

THESIS

MINDFULNESS-BASED GROUP INTERVENTION FOR AN ADOLESCENT GIRL
AT RISK FOR TYPE 2 DIABETES: A CASE STUDY

Submitted by

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ABSTRACT

MINDFULNESS-BASED GROUP INTERVENTION FOR AN ADOLESCENT GIRL AT RISK FOR TYPE 2 DIABETES: A CASE STUDY

Adolescent-onset type 2 diabetes (T2D) is a rising healthcare problem that disproportionately impacts females and historically disadvantaged racial/ethnic groups. Standard behavioral lifestyle interventions to prevent T2D by lowering body mass index (BMI) to lessen insulin resistance, a key precursor to T2D, unfortunately have had limited long-term success. Underlying psychosocial factors, particularly depressive symptoms, have been related to insulin resistance and T2D, independent of BMI. Mindfulness-based group interventions are being utilized increasingly in adults with T2D to address depression. More recently, using a prevention lens, mindfulness-based programs have shown preliminary promise for intervening with elevated depressive symptoms and insulin resistance in adolescents at risk for T2D. Yet given the newness of this area, little research exists to deepen understanding around clinical implementation and acceptability with this at-risk, adolescent population. In the current case study, we present the experience of an adolescent girl with elevated depressive symptoms, obesity, insulin resistance, and a family history of T2D, who participated in a six-week mindfulness-based group program delivered at an outpatient therapy clinic in the context of a pilot clinical research study. At baseline, immediately following the group program, and at one-year follow-up, surveys and interviews were administered to evaluate mindfulness and depression; hypothalamic-pituitary-adrenal axis activity; BMI and body fat were assessed; and insulin resistance was estimated from the homeostasis model assessment of insulin resistance

(HOMA-IR). Case results indicated increased dispositional mindfulness, decreases in depressive symptoms, and lessening of insulin resistance. BMI and body fat were stable. Key therapeutic themes that emerged for the participant included increased recognition of internal experience and decreased reactivity to stress, which might help to explain the positive psychological and insulin outcomes. We discuss several implications of the case study for potentially increasing the success of implementing mindfulness-based programs in this population, including more emphasis on the promotion of social connections among group members, increasing adherence to home practice, and facilitation techniques to promote concrete understanding of abstract mindfulness concepts. The current case results suggest that teaching mindfulness skills to adolescent girls at risk for T2D with depressive symptoms possibly may offer benefits for depression and T2D risk. Adequately-powered clinical trial data are required to evaluate these results on a larger scale.

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INTRODUCTION

Growing Concern of Type 2 Diabetes in Adolescents

The prevalence of adolescent-onset type 2 diabetes (T2D) has grown significantly in the last twenty years (Lawrence et al., 2014), a trend that is largely explained by the epidemic rise in childhood and adolescent obesity (Ogden et al., 2015, Pinhas-Hamiel & Zeitler, 2000). The manifestation of T2D in younger people is particularly concerning considering that adolescent-onset of the disease has been associated with a more aggressive disease course and earlier mortality, as compared to adult-onset T2D (Copeland et al., 2011; Hirst, 2013; Lynch et al., 2013; Nadeau et al, 2016). While T2D prevalence is increasing generally in adolescents, females and individuals who have elevated social vulnerability and stress, including historically disadvantaged racial/ethnic groups and those in lower socioeconomic status households, have been disproportionately impacted (Dabelea et al, 2014; Gregg et al., 2014).

Traditional risk factors in adolescents for developing T2D are having overweight or obesity (body mass index [BMI] $\geq 85^{\text{th}}$ percentile) and elevated insulin resistance, referring to a physiological state in which insulin has a diminished effect on regulating blood sugar (Morrison et al., 2010). Current prevention efforts for T2D have primarily focused on behavioral interventions to promote the adoption of a healthier lifestyle through diet and exercise changes in order to lower BMI and ameliorate insulin resistance (Nadeau et al, 2016). However, maintenance of weight loss in the long-term for adolescents remains a challenge (Wilfley et al, 2007). In fact, evaluations of programs focused on prevention of excess weight gain indicate that only 21% of adolescent programs result in significant improvements in weight outcomes (Stice, Shaw, & Marti, 2006). While reducing elevated BMI has been a standard target for T2D

prevention efforts, research suggests that psychological factors, including depressive symptoms, also may impact the risk of T2D in adolescents.

Role of Depressive Symptoms in Adolescent T2D Risk

Emerging data support the notion that depressive symptoms are linked to T2D risk (Holt, de Groot, & Golden, 2014). Adolescence is a particularly salient time for increased stress and the onset and worsening of depressive symptoms. One in seven adolescent girls age 12 to 20 years have experienced elevated depressive symptoms, with rates as high as 25-75% in girls from historically disadvantaged racial/ethnic groups (Rohde et al., 2009). Youth with overweight and obesity more frequently experience depressive symptoms than their lean peers (Goodman & Whitaker, 2002; Robinson, Haydel & Killen, 2000), which partly may be related to peer victimization and social exclusion related to weight (Latner & Schwartz, 2005). Moreover, authors of cross-sectional studies with adolescent populations found a positive association between depressive symptoms and insulin resistance, after accounting for BMI or body fat (Hannon, et al., 2013; Jaser et al., 2009; Shomaker et al., 2010). In prospective studies, adolescent depressive symptoms have been predictive of worsening insulin resistance over time and the onset of T2D, after accounting for BMI (Shomaker et al., 2011; Suglia et al., 2016). While the specific mechanisms linking depression and T2D risk remain unclear, it has been hypothesized that explanatory pathways include both stress-related behaviors, such as overeating and type of food consumed, and stress-related physiology, which are proposed to exert an impact on insulin resistance independent of energy balance (Golden, 2007). Thus, intervening with depressive symptoms as an antecedent to insulin resistance via reducing stress may offer a novel, targeted approach to the prevention of adolescent-onset T2D that has not been addressed by standard lifestyle interventions.

Mindfulness for Elevated Depressive Symptoms and Prevention of T2D

Mindfulness-based intervention modalities have become increasingly popular and of interest in their application to chronic disease prevention and management. Kabat-Zinn (1994) defined mindfulness as “paying attention in a particular way: on purpose, in the present moment, non-judgmentally” (pg. 4). In practice, mindfulness is a way of being that involves present moment awareness of internal and external experiences and acceptance of, rather than preoccupation with or suppression of, these experiences (Kallapiran et al., 2015; Keng, Smoski, & Robins, 2011). Characteristics of mindfulness may be trait-like in nature, but importantly, also may be altered through mindfulness training (Shapiro et al., 2006).

