during childhood and adolescence, and similarly, the majority of adults who report anxiety symptoms also experienced symptoms as adolescents (Merikangas et al., 2010; Woodward & Fergusson, 2001). Adolescents with an anxiety disorder

not only suffer direct impairment from their anxiety, but they also are at risk for depression, suicidal ideation, substance abuse problems, early pregnancy, as well as being at an increased risk for continuing to have an anxiety disorder into adulthood (Beesdo, Knappe, & Pine, 2009; Woodward & Fergusson, 2001). The origins of adolescent anxiety in some cases can be traced back to various anxiety disorders in childhood, including social phobia and separation anxiety. However, full-syndrome generalized anxiety disorder, which affects about 3% of adolescents (Burstein et al., 2014), may develop in adolescence with no prior childhood anxiety symptoms (Rapee, 1991; Rapee, Schniering & Hudson, 2009).

Subthreshold Symptoms of Depression and Anxiety in Adolescence

Over and above the adolescents who develop major depressive disorder at some point in the second decade of life, another 10-25.9% of adolescents in community-based samples have elevated symptoms of depression without meeting criteria for major depression (Cuijpers, Graaf & Dorsselaer, 2004; Kessler, Zhao, Blazer & Swartz, 1997; Lewinsohn et al, 2004). Large community-based samples of adolescents suggest that approximately 16-18% of adolescents endorse subthreshold anxiety (Lewinsohn et al, 2004; Shankman et al., 2009). In a 15-year study of 1505 adolescents who were in high school at baseline, subthreshold depression, anxiety, alcohol and conduct symptoms each significantly predicted the development of their respective full-syndrome disorder over the follow-up period, underscoring the potential to prevent worsening of socio-emotional and behavioral symptoms by intervening with subthreshold symptoms during adolescence (Shankman, Lewinsohn, Klein, Small, Seeley & Altman, 2009). Adolescents who have elevated symptoms of depression and/or anxiety are at an increased risk for a host of later full-syndrome mental health disorders (Cuijpers, Graaf & Dorsselaer, 2004; Fergusson, Horwood, Ridder, & Beautrais, 2005). Most adolescents with subthreshold

depression and anxiety symptoms do not receive any intervention, putting them at risk for later adverse outcomes. Indeed, subthreshold elevated symptoms of depression in adolescents have very similar negative outcomes as adolescents who have been diagnosed with a depressive disorder (Cuijpers, Graaf & Dorsselaer, 2004; Fergusson, Horwood, Ridder & Beautrais, 2005; Gonzalez-Tejera, 2005). Thus, intervening to address subthreshold depressive and anxiety symptoms in adolescents would benefit teens' current functioning and also have the potential to improve longer-term mental health outcomes.

Associations Between Adolescent Depression/Anxiety and Obesity

There is a cross-sectional association between depression/anxiety symptoms and body weight in adolescents. Adolescents who have overweight and obesity frequently report more symptoms of depression and anxiety than their peers who are lean (Eddy et al., 2007; Goodman & Whitaker, 2002). As compared to adolescents who are lean, adolescents with overweight and obesity also appear to have a greater risk of suffering from major depressive disorder or an anxiety disorder (Anderson et al., 2007). The connection between internalizing symptoms of depression and anxiety and body weight in adolescents likely operates bi-directionally. On the one hand, adolescents who struggle with excess weight or obesity frequently experience teasing, bullying, and stigmatization, which purportedly puts them at risk for poor body image, low self-esteem and self-appraisal, increasing their risk of developing depression and anxiety (Anderson et al., 2007; Roberts & Duong, 2015).

Conversely, there are also data supporting the notion that depression and anxiety symptoms are prospective risk factors for excess weight gain in adolescents. Both subthreshold depression and anxiety symptoms predict more excess gains in body mass index (BMI) percentiles among youth ages 8-18 years as they grow (Rofey et al., 2009). In adolescent boys,

having an anxiety disorder was associated with a 46% higher likelihood of developing obesity than adolescent boys not diagnosed with an anxiety disorder (Roberts & Duong, 2016), though the same effect was not observed in girls. Collectively, the data lend support to recognizing the long-term impacts of depression and anxiety symptoms in adolescence and the importance of addressing both mental health and excess weight gain in adolescence.

Depression and anxiety symptoms theoretically may lead to excess weight gain through a number of different mediators that are not yet thoroughly understood. One central notion is that the connection between such symptoms and weight gain may be explained by how a person processes stress exposure. Depression and anxiety relate to an individual's ability to respond to and cope with stressors. Depression and anxiety have been related to negative coping strategies, including lack of physical activity and overeating, which both promote a positive energy balance (Daubenmier et al, 2011). Anxiety sensitivity, referring to a fear of anxiety and the belief that anxiety has negative consequences, is correlated with greater calorie consumption and less physical activity, as measured by an accelerometer worn by participants for a three-day period (Hearon, Quatromoni, Mascoop, & Otto, 2014; Roberts & Duong, 2016).

Emotional Eating as an Explanatory Mechanism

Available data provide a strong case that depression and anxiety symptoms are related, in particular, to overeating patterns in response to negative emotions that are promoting of excess weight gain (Mooreville et al., 2014; Ranzenhofer et al., 2013). Emotional eating, referring to consuming foods in response to negative feelings, is typically characterized by consuming high-fat, high-sugar low nutrition foods. Typically, when an individual eats in response to emotions, as opposed to physiological hunger, s/he both eats an increased amount of food and consumes foods that are less nutritious. While turning to food to cope may initially occur because the

intake of palatable food is physiologically pleasing (Ranzenhofer et al., 2013), the mood-enhancing aspect of emotional eating diminishes over time, increasing the likelihood and frequency of loss-of-control or binge eating (Eddy et al., 2007). Adolescents who engage in emotional eating in response to stress are more likely to use emotional eating as a coping strategy when they perceive stress (Nguyen-Rodriquez, Chou, Unger, & Spruit-Metz, 2009). In a study of above-average weight girls with a propensity for loss-of-control eating, negative affect prior to a laboratory test meal related to girls' greater consumption of carbohydrates, sugary foods, and less intake of protein (Razenhofer et al., 2013). In adolescents who experience loss-of-control episodes over their eating, frequency of emotional eating is related to more excessive weight and body fat gains over time (Stojek et al., 2016). Life stressors, including weight-related teasing and other interpersonal daily hassles such as fighting with a family member, positively relate to disordered eating in adolescents seeking weight management intervention (Gerke et al., 2013).

Together, these studies highlight the potential importance of addressing psychological components that may be contributing to excess weight gain through their impact on disordered and overeating patterns. In theory, insufficient and ineffective coping skills to deal with the daily stressors and major negative events in their lives – such as bullying, other stressful social interactions/events, and school demands – are posited to be an important factor in triggering adolescents to engage in emotional eating, in turn, leading to excess weight gain. As such, interventions that specifically address adolescents' "inner world," promote better stress management, and enhance self-regulation and decision-making may be especially suitable to reduce depressive/anxiety symptoms as underlying drivers of excess weight gain in adolescents who are at risk for excess weight gain. Mindfulness-based interventions may offer this opportunity.

Defining Mindfulness

Mindfulness is a multi-faceted construct that involves in-the-moment, nonjudgmental awareness, characterized by paying attention in a specific way, as non-reactively and non-judgmentally as possible (Kabat-Zinn, 2015). Mindfulness refers to awareness of what thoughts, emotions, and sensations are occurring within the body at any given moment (Creswell, 2017). Mindfulness can be trait-like, in that it is an enduring, stable characteristic. However, mindfulness can also be malleable, learned, and practiced, and for most people in modern times, there is a need to learn and practice it to be refined (Kabat-Zinn, 2015). Mindfulness-based training has been developed to not only increase present-moment, non-judgmental attention, but such training may translate into stress reduction by fostering more effective coping practices (Creswell, 2017). By concentrating one's attention on a central element (such as breathing) that is occurring in the present moment, the thoughts, feelings, and bodily sensations centered around emotional or physical ailments or other aspects of one's experience leading to pain or distress can be alleviated. In terms of depression and anxiety specifically, the non-judgmental attitude central to mindfulness is thought to be vital in combating the negative thinking and rumination that are common to the initiation and maintenance of depression and anxiety symptoms (Creswell, 2017). In addition, in contrast to other approaches (e.g., cognitive-behavioral therapies) to intervening with depression and anxiety symptoms, mindfulness uniquely focuses on the body, with attention to where stress manifests in the body, and involves practices that alleviate physiological and psychosomatic distress. Additionally, mindfulness techniques may have positive effects in domains such as ruminative thought, cognitive appraisal, and positive shifts in metacognition (Epel, Daubenmier, Moskowitz, Folkman & Blackburn, 2009).

Dispositional mindfulness in adults has been shown to be inversely related to eating behaviors that may contribute to obesity, such as loss-of-control eating and eating in response to stress (Jordan, Wang & Donatoni, 2014). Although less data have been evaluated in adolescents, dispositional mindfulness in adolescents with overweight and obesity was inversely related to the odds of having reported loss-of-control eating (Pivarunas et al., 2015). Also, dispositional mindfulness related inversely to eating in the absence of hunger, measured objectively with a laboratory test meal, such that the more dispositionally mindful adolescents were, the more their food intake was governed by physiological hunger cues (Annameier et al., 2018).

Given the relationship of mindfulness to overeating patterns, mindfulness-based interventions for adolescents at risk for excess weight gain are anticipated to lessen excess weight gain by encouraging adolescents to slow down, notice when they may be overeating when they are not hungry, and choose healthier coping skills for managing stress or negative affect. Mindfulness also may, more generally, provide adolescents with more opportunities to attend to the hassles that they are dealing with in their daily lives, the impact the hassles have on their bodies, minds, and emotions, and to develop coping skills that may work more effectively for them.

Mindfulness-based Interventions for Overeating and Obesity

Mindfulness-based stress reduction (MBSR) is a mindfulness program that was developed for adults to increase awareness around emotional stress and the negative behaviors that can occur in response to stress, as well as how to practice mindfulness to more effectively respond to stressors (Daubenmier et al., 2011; Kabat-Zinn, 2011). MBSR was originally implemented in adults with chronic pain and other medical problems; however, adaptations of

MBSR have been more recently used in a number of studies to address overeating patterns and obesity in adults, with some promising preliminary results.

Daubenmier et al. (2011) conducted a small randomized controlled pilot trial to evaluate the effects of a 4-month mindfulness program on stress eating as compared to a waitlist control group in generally healthy women with overweight and obesity. Participation in the mindfulness-based intervention led to maintenance of weight at post-intervention, while those in the waitlist control group tended to gain weight. Also, intervention participants who reported the greatest increases in mindfulness after the intervention, by noticing their body sensations and paying greater attention to chronic stressors, also showed the largest decreases in abdominal fat (Daubenmier et. al. 2011). In a separate randomized controlled trial in adults with binge eating disorder, Kristeller, Wolever and Sheets (2013) found that a 12-week adaptation of MBSR, mindfulness-based eating awareness training (MB-EAT), more significantly decreased binge eating episodes over the 12-week treatment program as compared to both a psychoeducational/cognitive-behavioral intervention and to a waitlist control condition. Ninety-five percent of participants who were in the MB-EAT group no longer met criteria for binge eating disorder at 4 months follow up after the intervention, compared to only 76% in the comparison intervention and participants in the MB-EAT condition had significantly smaller binges when the binges did occur. The MB-EAT condition focused on helping participants become more aware of emotional triggers, the sensations of fullness and emptiness, and their body sensations generally, through guided mindfulness sessions (Kristeller, Wolever, & Sheets, 2013).

Mindfulness-based interventions have shown preliminary efficacy in a variety of populations of adults who have overweight or obesity, including those with type 2 diabetes,

community members looking for general stress reduction, and individuals who have had bariatric surgery (Katterman et al., 2014). In a meta-analysis of 15 studies investigating mindfulness-based interventions for weight loss and weight management, it was concluded that mindfulness-based interventions improved eating behaviors in adults with overweight or obesity (Rogers, Ferrari, Mosely, Lang & Brennan, 2016). This meta-analysis also found a moderate effect size of mindfulness-based interventions on depression, anxiety, and eating attitudes (Rogers et al., 2016). Similarly, mindfulness-based interventions for adults have also been shown to decrease impulsive eating behaviors and binge eating episodes in adults with overweight and obesity and to have a positive effect on physical activity levels (O'Reilly, Cook, Spruijt-Metz & Black, 2014; Ruffault et al., 2016).

Very little data have evaluated mindfulness-based interventions for eating or weight-related outcomes in adolescents. In one small feasibility study with adolescent Latina girls with a BMI at the 90th percentile and above, participants were randomized to a six-week mindfulness-based eating intervention or a usual care nutrition and exercise information condition (Daly et al., 2016). Participants in the mindfulness-based eating intervention met for 90-minute sessions after school. Only 57% of the mindfulness-based condition and 65% of the comparison group persisted in the program. Among those who did persist, participants in the mindfulness-based program showed lower BMI at the end of the intervention as compared to the control comparison, both at the conclusion of the programs and at a four-week follow up after the completion of the program, or 10 weeks into the intervention (Daly et al., 2016). This study indicates promising results for the receipt of mindfulness-based interventions in adolescents with overweight and obesity, however the low retention in the program leaves open the question of

whether mindfulness-based interventions are feasible and acceptable to adolescents at risk for excess weight gain.