Theoretically, mindfulness has been proposed to impact the connection between depression and T2D in three ways: (1) lessening the adverse impact of stress through acceptance of unpleasant experiences; (2) decreasing stress-related behaviors through attention and greater attunement to internal experience; and (3) decreasing physiological response to stress through mindfully relating to negative experiences (**Fig. 1**; Corstorphine, 2006; Forman et al., 2013; Godsey, 2013). Correlational research has linked trait mindfulness with the theoretically proposed mechanisms relating symptoms of depression and insulin resistance. For instance, in non-clinical adults, dispositional mindfulness has been inversely associated with stress-related behaviors including eating in response to psychological distress, uncontrolled eating, and a preference for sweets and fats (Jordan, Wang, & Donatoni, 2014; Pidgeon, Lacota, & Champion, 2013). Likewise, in adolescents at risk for T2D, dispositional mindfulness has been inversely associated with the likelihood of binge eating (Pivarunas et al., 2015). Trait mindfulness has also been associated with buffering physiological stress responses, including cortisol awakening response, in women with overweight and obesity (Daubenmier et al., 2014). Therefore, may be

the attentive and non-judgmental way in which mindful people relate to stress, rather than a decrease in the amount of stress, which is proposed to lessen the likelihood of stress-related behaviors and stress physiology (Daubenmier et al., 2014).

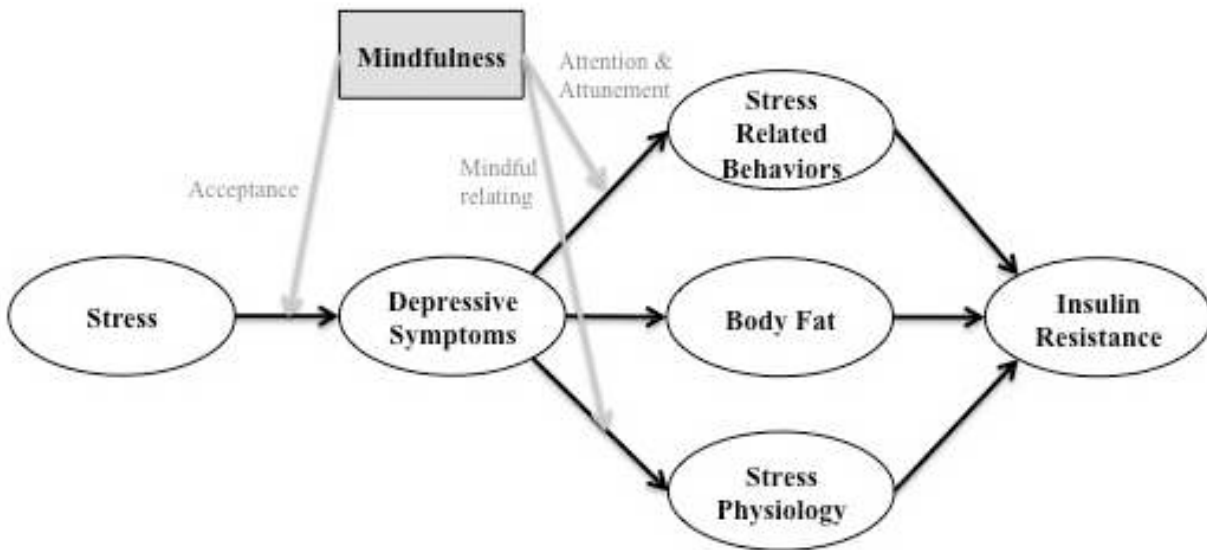


Figure 1. Proposed model of the chain of psychological and physiological antecedents to increased insulin resistance and the role of mindfulness in prevention

A small body of research has evaluated mindfulness-based interventions in adults with T2D and/or type 1 diabetes. In randomized controlled trial (RCT) studies with adults who have diabetes, mindfulness-based interventions produced greater decreases in depressive symptoms as compared to the treatment-as-usual or a waitlist condition (Hartmann et al., 2012; Schroevers et al., 2015; Tovote et al., 2015; van Son et al., 2014). Results have been more mixed for physical health outcomes, with some studies providing preliminary support that mindfulness-based interventions improve glycemic control (Gainey et al., 2016; Gregg et al., 2007) and lower blood pressure (Gainey et al., 2016; Kopf et al., 2014) in adults with T2D as compared with treatment-as-usual. Other researchers have failed to find effects of mindfulness training on glycemic control (Schroevers et al., 2015; Tovote et al., 2015; van Son et al., 2014).

In adolescents, mindfulness-based interventions have been evaluated primarily in non-treatment seeking community samples or adolescents at risk for, or with, mental and behavioral health problems (Black, Milam, & Sussman, 2009; Burke, 2009; Sibinga et al., 2016). A small body of RCT studies of mindfulness-based programs have shown efficacy in decreasing depressive and anxiety symptoms in both community samples and adolescents with mixed-psychiatric diagnoses (Beigel et al., 2009; Bluth et al., 2016; Sibinga et al., 2016; Tan & Martin, 2015). Even fewer studies have explored the impact of mindfulness on physical health outcomes in adolescents. However, in a series of trials, a breath awareness training program conducted with adolescents at risk for hypertension was shown to lower blood pressure as compared to an active control comparison condition (Barnes & Orme-Johnson, 2012).

Current Study

The current case study report follows the experience of an adolescent girl, determined to be at joint risk for depression and T2D, who participated in a mindfulness-based group program. This case report was drawn from a small, randomized controlled pilot study conducted to evaluate the feasibility and acceptability of a mindfulness-based group in adolescent girls with elevated depressive symptoms, overweight/obesity, and a familial risk of T2D (Shomaker et al., 2017). In this parent study, we found that a mindfulness-based group intervention was, overall, both feasible and acceptable for this population (Shomaker et al., 2017). Additionally, as compared to a cognitive-behavioral therapy depression intervention, adolescents who participated in the mindfulness program showed similar reductions in depressive symptoms and larger decreases in insulin resistance at post-treatment (Shomaker et al., 2017). Given the novelty of this approach and the limited use of mindfulness-based programming in adolescents who are, the current study used a case study format to make the following unique contributions

(a) highlight clinically significant outcomes to qualitatively explore implications associated with feasibility and acceptability, (b) discuss findings in the context of theoretical explanations of mindfulness for use in prevention of adolescent-onset T2D, and (c) discuss the specific clinical factors for success versus barriers to implementation of the program.

METHODS

Parent Study Overview

The case study reported in the current project was drawn from a sample of adolescent volunteers taking part in a pilot randomized controlled clinical trial, with the main goal of evaluating the feasibility and acceptability of a mindfulness-based group for the prevention of T2D (Shomaker et al., 2017). Recruitment materials invited girls ages 12-17 years who had family members with diabetes to participate in a brief group program aimed at lowering their risk of developing the disease. Recruitment methods included direct mailings to families within a 60-mile radius of Fort Collins, Colorado, flyers distributed at local health fairs and schools, notices to community physicians' offices, and community e-mail listservs. Inclusion criteria for the study were: (i) female, (ii) age 12 to 17 years, (iii) overweight or obesity (BMI at the 85th percentile or above for age and sex), (iv) parent-reported history of T2D, prediabetes, or gestational diabetes in one or more first- or second-degree relatives, (v) good general health, (vi) the ability to speak and understand spoken English, (vii) mild-to-moderate depressive symptoms, as indicated by a total score of 16 or higher on the 20-item Center for Epidemiologic Studies-Depression Scale (CES-D) (Radloff, 1977). Volunteers were excluded from participating if they: (i) had major depressive disorder (MDD) or another full-syndrome psychiatric disorder that necessitated more intensive psychological treatment: (ii) had major medical issues such as T2D (evaluated as fasting glucose >126 mg/dL), (iii) were using any medications which could affect mood or insulin resistance such as stimulants or anti-depressants, or (iv) if they were pregnant.

Case Description

“Abby” was a 16-year-old Caucasian female in the 11th grade, who was living with her biological mother, biological father, and one older, 20-year-old brother. At her baseline visit, Abby had obesity, with a BMI of 42 kg/m², at the 99th percentile for her age and sex (Centers for Disease Control and Prevention, 2000). As assessed by self-report of breast development, Abby’s pubertal stage was Tanner 5, indicating that she was in late puberty (Morris & Udry, 1980). Abby reported having a very close relationship with her father. She described periodic arguments with her mother and brother, which were not highly distressing, but did lessen the perceived closeness and trust in those relationships. Abby reported above-average academic achievement. She was enrolled in simultaneous coursework at a public high school and local college, which she perceived as stressful academically, but rewarding socially in that it offered the opportunity to interact with more mature peers. Abby reported having a best friend, yet, she described having difficulty making friends and had only a few friends in her high school. Abby denied being a victim (or perpetrator) of bullying. She was involved in a number of extracurricular activities including volunteering with an arts-based program for younger children and participating in youth activities at her church.

At baseline, Abby endorsed objective overeating episodes about twice per month, referring to eating characterized by the reported consumption of an unambiguously large amount of food. She denied uncontrolled or binge-eating, and she did not engage in compensatory or extreme weight loss control behavior. At baseline, Abby reported moderate depressive symptoms, as indicated by a CES-D score of 27. She did not, however, meet criteria for MDD or another full-syndrome psychiatric disorder according to DSM-IV-T-R (American Psychiatric Association, 2000). By interview, she endorsed mild to moderate depressive symptoms,

including depressed mood, moderate difficulty sleeping, and mild feelings of irritability and worthlessness. She denied current, or past, suicidal ideation or behavior. Of note, Abby reported a past history of MDD, which occurred when she was 13 years old and lasted approximately four months in duration. She perceived that this episode had been triggered primarily by feelings of loneliness related to social difficulties, such as a lack of close friendships in middle school and feeling socially isolated.

Procedure

Overview. All procedures were conducted at Colorado State University in Fort Collins, Colorado. After a brief phone screen to evaluate eligibility, Abby attended a baseline screening appointment. She provided informed, written assent to participate, and her parents provided informed consent. At the screening appointment, a family health history was conducted with her parent and baseline measures of mindfulness, mood and psychological functioning, eating behavior, hypothalamic-pituitary-adrenal axis activity, BMI, body composition, and insulin resistance were collected. After the screening, Abby was randomized to participate in a six-session weekly mindfulness-based group, Learning to BREATHE. Abby's mindfulness, mood and psychological functioning, eating behavior, hypothalamic-pituitary-adrenal axis activity, BMI, body composition, and insulin resistance were re-evaluated directly after the group and again, one-year later.

Mindfulness-based Group

Learning to BREATHE is a manualized, mindfulness-based group program designed as a universal prevention curriculum for the socioemotional health of middle and high school aged adolescents (Broderick, 2013). The parent study, which included Abby's cohort, utilized a six-session version of the program. Content of the one-hour, weekly sessions focused upon six

themes that correspond to the letters in the word BREATHE: (1) Body: body awareness, (2) Reflection: understanding and working with thoughts, (3) Emotions: understanding and working with feelings, (4) Attention: integrating awareness of thoughts, feelings, and bodily sensations, (5) Tenderness: reducing harmful self-judgments, and (6) Healthy Habits of Mind: integrating mindful awareness into daily life, and the last E standing for Empowerment, the overall goal of the program (Broderick, 2013). All sessions were held in the Center for Family and Couples Therapy, an outpatient psychotherapy clinic at Colorado State University. The program was co-facilitated by a licensed clinical child psychologist and a graduate student in Marriage and Family Therapy. Facilitators participated in a two-day training workshop on Learning to BREATHE and received weekly facilitation feedback by the curriculum developer (PB). They also maintained a personal mindfulness practice throughout program delivery.

Facilitators adhered to the Learning to BREATHE program curriculum, which includes core mindfulness practices such as the body scan, mindfulness of thoughts, mindfulness of emotions, loving kindness practice, and mindful, gentle movement or yoga (Broderick, 2013). These practices are woven together during sessions with psycho-education about mindfulness and interactive, group activities. The manual provides for the selection among various options of activities within each content area. In the current administration of Learning to BREATHE, the choice of activities was tailored to the target population. For example, the mindful eating practice activity provides practice in using the senses to fully experience the present moment and was administered in order to facilitate discussion around the difference in experience when one eats mindfully as compared to eating mindlessly. To promote continued practice and engagement with the content in between group sessions, group members were asked to complete homework. Homework assignments included the combination of making time for a brief (5-10

minute) formal mindfulness practice at least once during the week and engaging in informal mindfulness practices that could be integrated into many parts of an adolescent's daily life. For example, in an activity called mindful dots, participants place a dot sticker on three objects or places that they see regularly as a reminder to stop what they are doing and take a mindful breath. To facilitate home practice, group members were provided with a home practice workbook, a yoga mat and meditation cushion, and audio-recordings of guided mindfulness practices.

A brief rating form was administered at the outset of all sessions to track weekly mood and to monitor suicidal ideation. Additionally, a 14-item program acceptability questionnaire was administered at the conclusion of the program to assess overall experience with the group, the facilitators, other group members, and the content of the curriculum.

Measures

The following measures were evaluated at baseline, repeated six-weeks later upon completion of the intervention, and again, at the one-year follow-up. Unless otherwise noted, assessments were completed at all three of these intervals.

Mindfulness. The 15-item Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003) was administered to measure dispositional mindfulness. Using a Likert scale ranging from 1 (*always*) to 6 (*almost never*), the MAAS measures trait mindfulness across cognitive, emotional, physical, and interpersonal domains (Brown & Ryan, 2003). A total score is calculated as the sum of all items, with higher scores reflecting greater mindfulness (possible range = 15-90). The MAAS has shown acceptable internal consistency and test-retest reliability in community and clinical samples of adolescents (Brown et al., 2011).