In theory, a mindfulness-based therapeutic approach potentially may reduce overeating by helping individuals to become more aware of what they are eating and what emotions may be accompanying this eating. The existing results suggest that enhancing mindfulness may make an individual more aware of their eating patterns and stress, which may over time help to decrease excess weight by eating more mindfully and having less emotional eating. Adolescence is a particularly vital time to intervene for a variety of reasons. Adolescence is a dynamic developmental period with large hormonal, physical, social and cognitive changes (Crone & Dahl, 2012). Frequently, exercise and eating behaviors that are developed in adolescence continue throughout adulthood (Lawlor & Chaturvedi, 2006). Adolescence is also a sensitive period to intervene for mental health symptoms, as development of depression and anxiety during this time period is a predictor of later depression and anxiety (Fergusson, Horwood, Ridder & Beautrais, 2005).

Mindfulness-based Programs for Depression/Anxiety

Consistent with extant data in adults (Mackenzie & Kocovski, 2016), mindfulness-based programs in adolescents have been shown to lessen depression and anxiety symptoms in a series of studies (Biegel et al., 2009; Bluth et al., 2016; Shomaker et al., 2017; Sibinga et al., 2016; Tan & Martin, 2015). A small number of randomized controlled trials have shown that mindfulness-based programs acutely lessen depression and anxiety symptoms and improve general mental health and self-esteem in adolescents (Biegel et al., 2009; Bluth et al., 2016; Shomaker et al., 2017; Sibinga et al., 2016; Tan & Martin, 2015), in comparison to usual care and active comparison conditions. However, research is still somewhat limited on follow-up, beyond

immediate post-intervention, to mindfulness interventions for adolescents, and even more limited in adolescents who are at risk for excess weight gain.

Feasibility and Acceptability for Adolescents At Risk for Excess Weight Gain

The feasibility and acceptability of mindfulness-based program remain to be determined in adolescents at risk for excess weight gain for a number of reasons. Past research of even relatively brief mindfulness programs in heavier adolescents suggests attendance may be inadequate (Daly et al., 2016). Aspects of mindfulness focus on body awareness, which is intended to reduce stress by increasing attention to the body's arousal signals and by learning skills (e.g., breathing, body scan) that decrease physiological and mental stress and tension (Creswell, 2017). However, adolescents with excess weight report more body dissatisfaction than lean adolescents (Alberga et al., 2012), suggesting that a focus on the body could present some challenges to acceptability in heavier participants. Similarly, to what extent the more abstract and cognitive-complex aspects of mindfulness-based training resonates with adolescents has been questioned (Johnson et al., 2017). Thus, direct tests of feasibility and acceptability in this specific population are required.

Current Study

The directionality of the relationship between adolescent depression and anxiety symptoms and weight gain is complex. Yet, extant data support the likelihood that depressive and anxiety symptoms contribute to excess weight gain in developing youth. Mindfulness-based interventions with adolescents have not been widely studied, however promising preliminary results support reductions in depression/anxiety symptoms in community-based and clinical samples of adolescents (Biegel et al., 2009; Bluth et al., 2016; Shomaker et al., 2017; Sibinga et al., 2016; Tan & Martin, 2015). Moreover, mindfulness-based interventions in adults with overweight and obesity have shown promising results in terms of decreasing binge-eating and impulsive eating behaviors (Katterman et al., 2014; O'Reilly, et al., 2014; Rogers et al., 2016; Ruffault, 2016).

Offering a mindfulness-based intervention to adolescents at risk for excess weight gain has not been evaluated. Theoretically, mindfulness-based skills might decrease the depressive/anxiety symptoms that are more elevated in heavier, versus leaner, adolescents (Daly et al., 2016) and help adolescents to gain more self-regulation and control over their eating habits, especially emotional eating, that may promote excess weight gain (Eddy et al., 2007; Nguyen-Rodriquez et al., 2009). The purpose of the current thesis project was to conduct a preliminary analysis of data from an existing randomized controlled pilot trial evaluating a brief mindfulness-based program for prevention of excess weight gain in adolescents at risk for excess weight gain. Specifically, I aimed: (1) to examine the feasibility and acceptability of a mindfulness-based group program in adolescent girls and boys who were at risk for excess weight gain and (2) to explore the efficacy of a mindfulness-based program compared to a health

education control group on decreasing perceived stress, depression and anxiety symptoms, and lessening excess weight gain. I hypothesized that the program would be feasible and that adolescents would perceive the program as acceptable. I also anticipated that adolescents in a mindfulness-based program would show a pattern toward greater decreases in perceived stress, depression and anxiety symptoms, and less BMI gain as compared to health education.

Method

Participants

Participants were recruited for a randomized controlled trial that was designed to pilot a mindfulness-based group program for the prevention of excess weight gain in adolescents at risk for excess weight gain. Participants were recruited from the Fort Collins and surrounding northern Colorado communities using flyers in schools and other community areas, letters to parents and physicians, information sessions at schools, and advertisements on the radio and in newspapers. Recruitment materials targeted adolescents who may be at risk for gaining too much weight and adolescents who felt stressed, to take part in a group program for lowering the chances of gaining too much weight. Participants were 12-17 year girls and boys determined to be at risk for excess weight gain by either having an above-average BMI, defined as equal to or exceeding the 70th percentile for age and sex, or having two biological parents with overweight, assessed as parent-reported BMI (kg/m²) value of 25 or greater. The link between an adolescent having two overweight parents and their own risk for excess weight gain has been well established (Davidson, Krahnstoever & Lipps, 2002; Garn, Sullivan & Hawthorne, 1989; Maffeis, Talamini & Tato, 1998). Participants were excluded if they had a major medical condition or were taking medication known to affect appetite, mood, or weight, such as stimulants, anti-depressants, or insulin sensitizers. They also were excluded and provided with referrals if they reported a current full-syndrome psychiatric disorder that, in the opinion of the investigators, necessitated more intensive treatment and/or would interfere with study compliance.

Procedure

Following an initial phone screen to determine possible eligibility, participants and their parents/guardians were seen for an initial screening visit at Colorado State University. At the laboratory screening appointment, participants' BMI was determined, they completed surveys and underwent a psychological interview, and a medical history was completed with the participant's parent. Adolescents who were eligible after the screening appointment were randomized to a six-session mindfulness-based group program or a six-session health education comparison group program. Following the interventions, participants were evaluated for an immediate post-intervention follow-up and a six-month follow-up. At post-intervention, adolescents completed an acceptability questionnaire. At both the post-treatment and six-month follow-ups, body measurements and assessments of psychological symptoms were repeated. The following specific measures were used.

Measures

Depressive symptoms. To assess adolescent depressive symptoms, participants completed at baseline, post-treatment, and six-month follow-up, the Children's Depression Inventory (CDI). The CDI is a 27-item questionnaire that evaluates depressive symptoms during the past 2 weeks. Each item is rated on a scale from 0-2, with higher scores indicating more severe depressive symptoms (e.g.: "I feel like crying everyday, I feel like crying many days, or I feel like crying once in a while") (Kovacs & Beck, 1977). The CDI is a commonly used continuous measure of depressive symptoms, and it has been shown to have good reliability (Smucker, Craighead, Craighead & Green, 1986).