Depressive Symptoms. A trained interviewer conducted the semi-structured Schedule for Affective Disorders and Schizophrenia for School-Age Children (K-SADS) (Kaufman et al.,

1997) with Abby. In the current case, the K-SADS was used to evaluate current psychopathology, history of diagnostic psychopathology over the past year, as well as lifetime history of MDD. At six-week and one-year follow-ups, only the depressive episode module was administered to determine occurrence of MDD. The K-SADS is a commonly used assessment tool for psychopathology in adolescents; it has excellent test-retest reliability, interrater reliability, and concurrent validity (Kaufman et al., 1997).

In addition, Abby completed the 20-item CES-D (Radloff, 1977) as a continuous measure of depressive symptoms. The CES-D uses a 4-point Likert scale to indicate how frequently participants are experiencing various symptoms from 0 (*rarely or none of the time*) to 3 (*most or all of the time*). The total score is calculated as the sum of all items, with higher values indicating higher levels of depressive symptoms (possible range = 0-60). Although the CES-D is not a diagnostic tool, a total score of 16-20 may reflect mild symptoms and scores exceeding 20 or 24 are thought to reflect moderately elevated symptoms (Chabrol et al., 2002). The CES-D is a commonly used measure for assessing continuous depressive symptoms or as a screening tool for MDD; it has been shown to have high reliability and adequate validity with adolescent populations (Stockings et al., 2015).

Anxiety Symptoms. Abby completed the 20-item State-Trait Anxiety Inventory for Children – Trait Version (STAI-C) (Spielberger et al., 1973) to assess anxiety symptoms. Items are rated on a Likert scale ranging from 1 (*never*) to 5 (*very often*). The total score is calculated as the sum of all items with higher scores indicating higher levels of trait anxiety (possible range = 20-100).

Perceived Stress. The 14-item Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) was used to assess subjective stress. This self-report instrument includes questions rated

on a Likert scale ranging from 0 (*never*) to 5 (*very often*). The total score is calculated as the sum of all items, with higher scores reflecting greater levels of perceived stress (possible range = 14-70).

Stress-Related Eating Behaviors. Abby completed the Questionnaire of Eating and Weight Patterns – Revised (QEWP-R) (Spitzer, Yanovski, & Marcus, 1993) to assess eating behaviors, including overeating episodes, loss of control over eating, and compensatory behavior, such as purging or fasting.

Hypothalamic-pituitary-adrenal axis activity. Hypothalamic-pituitary-adrenal axis activity was assessed using salivary cortisol awakening response (Pruessner et al., 1997). Cortisol is widely regarded as a physiological marker of stress. Abby was instructed to take a saliva sample upon waking and then again 15 minutes after waking in her own home. Saliva samples were kept at -20° C until being shipped for analysis at Biochemisches Labor at the University of Trier in Trier, Germany, utilizing radioimmunoassay.

BMI, Body Composition, and Puberty. After an overnight fast, weight was measured in kg and height was measured in cm to compute BMI (kg/m^2) and age-adjusted BMI indices (Centers for Disease Control and Prevention, 2000). Percent body fat was determined with dual-energy x-ray absorptiometry (Hologic, DiscoveryW, QDR Series, Bedford, MA, USA). Breast development was assessed using self-reported Tanner stage (Morris & Udry, 1980).

Insulin Resistance. Blood samples were collected following a 10-hour, overnight fast to determine fasting insulin and glucose concentrations. Serum insulin was analyzed at the University of Colorado Denver's Clinical and Translational Research Center core laboratory with radioimmunoassay (Millipore, Billerica, Massachusetts). An automated device (2300 STAT Plus Glucose Lactate Analyser, YSI Inc., Yellow Springs, Ohio) was used to evaluate

glucose immediately. The homeostasis model assessment of insulin resistance (HOMA-IR) index was used to estimate insulin resistance, which is calculated as: (fasting insulin [μ U/mL] X fasting glucose [mmol/L])/22.5 (Yeckel et al., 2004). One recommended cut-point for clinically elevated insulin resistance in adolescents is 3.16 (Atabek & Pirgon, 2007; Keskin et al., 2005).

Intervention Course

A total of eight adolescent group members participated in Abby's Learning to BREATHE intervention program. By design, the group was comprised entirely of female participants aged 12 to 17 years, all of whom met criteria for the parent study. Five of the eight participants, including Abby, identified as Caucasian/White and three of the participants identified as Latina/Hispanic.

Abby attended all six of the Learning to BREATHE sessions. She presented in the group as forthcoming, thoughtful, and engaged in activities and session content. Across all six sessions, Abby was one of the most vocal group members. She was often the first adolescent to answer questions posed by the facilitators. She was friendly and interacted with her peers prior to the start of sessions and during small group activities. Of note, Abby commented several times on how the mindfulness practices in a group setting felt awkward for her, including eating mindfully in front of others and feeling uncomfortable with sharing in front of the group. In spite of these comments, she participated openly and toward the end of the program (session 5), indicated feeling more connected to the group, including talking about how she had a very similar personality to two of the other group members.

At the beginning of each session, Abby completed a self-report mood monitoring form which used a 10-point scale assess mood from *1 (best it has ever been)* to *10 worst it has ever been*). She rated herself 6, 3, 4, 4, 1, and 1 for weeks 1-6 respectively (**Fig. 2**). Abby completed

at least some portion of assigned home practice following sessions one to four; however, the degree of homework completion was inconsistent. She completed 100% of assignments, 25%, 50%, 100%, and 0% of assignments for weeks 2-6, respectively (**Fig. 3**). Abby indicated in her program acceptability questionnaire that although it was “extremely easy” for her to access the homework, she did not complete all of her homework because she “forgot a lot.” Abby reported doing the informal mindfulness practices including mindful dots and mindful breathing more frequently than the formal practices such as the audio-recordings of guided meditation or mindful movements. As an example of Abby’s informal home practice, she reported utilizing the mindful dot stickers regularly. Abby talked about the place that she was most mindless in her life was driving to school in the morning, and therefore, she reported placing the mindful dot on the steering wheel of her car to help practice mindfulness during this routine activity of daily life.

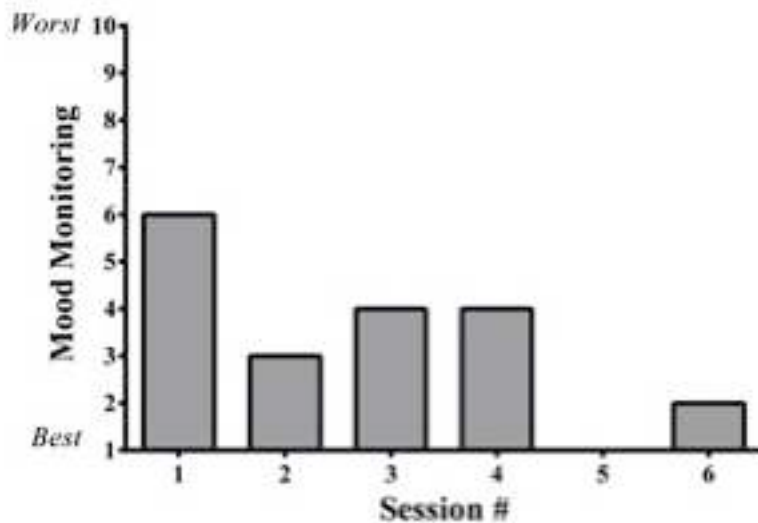


Figure 2. Mood Monitoring rating by session

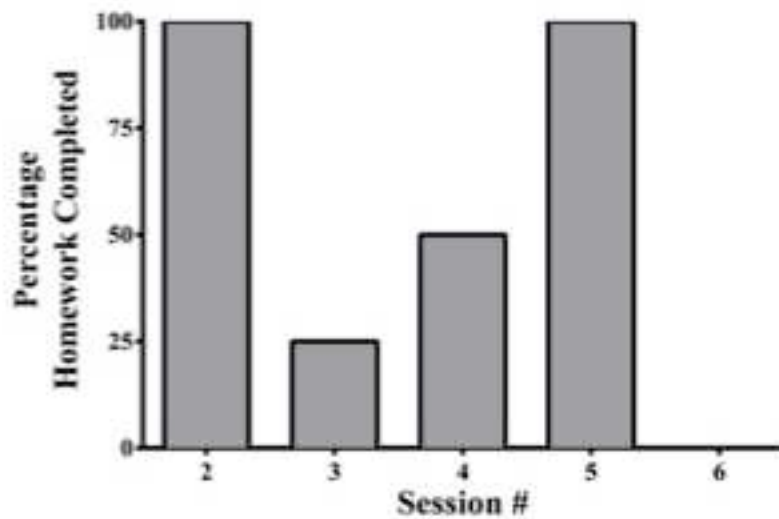


Figure 3. Percentage of Learning to BREATHE homework completed by session

In the final session, Abby commented that she connected most with the content of program material related to mindfulness of emotions. She expressed that, as the program progressed, she had been gaining awareness of the automatic nature of emotional responses related to stressors in her life. Specifically, she perceived that she easily lost her temper when stressed, and she had been working on paying attention to her feelings before she responded, so that she could respond more calmly.

Abby indicated on the program acceptability questionnaire that following participation in the group program her mood was “happier” and that compared to the start of the groups she felt “healthier.” On this questionnaire, she also indicated her level of satisfaction with the group; she stated that she enjoyed the group “very much” and found the group leaders “very helpful” and supportive. Consistent with her comments during the intervention, Abby indicated that she felt only “a little comfortable” to open up and talk about tough topics during the group. She indicated that she felt neutral about how well she could relate to others in the group, responding that the one thing she would change about the group would be: “I think we should do an activity

to get to know one another before diving right in. I think that's why there were so many awkward moments.”

RESULTS

Abby had an increase in dispositional mindfulness following the Learning to BREATHE intervention (**Fig. 4**). At baseline, she had a total dispositional mindfulness (MAAS) score of 34 (possible range = 15-90), with higher scores reflecting a greater degree of dispositional mindfulness. Upon completion of the mindfulness group program, Abby's mindfulness score increased by 19% to a raw score of 51. This increase was sustained, even slightly improving, to a MAAS score of 56 one-year later.

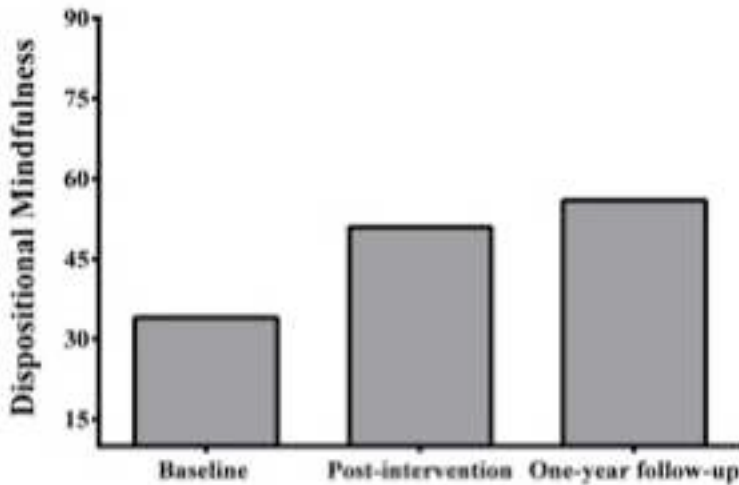


Figure 4. Mindful Attention and Awareness Scale (MAAS) by timeframe

On the CES-D, Abby's depressive symptoms total score was 27 at baseline, 21 directly after the intervention, and 12, a decrease of 56%, at the one-year follow-up (**Fig. 5**). On the K-SADS assessment, she reported a decrease in depressed mood, from mildly symptomatic at baseline and post-intervention to non-symptomatic at one-year follow-up. Abby did not meet diagnostic criteria for MDD at any point in the follow-up timeframe. Thus, she had elevated depressive symptoms throughout the one-year follow-up period; however, her symptoms were mild one-year following the intervention and decreased relative to baseline.

Similar results were observed for perceived stress and anxiety symptoms. Abby showed a decrease in self-reported perceived stress on the PSS, starting with a total score of 49 at baseline (possible range = 14-70), 39 at post-intervention, and then 41, a decrease of 11%, at one-year follow-up (**Fig. 6**). She also reported decreased anxiety symptoms from baseline through one year following the intervention, as indicated by a STAI-C score of 48 at baseline (possible range = 20-100), 41 at post-intervention, and 32, a decrease of 16% from her baseline symptoms level, at one-year follow-up (**Fig. 7**).

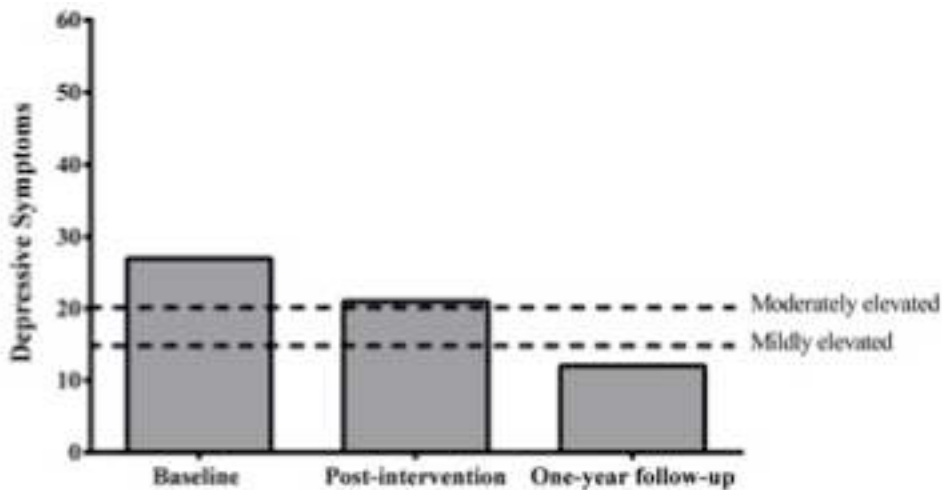


Figure 5. Center for Epidemiologic Studies - Depression Scale (CES-D) by timeframe with suggested cut-points for mildly and moderately elevated depressive symptoms