Anxiety symptoms. At all intervals, participants completed the State Trait Anxiety Inventory for Children-Trait Version (STAI-C). This 20-item scale assesses anxiety symptoms on a Likert scale ranging from, *1 (never)* to *5 (very often)*. The total score ranges from 20 and 100, and is calculated as a sum of all items, with higher scores indicating higher levels of trait anxiety (Spielberger, Edwards, Montuori & Lushene, 1973).

Full-syndrome psychopathology. At the baseline screening visit, the Schedule for Affective Disorders and Schizophrenia for School-Age Children (K-SADS PL) was administered to rule out the presence of a full-syndrome psychiatric disorder by a trained interviewer. If a full-syndrome psychiatric disorder was present, participants were excluded from the study and a referral was provided. The K-SADS PL is a semi-structured interview to detect the presence or absence of 32 DSM-IV diagnoses. Interviewers score each diagnosis as definite, probable, or not present. Participants are asked about current symptoms, as well as past episodes in each of the following diagnostic supplements: affective disorders, psychotic disorders, anxiety disorders,

behavioral disorders and substance abuse, eating and tic disorders. Interviewers score each response on a scale ranging from 1 to 3, with *1 indicating symptom is not present, 2 subthreshold levels of symptomology, and 3 indicating threshold criteria* (Kaufman et al., 1997).

Perceived stress. To assess participants' current level of stress that they perceived in their lives, adolescents completed the 10-item Perceived Stress Scale, with questions such as, "In the last month, how often have you found that you could not cope with all the things that you had to do?." Items were rated on a 5-point Likert scale that ranged from "Never" to "Very Often." The total summed score is calculated with higher scores reflecting greater levels of perceived stress (Cohen, Kamarck & Mermelstein, 1994). This measure has good psychometric properties and has been used extensively in adolescent samples (Roberti, Harrington & Storch, 2006).

Body composition. At the baseline/screening, post-intervention follow-up, and six-month follow-up, participants' fasting weight was measured by digital scale, and their height was collected in triplicate by stadiometer and averaged. These measures were used to compute BMI as weight (kg) divided by the square of height (m) and then converted to a standardized BMI z-score and BMI percentile for age and sex.

Feasibility and acceptability. Feasibility was conceptualized as program attendance equal to or exceeding 80% of the program (5 of 6 sessions). At the post-intervention assessment, an acceptability questionnaire was administered to participants to evaluate their attitudes about the program. The post-intervention assessment included a series of questions about adolescents' perceived support from facilitators and from other group members, perceived health and mood benefits, and perceived comfort of participating in the group.

Interventions

Following eligibility determination and the collection of baseline assessments, participants were randomized to either a six-week mindfulness-based program or a six-week health education control group. Eligible participants were randomized, stratified by sex and BMI percentile. Girls and boys were studied together in mixed-sex group sessions that ranged from 3 to 7 adolescents within each mindfulness or health education group. Mindfulness and health education groups were run in parallel.

Mindfulness-based Group Program

Adolescents randomized to the mindfulness-based group program met once per week for six weeks. Sessions were one-hour in length, and the intervention was based on an adolescent mindfulness curriculum, Learning to BREATHE (Broderick, 2013). The Learning to BREATHE curriculum bases each of the six weeks of the program on the acronym BREATHE: Body awareness, Reflections: understanding and working with thoughts, Emotions: understanding and working with feelings, Attention: integrating awareness of thoughts, feelings, and bodily sensations, Tenderness: reducing harmful self-judgments, Healthy habits: integrating mindful awareness into daily life, to achieve the overall goal of Empowerment (Broderick, 2013). While the original manual contains multiple exercises to choose from within each content area, in the current study, the same exercises were administered consistently as part of a manualized program developed by the research team (Shomaker et al., 2017). The content was not modified specifically for weight and eating-related issues, other than providing a brief rationale in session one to explain the notion that mindfulness practices may be helpful for leading a healthier life and having a lower chance of gaining too much weight as teens grow. Adolescents participated

in traditional mindfulness-based exercises including breath and body awareness, mindful eating, and loving kindness meditations, and they were given brief homework assignments to complete between sessions.

Homework was assigned to participants to help them learn to practice skills at home and apply them to their daily lives. Homework was expected to take about 10 minutes per day. Facilitators asked participants about completion of the homework at the following session and rated the percent of homework completed at sessions two through six based on participant self-report. The group was co-facilitated by two graduate students in Marriage and Family Therapy, who received weekly supervision through audio-recorded sessions from a licensed child clinical psychologist.

Health Education Comparison Group Program. The health education comparison group program was made up of six one-hour sessions co-facilitated by two graduate students in Food Science and Human Nutrition, Public Health, or Prevention Science. This didactic curriculum was drawn from a health education program called “Hey Durham” (Bravender, 2005). Sessions incorporated a variety of teaching methods including handouts, videos, and presentations. Sessions focused on six topics, which included alcohol and drug use, nutrition and body image, domestic violence, sun safety, exercise, and identifying major depressive disorder as well as suicide risk. No direct counseling was provided, and referrals were provided if suicidal ideation or other mental health concerns emerged during the program. Homework was not assigned in health education.

Data Analysis Plan

Independent samples t-test and chi-square were used to compare baseline characteristics of adolescents randomized to the mindfulness-based group program or to the health education control group program. To analyze feasibility and acceptability (Aim 1), median session attendance was compared with a non-parametric test by condition (mindfulness versus health education). I also generated descriptive information about average homework completion in the mindfulness group. Independent samples t-test and chi-square were used to compare program acceptability ratings by condition. To address exploratory outcomes (Aim 2), a series of analysis of covariance (ANCOVA) were conducted with the dependent variable being change from baseline to post-intervention or change from baseline to six-month follow-up in (i) depressive symptoms, (ii) anxiety symptoms, (iii) perceived stress, and (iv) BMI metrics (percentile, z-score, and kg/m^2). The covariates in all models were baseline age, sex (male, female), race/ethnicity (non-Hispanic White vs. Other), and the baseline level of the change score (i.e., baseline depressive symptoms, anxiety symptoms, perceived stress, or BMI metric) so that the group effect on change could be determined after accounting for the level at which participants' began the study. I also conducted paired samples t-tests within condition for all key variables to describe whether the unadjusted values at baseline and post-intervention and the unadjusted values at baseline and six-months follow-up were significantly different (i.e., significantly changed over time within condition). Based on previous pilot trials, I estimated that a recruitment goal of $N = 50$ (assuming 20% attrition at six-months) would be adequate for the purposes of this pilot study to evaluate feasibility/acceptability and to estimate effects.

Results

Study Flow and Baseline Characteristics

Figure 1 contains the entire study flow. An initial 556 people were contacted by the study team. We conducted screening visits with 84 participants. Of those who came to a screening visit, 54 were eligible and randomized to the mindfulness-based program ($n = 29$), or Health Education group ($n = 25$). Table 1 shows descriptive characteristics of the participants by group assignment. There were no significant baseline differences in participant age by condition; adolescents in the mindfulness group were on average 13.97 (SD = 1.42) years old, and adolescents in the health education group were on average 14.49 (SD = 1.72) years old ($p = .23$). Participants were primarily non-Hispanic White in both the mindfulness-based group and health education group, 66% versus 72% non-Hispanic White in mindfulness and health education, respectively ($p = .61$). At baseline, the vast majority of adolescents had overweight or obesity in both the mindfulness condition (90%) and in the health education condition (84% $p = .63$). There were no significant differences between group conditions in BMI metrics, depression or anxiety symptoms, or perceived stress (all p -values $> .23$).

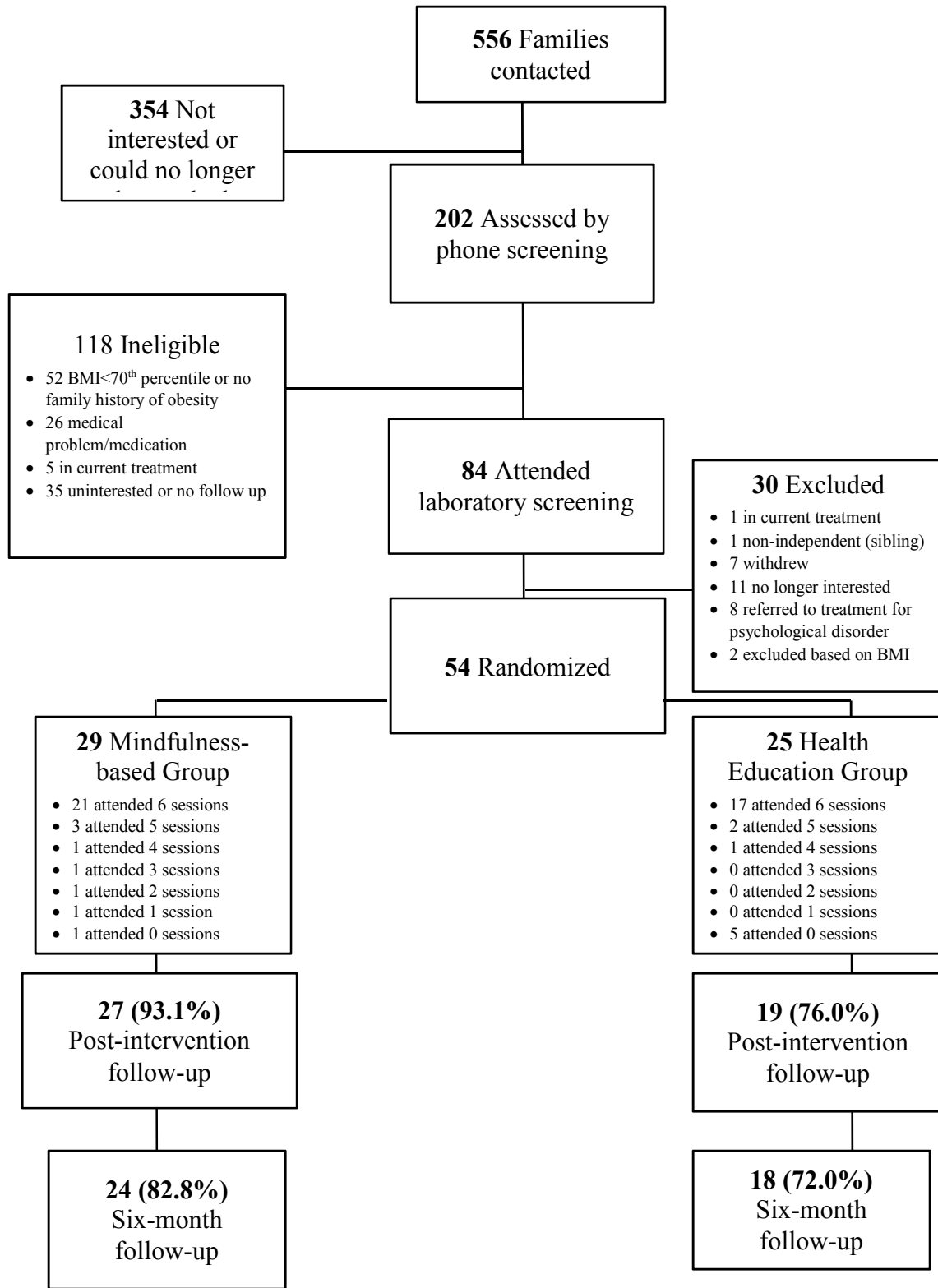


Figure 1. Study flow

Table 1. Descriptive characteristics of adolescents who participated in the mindfulness-based group and health education group at baseline, post-intervention, and six-month follow-up

	Mindfulness-based Group			Health Education Group		
	Baseline	Post- intervention	Six-month Follow-up	Baseline	Post- intervention	Six-month Follow-up
Female, % (<i>n</i>)	55.2 (16)	--	--	56.0 (14)	--	--
Race/ethnicity, % (<i>n</i>)		--	--		--	--
Non-Hispanic	65.5 (19)	--	--	72.0 (18)	--	--
White						
Hispanic	27.6 (8)	--	--	28.0 (7)	--	--
American Indian	3.4 (1)	--	--	0 (0)	--	--
Asian	3.4 (1)	--	--	0 (0)	--	--
Age, y	13.97 (1.42)	--	--	14.49 (1.72)	--	--
BMI, kg/m ²	27.28 (4.47)	27.49 (4.95)	28.23 (4.74)	27.48 (5.39)	27.60 (5.62)	29.29 (7.11)
BMI, percentile	92.69 (7.59)	90.66 (13.18)	91.20 (13.23)	89.30 (16.31)	88.15 (19.31)	88.28 (20.11)
BMI z-score	1.62 (0.49)	1.58 (0.63)	1.64 (0.64)	1.53 (0.74)	1.49 (0.84)	1.58 (0.91)
Depressive symptoms	13.75 (7.80)	9.37 (8.18)	10.21 (6.26)	12.0 (6.70)	10.68 (7.33)	9.50 (7.80)

Anxiety symptoms	35.24 (9.18)	29.48 (7.67)	32.17 (9.10)	34.08 (8.03)	30.21 (7.96)	31.06 (6.93)
Perceived stress	25.38 (6.84)	22.50 (7.17)	23.68 (8.70)	25.08 (6.54)	24.68 (6.23)	21.24 (6.86)

Values displayed are unadjusted means (standard deviations) unless otherwise noted as a percentage. Depressive symptoms were assessed with the Children’s Depression Inventory (CDI). Anxiety symptoms were assessed with the total summed score of the State Trait Anxiety Inventory for Children-Trait Version (STAI-C). Perceived stress was assessed with the total summed score of the Perceived Stress Scale.