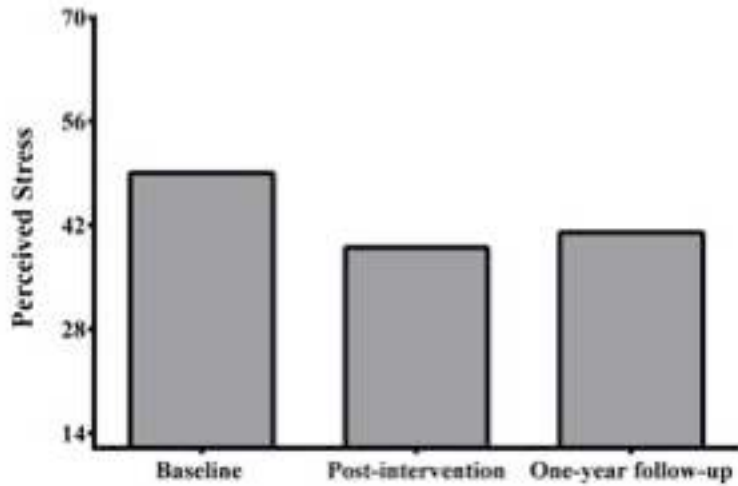


Figure 6. Perceived Stress Scale (PSS) by timeframe

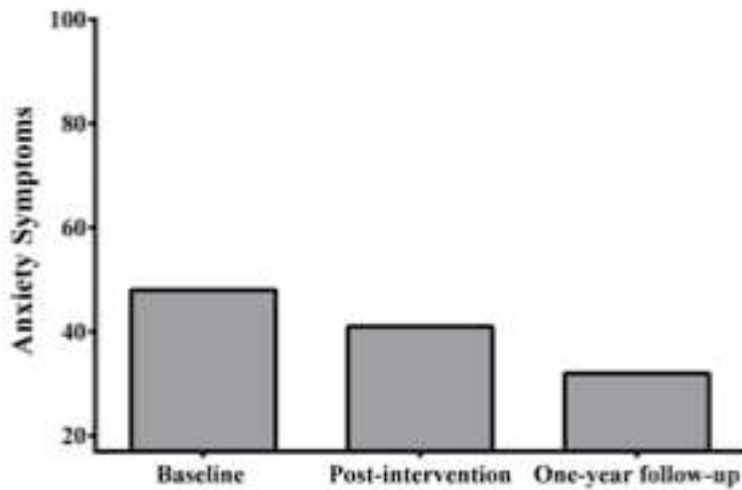


Figure 7. State-Trait Anxiety Inventory for Children – Trait Version (STAI-C) by timeframe

In contrast to the linear, declining patterns observed in psychological adjustment over one year, Abby had fluctuations in disinhibited eating from baseline to one-year follow up. At baseline, Abby reported engaging in objective overeating only. Following the intervention, she continued to report objective overeating, but she also perceived having felt loss of control during her overeating, referring to binge-eating. By Abby’s one-year follow up assessment, she had fully remitted from disinhibited eating behaviors, including both objective overeating and binge-

eating or loss of control eating behavior. She did not meet criteria for binge eating disorder or any other eating-related psychopathology at any time point.

The trajectory of Abby's cortisol awakening response followed a decreasing, linear pattern over time. At baseline, Abby's cortisol awakening response was 2.00 nmol/L, decreasing to 1.06 nmol/L immediately following the mindfulness-based group, and to -0.23 nmol/L at her one-year follow-up (**Fig. 8**).

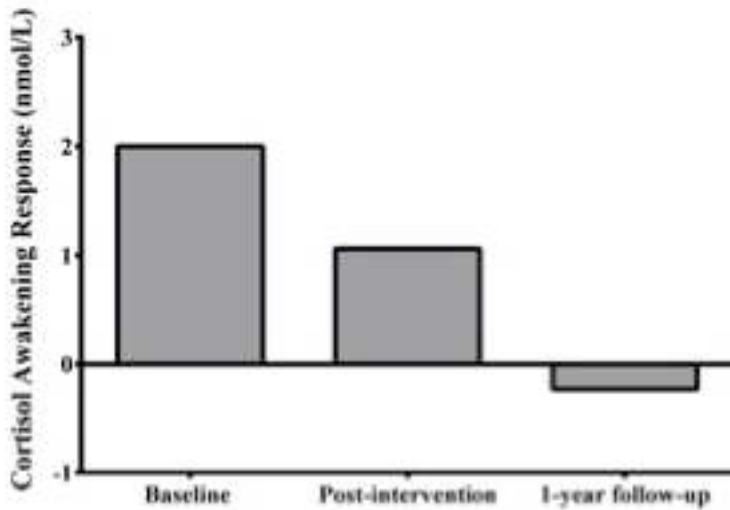


Figure 8. Cortisol awakening response by timeframe

At baseline, Abby's BMI was at the 99th percentile and her BMI remained at the 99th percentile throughout the follow-up (**Fig. 9**). Similarly, her BMI was 42 kg/m² at baseline, 41 kg/m² directly following the program, and 42 kg/m² one year later (**Fig. 10**). Likewise, Abby's percentage body fat remained stable over time (**Fig. 11**).

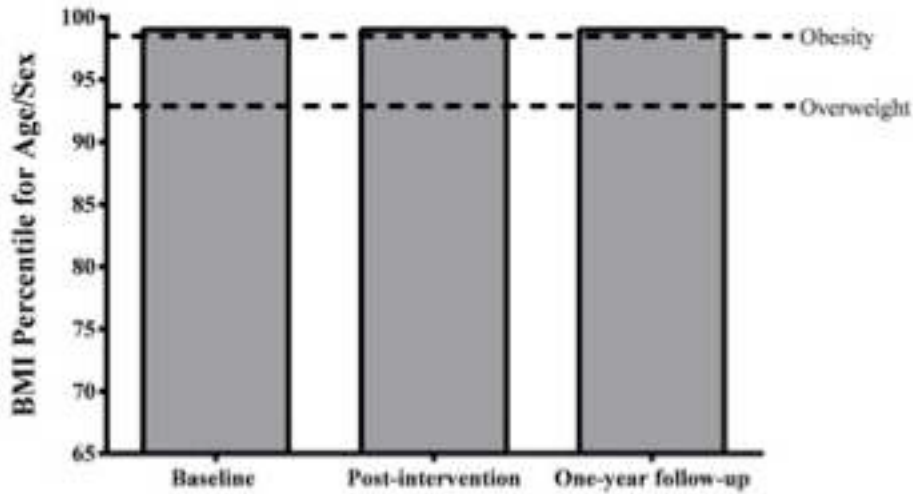


Figure 9. Body mass index (BMI) percentile for age and sex by timeframe with clinical cut-points for overweight and Obesity