Aim 1: Feasibility and Acceptability

Feasibility was determined as average attendance of at least five of six possible sessions, or 80% of the program. In both the mindfulness-based group and the health education group, median session attendance was six sessions. Median session attendance did not differ by group condition ($p = .29$). Prior to group initiation and to knowing their group assignment, five participants from the health education group dropped out of the study due to scheduling conflicts, and one participant withdrew, prior to knowing their group assignment, who had been randomized to the mindfulness-based group condition.

Homework completion among adolescents who were randomized to the mindfulness-based intervention averaged 63% (SD = 22.66%) as rated by self-report of participants and tracked by group facilitators at sessions. Homework completion ranged from 0%-100% across adolescents throughout sessions one to six.

Table 2 displays program acceptability ratings of adolescents in the mindfulness-based group and the health education group conditions. Ratings were generally positive for acceptability, with a few significant differences by condition. Participants rated how supported they felt by group leaders as 3.96 (SD = .60) on a scale of 1 = “*Definitely not*” to 5 = “*Definitely yes*” in the mindfulness-based program and as 4.32 (SD = .48) in the health education control group ($p = .04$). Similarly, participants in the health education group rated perceived helpfulness of their group leaders on average as 4.53 (SD = .51) on a scale of 1 = “*Not at all helpful*” to 5 = “*Extremely helpful*,” whereas adolescents in the mindfulness group perceived helpfulness of group leaders as 3.88 (SD = .99; $p = .01$). Additionally, participants in the health education group as compared to the mindfulness based group tended to report greater comfort to open up within

group (3.11 (1.11) versus 3.68 (1.00), $p = .08$) on a scale of 1 = “Not at all comfortable” to 5 = “Extremely comfortable.”

Table 2. Program acceptability ratings of adolescents who participated in the mindfulness-based group and health education group

Item	Mindfulness	Health Education	<i>p</i>
	Group	Group	
	Mean (SD)		
Felt comfortable to open up	3.11 (1.11)	3.68 (1.00)	.08
Group leaders were helpful	3.88 (.99)	4.53 (.51)	.01
Enjoyed coming to sessions	3.65 (.89)	3.68 (.75)	.91
Mood improved versus before group	3.65 (.56)	3.53 (.51)	.44
Supported by group leaders	3.96 (.60)	4.32 (.48)	.04
Related to other group members	3.73 (.83)	3.84 (.76)	.65
	% (<i>n</i>)		
Addressed my concerns (yes)	92.3 (24)	88.9 (16)	.70
Group would help others like me (yes)	100.0 (25)	88.9 (16)	.09

Continuous items were rated on a Likert scale from 1 to 5, with 1 representing the poorest response and 5 representing the most positive response; $n = 26$ in the mindfulness-based group and $n = 19$ in the health education group completed program acceptability ratings.

Aim 2: Exploratory Effects of Mindfulness Training on Psychological Outcomes and Weight Gain

Table 3 shows a summary of group condition effects on baseline to post-treatment changes and baseline to six-month follow-up changes on key psychological and body measurement variables. These analyses accounted for baseline age, sex, race/ethnicity, and the baseline scores in each respective variable.

Adolescents in the mindfulness group had greater decreases in perceived stress at post-treatment than adolescents in the health education group ($p = .05$). This difference did not persist at six-months, and tended to show the opposite pattern ($p = .06$). There were no significant between-group differences observed in any other variable at post-treatment or six-month follow up (all p -values $> .20$).

I next explored within-condition changes over time in unadjusted key variables. In the mindfulness condition, depression symptoms decreased, on average, by 3.52 (SD = 7.08; $p = .02$) from baseline to post-treatment follow-up. In contrast, in the health education control group, there was no significant change in depression symptoms from baseline to post-treatment ($p = .58$). Depressive symptoms were also significantly lower at six-month follow-up as compared to baseline values, decreasing by an average of 2.75 (SD = 6.01; $p = .04$), within the mindfulness group. The health education group also had a significant decrease in depressive symptoms of 2.56 (SD=4.64; $p = .03$) from baseline to six month follow up.

Within the mindfulness condition, perceived stress decreased significantly by an average of 2.26 (SD = 5.39; $p = .04$) at post-treatment; however six-month follow-up levels of perceived stress were not significantly different from baseline values within the mindfulness condition. In contrast, within the health education group, perceived stress decreased by 3.56 (SD = 5.40; $p =$

.01) at six-month follow up despite showing no significant change from baseline to post-intervention ($p = .96$).

Anxiety symptoms within the mindfulness condition decreased by an average of 5.00 (SD = 7.03; $p < .001$) from baseline to post-treatment follow-up, and also significantly decreased, by an average of 2.38 (SD = 5.31; $p = .04$), at six-month follow-up within the mindfulness condition. In the health education condition, anxiety symptoms also decreased significantly by 4.31 (SD = 7.96; $p = .03$) at post-treatment, and by 3.06 (SD = 5.42; $p = .03$) at six-month follow-up.

As would be expected in developing youth, raw BMI-score increased from baseline to six-months, by an average of .92 kg/m² (SD = 2.02; $p = .04$) within the mindfulness group and by 1.02 kg/m² (SD = 1.74; $p = .02$) within the health education control group. No significant change occurred in BMI from baseline to post-treatment (p -values $> .56$). In addition, there was no significant increase in other BMI metrics (z-score, percentile) at either post-treatment or six-months (p -values $> .13$).

Table 3. Summary of group condition effects on changes in post-treatment and six-month outcomes from baseline

	Post-Treatment Change				Six-Month Change			
	Mindfulness	Health Education	Group Effect‡	<i>p</i>	Mindfulness	Health Education	Group Effect‡	<i>p</i>
Depressive symptoms	-1.67 (1.45)	.78 (1.90)	-1.73, 6.64	.24	-2.44 (1.14)	-3.80 (1.54)	-4.65, 1.93	.41
Anxiety symptoms	-3.60 (1.35)	-3.67 (1.77)	-3.94, 3.80	.97	-1.69 (1.20)	-3.20 (1.61)	-4.94, 1.91	.38
Perceived stress	-1.69 (1.08)	1.36 (1.40)	-.05, 6.16	.05	.50 (1.33)	-3.17 (1.79)	-7.48, .14	.06
BMI, kg/m ²	-.03 (.27)	-.11 (.35)	-.86, .69	.83	.89 (.47)	.92 (.63)	-1.31, 1.37	.96
BMI, z-score	-.07 (.05)	-.04 (.06)	-.10, .18	.61	-.21 (.07)	.02 (.10)	-.12, .24	.70
BMI, percentile	-2.10 (1.32)	.37 (1.73)	-1.39, 6.32	.20	-1.87 (1.78)	.19 (2.42)	-3.16, 7.29	.43

‡ 95% CI for mindfulness-based group versus health education group difference. Values displayed for mindfulness and health education group conditions are means (standard errors). All estimates are adjusted for baseline age, sex, race/ethnicity, the respective baseline level of each outcome. Depressive symptoms were assessed with the total summed score of the Center for Epidemiologic Studies-Depression Scale (CES-D); Anxiety symptoms were assessed with the total summed score of the State Trait Anxiety Inventory for Children-Trait Version (STAI-C). Perceived stress was assessed with the total summed score of the Perceived Stress Scale.

Discussion

The purpose of this study was to explore the potential utility of a mindfulness-based intervention for adolescent girls and boys at risk for excess weight gain. The current thesis project comprised the initial data from a randomized controlled pilot trial designed to evaluate a relatively brief, six-session mindfulness-based program for prevention of excess weight gain in adolescents at risk for adult obesity. The aims were to: (1) examine the feasibility and acceptability of a mindfulness-based group program in adolescents at risk for excess weight gain and (2) explore the efficacy of a mindfulness-based program compared to a health education control group on decreasing depression and anxiety symptoms, perceived stress, and lessening excess BMI gain over the course of a six-month follow-up period.

Aim 1: Feasibility/Acceptability

In support of feasibility and acceptability, adolescents' median session attendance was six out of six possible sessions for the mindfulness-based program among this sample of 12-17-year-old girls and boys at risk for excess weight gain. This rate matched the rate of attendance in the health education comparison condition, which was also six out of six sessions. Observed attendance exceeded the benchmark we set of 80% attendance as an indicator of feasibility and acceptability. These findings are in contrast to a previous pilot study of a mindfulness-based eating intervention in adolescent girls, at the 90th percentile for weight, which only had 57% program attendance (Daly et al., 2016). There are a number of possible explanations for why this study had better attendance than previous work. One explanation is that the current study's more preventative focus on mindfulness skills for gaining a healthy amount of weight in the future, as opposed to a focus on mindfully changing eating for weight loss may have been more

acceptable to adolescent participants. It is also possible that racial/ethnic diversity may have played a role, as the current sample was primarily non-Hispanic White, whereas Daly et al. (2016) studied Latina adolescent girls. Similarly, there was a difference between having all female participants in the previous study, as opposed to a mixed-sex design in the current project. Also, it is important to note that adolescents in the current study received a monetary incentive (\$50) for attending at least five sessions; thus, to what extent attendance would be strong without this incentive, or with alternative incentives, should be determined in future research.

Homework completion in the mindfulness-based group program was adequate, averaging 63%. This finding suggests that adolescents were using the mindfulness skills that they were assigned to practice at home, including both mindfulness activities that teenagers could incorporate into their daily life (such as a three-minute body scan or taking a single deep breath), as well as more formal guided meditation practices through the assistance of audio recordings. Some evidence supports that at-home practice positively impacts outcomes of mindfulness-based programs (Carmody & Baer, 2008). However, research is mixed, with other studies showing less impact (Toneatto, Stea, Ngyuen, & Wang, 2009). Future, larger studies could test to what extent homework completion is related to psychological and weight-related outcomes in mindfulness-based intervention with adolescents at-risk for excess weight gain, and also if certain homework exercises are more important than others. In addition, one limitation of the assessment of homework completion is that ratings were self-reported by participants, to facilitators during sessions, and future studies should consider incorporating adolescents' at-home ratings of their homework completion throughout their week.

When asked about their enjoyment of coming to group, adolescents' average answer was between "somewhat" and "very much." When asked if they felt that they related to other members of the group, adolescents answered on average "yes." The vast majority (92%) thought the group addressed their concerns and 100% would recommend the group to others like them. These ratings provide support for acceptability of a mindfulness-based group intervention in the specific group of adolescents at-risk for excess weight gain, the majority of whom had overweight or obesity.

Although acceptability ratings of the mindfulness-based were positive, there were some significant differences between the mindfulness-based group program as compared to the health education control group. Specifically, adolescents in health education rated how much they felt supported by group leaders and group leader helpfulness higher relative to adolescents who participated in the mindfulness program. There are several possible explanations for these observed differences. One possibility is that the mixed-sex design of this study, including both adolescent girls as well as boys at-risk for excess weight gain, may have contributed. Because the groups were small, ranging from 3 to 7 participants, some groups were uneven in gender (e.g., 3 girls and 1 boy). Whereas in the health education curriculum, the group discussed didactic topics that could have been personally sensitive (e.g., body image, depression and suicide) only the mindfulness-based program focused explicitly on increasing attention to and awareness of the body (Broderick, 2013). Body awareness is a core and unique component of most mindfulness-based training programs (Creswell, 2017). In another mindfulness-based pilot study that we conducted comprised exclusively of adolescent girls at-risk for type 2 diabetes (Shomaker et al., 2017), adolescents perceived that they highly related to other group members and perceived strong support from facilitators. Thus, it is possible that the mixed-sex context of

the current study contributed to the relatively lower comfort in the group. It is important to note that, while we want adolescents to find interventions acceptable, some disagree of discomfort may be necessary to making important changes in habitual responding to stress and lifestyle habits. Indeed a core principle of mindfulness-based training is learning to turn toward, rather than to cover up, unpleasant feelings that arise from external and internal stressors (Broderick, 2013). It is promising that, even in spite of these differences, session attendance was excellent and the vast majority of adolescents perceived that the mindfulness-based group program benefited them.

One pertinent limitation of this study design was that the group facilitators did not alternate between facilitating health education and mindfulness-based programs, so we cannot rule out to what extent the observed differences in facilitator acceptability ratings were due to the programs themselves as compared to the particular leaders who facilitated the respective programs. In future studies, facilitators should alternate between leading both intervention and control programs in order to account for any potential leader differences.

Aim 2: Exploratory Effects of Mindfulness Training on Psychological Outcomes and Weight Gain

In a preliminary comparison of post-treatment and six-month changes in perceived stress, depression and anxiety symptoms, and BMI metrics between the mindfulness-based program and the health education control group, the only significant difference was that adolescents in the mindfulness-based program had greater decreases in perceived stress at post-intervention than adolescents in the health education group. Previous studies evaluating changes in perceived stress following mindfulness-based intervention have shown decreases in perceived stress in both adolescents (Edwards et al., 2014), as well as adults (Baer, Carmody & Hunsinger, 2012). A

mindfulness-based intervention may have acutely decreased perceived stress in this study because of the nature of mindfulness-based skills that encourage adolescents to focus on the present moment and to use mindfulness to work with negative thoughts and emotions. However, there is also the possibility that this increased focus on internal processes may ultimately increase awareness of stress, perhaps contributing to the non-significant within-condition change in perceived stress from baseline to six-month follow-up.