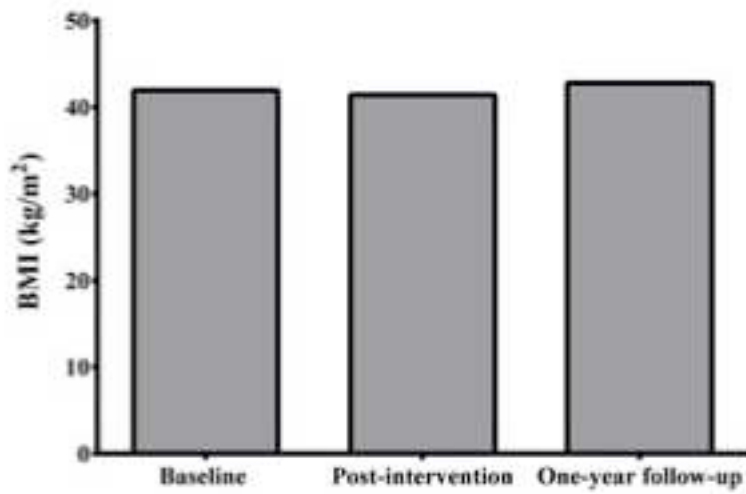


Figure 10. Body mass index (BMI) by timeframe

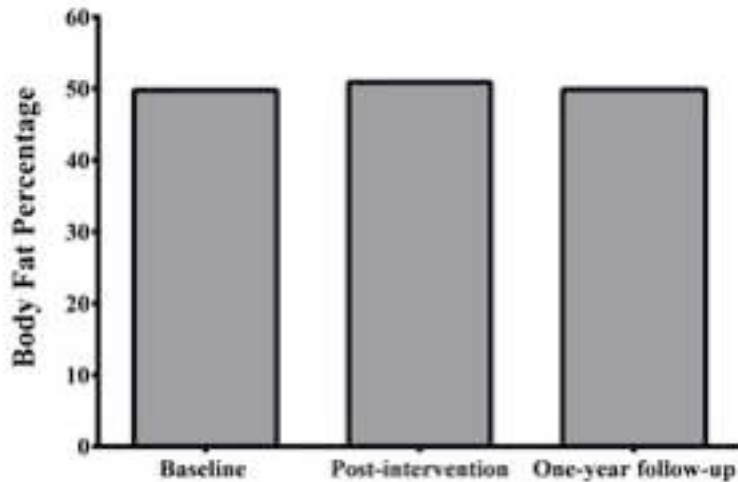


Figure 11. Percentage body fat by timeframe

At baseline, Abby had severe insulin resistance, as indicated by a HOMA-IR value of 6.18, well above a suggested, clinically elevated cut-point of 3.16 for adolescents (Atabek & Pirgon, 2007; Keskin et al., 2005). Following the completion of the intervention, her HOMA-IR was 2.84 and at one-year follow-up was 2.94, just below the recommended cut point for elevated insulin resistance in adolescents and notably decreased from her own baseline HOMA-IR (Fig. 12).

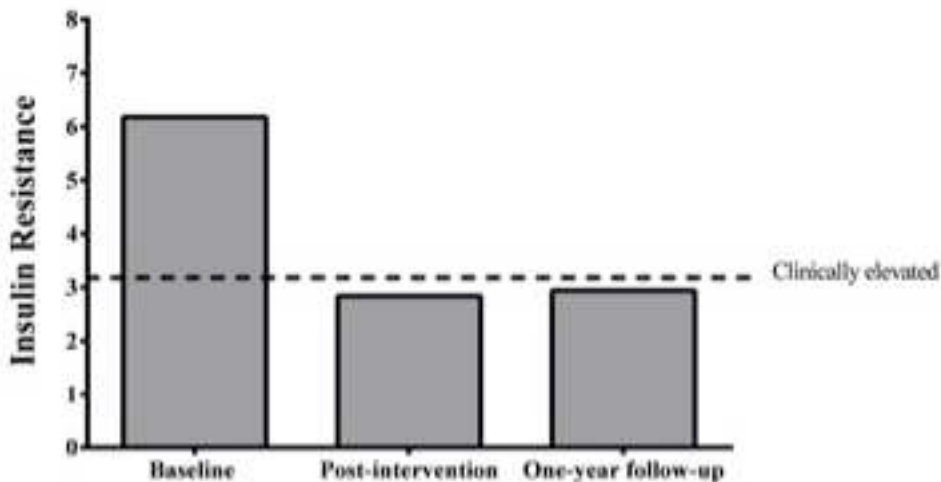


Figure 12. Homeostasis model assessment of insulin resistance (HOMA-IR) by timeframe with suggested cut-point for clinically elevated value

DISCUSSION

Consistent with prior research and the guiding theoretical model, Abby's response from participation in Learning to BREATHE illustrates a successful case example, in many ways, of a manualized mindfulness-based curriculum for the prevention of T2D for those at risk for the disease. Prior to participating in the program, Abby had several characteristics related to high risk for continued progression toward worsening insulin resistance and eventual T2D onset, including having obesity and a family history of T2D (Morrison et al., 2010). In addition, Abby had elevated insulin resistance. She had a past history of MDD in early adolescence and currently was experiencing moderately elevated depressive symptoms.

The most common intervention approach for adolescents at risk for T2D is lifestyle modification focused on reducing caloric intake and increasing physical activity in order to achieve weight loss and ameliorate insulin resistance (Nadeau et al, 2016). Unfortunately, such programs are intensive, costly, and often necessitate caregivers' own commitment to behavioral change and significant time investment; successful long-term outcomes have been limited (Wilfley et al., 2007). Utilizing an alternative approach, the Learning to BREATHE mindfulness-based intervention was designed to reduce adolescents' stress and lessen depressive symptoms in order to improve insulin resistance, regardless of weight change. Learning to BREATHE is not, by design, a weight loss program (Broderick, 2013). Consistent with these targeted outcomes, Abby had improvements in trait mindfulness and decreases in perceived stress, anxiety symptoms, and depressive symptoms, which were maintained over the course of the one year following the program.

Abby's BMI and adiposity remained stable, but her initially, clinically elevated insulin resistance decreased notably to a degree that may be considered in the high end of the normal range. Abby was in the late stages of puberty (Tanner 5), making it unlikely that this effect could be entirely accounted for by the resolution of pubertal insulin resistance. This pattern of improved insulin resistance, without BMI or adiposity change, is consistent with our theoretical foundation and past research suggesting that stress-related factors may impact insulin resistance and the T2D risk, independent of BMI or adiposity (Shomaker et al., 2011; Suglia et al., 2016).