Likewise, between-intervention condition differences in perceived stress did not persist at six-month follow-up, and if anything, showed a pattern in the reverse direction. Also, there were no between-group differences in depression or anxiety symptoms at any follow-up interval. With respect to depression and anxiety symptoms, these symptoms decreased over time within both interventions at the 6 month follow up when looking at unadjusted significant changes within group. While the current pilot study was not powered to detect between-condition differences in psychological outcomes, there are several points for discussion. First, it is important to note that depression and anxiety symptoms at the beginning of the study were not elevated. For instance, the average depression total score on the Children's Depression Inventory was 13.75 (SD = 7.80) in the mindfulness group and 12.00 (SD = 6.70) in the health education control group, and a recommended cut-point of 15 for "mild" symptoms and "20" for moderately elevated symptoms is often considered suggestive of meaningful elevations in depressive symptoms (Bang, Park, & Kim, 2015). Teens who have obesity have more depression and anxiety symptoms than lean teens (Anderson et. al., 2007; Roberts & Duong, 2016); yet, this sample was not specifically selected to be at risk for elevated depression, anxiety, or perceived stress. This overall non-elevated symptomatology likely made it more difficult to detect patterns of differential between-condition effects with less initial elevations in symptoms

or stress. A possible future direction may be to investigate if a mindfulness program would be more effective in adolescents that are initially presenting with elevated depression symptoms, anxiety symptoms, or greater perceived stress. Indeed, findings from the adult literature suggest that mindfulness interventions have psychological benefits in contrast to treatment-as-usual, in adults with type 2 diabetes and depressive symptoms (21% of whom met criteria for a depressive disorder; Hartmann et al, 2012), binge eating disorder as compared to cognitive-behavioral and waitlist-control comparison groups (Kristeller, Wolever, & Sheets, 2013), and overweight or obesity (Katterman et al., 2014). Likewise, among adolescent girls at-risk for diabetes and also selected to have elevated depressive symptoms, a mindfulness program led to greater decreases in depression symptoms up to six-months later than an active comparison of cognitive-behavioral group therapy (Shomaker et al., 2017). Thus, a more targeted approach for adolescent participants at risk for excess weight gain with elevated internalizing symptoms may ultimately be more suitable.

Second, there is potential that participating in a health education group program could be just as efficacious as mindfulness-based training in addressing depression and anxiety symptoms in adolescents. Participating in a group with peers can be psychologically beneficial in itself in that adolescents have an added opportunity to socialize and can often relate to similarities with peers, especially in a group that was selected based on a number of similar factors.

Third, the follow-up period of six-months was longer than many adolescent mindfulness-based trials (Daly et al., 2016; Biegel et al., 2009; Bluth et al., 2016); yet, this time period is still a relatively short developmental window to track changes in internalizing symptoms and even more so, in BMI change over time. When looking at unadjusted significant within group changes, BMI did increase in both the mindfulness condition as well as the health education

condition at six-month follow-up which is anticipated for developing youth; yet BMI z-score and percentile were stable in both conditions. Other studies evaluating psychological intervention effects on adolescent growth in youth at-risk for adult obesity and/or diabetes, suggest that a period of one to three years may be necessary before differential change in BMI and/or related metabolic outcomes unfolds (Shomaker et al., 2017; Tanofsky-Kraff et al., 2017). In future studies, a longer follow-up would be ideal in order to determine to what extent a mindfulness-based intervention may confer any unique benefits for psychological adjustment and weight gain over time.

Limitations, Strengths, and Future Directions

This study was a pilot study designed to determine feasibility and acceptability of a mindfulness-based group intervention in adolescents at risk for excess weight gain. By design, it was not powered to detect differences in psychological outcomes or BMI metrics. Posthoc power analysis indicated that with the sample size and observed small effects, we only had ~11% power to detect a significant effect for BMI change. Thus, results exploring between-group differences in mindfulness compared to health education should be interpreted with extreme caution, given this pilot study design and the lack of adequate power. Also, generalizability of the results are limited to adolescents who are at risk for adult obesity by virtue of either having an above-average BMI, defined as equal to or exceeding the 70th percentile for age and sex, or having two biological parents with overweight, assessed as parent-reported BMI (kg/m²) value of 25 or greater. We cannot conclude to what extent the main outcomes of feasibility and acceptability would be similar in adolescents who are not at-risk for excess weight gain and/or to those who are reporting more stress, depression or anxiety symptoms. The mindfulness group was facilitated by graduate students in Marriage and Family Therapy and the health education group by graduate students in Food Science and Human Nutrition, Public Health, or Prevention Science; interventionists did not alternate conditions, making it impossible to rule out the influence of interventionists on observed results. Another notable limitation is the relatively homogenous non-Hispanic White nature of sample, which limits generalizability to other racial/ethnic groups. We also cannot compare directly mixed versus same-sex groups, and as discussed previously, this feature may have diminished some aspects of acceptability.

A strength of the study includes the randomized controlled trial design with an active attention and time matched comparison condition. Most mindfulness-based research, particularly in the area of obesity, has focused on treatment of adults; thus, the focus on adolescents at risk for excess weight gain from a prevention lens fills an important gap in the literature. Assessments of psychological outcomes relied on instruments with sound psychometric properties and BMI metrics were based upon objective measurements of height and weight in a fasted state.

While these measures were sound, one possible future direction may be to incorporate novel methods, such as ecological momentary assessments of stressors, affect, and anxiety (Shiffman, Stone & Hufford, 2008). This type of measure has some advantages by measuring in-the-moment present or state-like responses, in comparison to asking teens to retroactively report their stress and symptoms over an extended period of time. Also, while we assessed homework completion from facilitators' ratings of adolescents' self-reports during group session, it would be preferable to hear directly from teens as well throughout their week, perhaps using ecological momentary assessment or daily diary measures. In addition, it is unknown if adolescents were continuing to use their mindfulness skills after the group was over and during the follow-up period. It is possible that participants had stopped using any skills they had learned in the intervention at the six-month follow-up, which may be a contributing factor to changes in some psychological and/or BMI outcomes. Such an understanding in future work would be useful in testing and understanding the use, longevity, and impact of learned skills after the program ends.

Summary and Conclusions

In conclusion, these data provided a contribution to our understanding of feasibility and acceptability of a six-week mindfulness group program for adolescents at risk for type 2 diabetes. Depression and anxiety symptoms decreased over the course a six-month period following both a mindfulness-based and health education control group program. Perceived stress more significantly decreased following the mindfulness-based group program at the post-intervention time point. These findings support the need for more research in this area to evaluate the possibility of mindfulness interventions offering an alternative or adjunctive approach to more traditional lifestyle strategies weight management in at-risk adolescents.

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