While specific mechanisms for Abby's improvements cannot be identified with certainty, we hypothesize that each of the theoretically-proposed impacts of mindfulness might be at play. Abby saw a reduction in perceived stress, anxiety, and depressive symptoms, results congruent with the larger sample of the parent study (Shomaker et al., 2017). Abby commented on the change in her ability to recognize her experience and remain calm in situations that would have previously been distressing. Learning to BREATHE encourages participants to relate to difficult emotions and thoughts with acceptance, which can prevent stress from turning into distress. Further, while Abby did not have extensive struggles with stress-related eating behaviors, she did report periodic overeating and loss of control over her eating. At one-year after the completion of the program, these stress-related eating behaviors had remitted, suggesting that there were potential impacts on stress-related behaviors. Mindfulness-based programs, such as Learning to BREATHE, specifically train participants to attend to sensations in their bodies through recognition of how emotion manifests in the body and breath awareness. It is proposed that greater awareness of the physical and emotional internal landscape, may decouple the need to act in response to emotional cues (Forman et al., 2013). Underlying stress physiology may have also been impacted, as Abby's cortisol awakening response levels decreased following the

completion of the program and continued this trajectory at one-year follow-up. This pattern is consistent with the notion that mindfulness training may improve the ability to identify, describe, and accept stressful situations, which research suggests may buffer the physiological impact of stress (Daubenmeier et al., 2014; Teper & Inzlicht, 2013).

While BMI and family risk are important, traditional markers for T2D risk, depressive symptoms also may influence stress-related behavior and physiology that contribute to T2D risk (Holt, de Groot, & Golden, 2014). Results from Abby's case both support these findings and indicate that there may be benefits to mindfulness training in our healthcare approach for youth at risk for T2D, particularly for adolescent girls with co-occurring elevated depressive symptoms.

Lessons Learned

Use of mindfulness-based programs for prevention of T2D is new, therefore much remains to be learned about the specifics of implementation and clinical considerations for this targeted, high-risk adolescent group. Moreover, mindfulness-based interventions were originally developed and have been more extensively tested in adults (Beigel et al., 2009), calling for a more detailed explanation and considerations of how mindfulness training can be most effectively delivered with an adolescent age group. A number of adaptations to mindfulness-based programs designed for adults have been proposed to fit the unique developmental needs of adolescents, specifically: shorter duration, more activity-focused, interactive lessons, and educational components specifically related to the developing self-regulatory neural networks of the teenage brain (Bluth et al., 2016; Broderick, 2013). Abby's case highlighted additional considerations for successful implementation of mindfulness-based groups with adolescents at risk for T2D.

The Learning to BREATHE curriculum focuses activities and discussions on situations that an adolescent is likely to encounter at school, in friendships, or at home. Abby, for example, reported that she was able to relate the content that she learned during the sessions about practicing mindfulness of emotions to her everyday life, in order to become more aware of situations when she might be otherwise emotionally reactive. She particularly applied this to interpersonal interactions with friends, especially on the telephone. Facilitators learned throughout the sessions that asking the group members to share examples specific to their personal lives was very valuable in helping adolescents to most effectively connect with the activities and educational content. To encourage the open sharing of personal experience, in session one facilitators acknowledged that while all activities are completely voluntary, that much of the benefits of the program come from connecting and sharing real-life experiences, which may require sitting with discomfort. Of note, this aspect may differ from the delivery of mindfulness programs for universal prevention, such as in classroom settings, where such sharing may be less fitting.

Practicing mindfulness outside of the group sessions is an important part of the Learning to BREATHE curriculum, but as Abby reported, these were “easy to forget” about once she had left the session. Abby reported doing the informal practices with some regularity, but that the longer, more formal home practices were more difficult to integrate, a problem which has been reported previously in feasibility studies of mindfulness-based programs with adolescents, including Learning to BREATHE (Bluth et al., 2016). To ensure accessibility was not the limiting factor in the current case, facilitators utilized technology, including loaning of iPods and flash drives that were pre-loaded with practice recordings and sending recordings to participants via online drop boxes. Yet, Abby, and her peers did not have regular adherence to formal

practices. To increase accountability, facilitators of Abby's group asked for specific commitments from participants about areas of their life in which they would like to apply the informal mindfulness practices; facilitators made a record of these commitments and checked in with group members at the following session. However, this approach was not used as consistently with formal meditation practices. Helping adolescents like Abby, who often have busy schedules, think about times when they could complete the formal meditation or movement practices might increase fidelity to these practices. Additionally, using automated text or phone reminders and/or asking teens to complete a checklist for weekly home practices may be useful tools both as a reminder to complete assignments and also as means of accountability.

One notable aspect of this case is that Abby struggled with social relationships, which is highly consistent with previous literature suggesting that adolescents with overweight or obesity are frequently more likely to be peripheral to social networks and to experience social isolation and victimization (Ratcliff et al., 2011; Strauss & Pollack, 2003). Research indicates that the support of a group in which members share the same health-related risk increases the potential for change in health-related behaviors (Sorkin et al., 2014). Furthermore, even the general availability of social and emotional support has direct effects on health-promoting behaviors (Sorkin et al., 2014) and buffers the effects of stress (Cohen, 2004; Hold-Lunstad et al., 2010). Thus, increasingly positive social connection is arguably an important component of preventative interventions for T2D. While mindfulness training has the potential to improve social connectedness in adolescents (Bluth et al., 2016), we also believe that the social support that a group format provides is of particular importance in the promotion of adherence to the curriculum and ultimately health-related outcomes in adolescents at risk for T2D.

Throughout the program and directly after, Abby reported feeling awkward with her peers in the group. She specifically provided feedback on wanting more time to get to know the other participants earlier in the program. Abby's initial discomfort in the group setting indicates that thoughtful facilitation of the program is necessary to foster social connections among participants in the group. Abby acknowledged feeling uncomfortable in front of her peers during the mindful-eating exercise, but by the final session she reported feeling connected to other group members. Ensuring adequate time for the group participants to build relationships, such as by including introductions in session one, incorporating sharing in dyads and small groups, rather than with the full group, and time set aside specifically for relationship building, may allow for more feelings of comfort with sharing personal experiences.

Researchers have wondered about adolescent's ability to understand mindfulness as an intervention, given that the training elements are internal and abstract. Group facilitator's ability to elicit recognition of internal experience is of utmost importance to efficacy of a mindfulness-based program. Facilitators of Abby's group frequently asked the question "what was that like?" and "how is that different from the way you usually experience (a given situation)?" Abby frequently answered reflective questions posed to the group, including commenting on the differences in experience between mindful and mindless eating. We believe, that while the Learning to BREATHE curriculum provides a strong framework for activities and effective talking points for reflecting after activities, the facilitator's ability to move slowly enough through content to allow participants time to discuss and reflect on internal processes was key to successful outcomes for Abby.

It was regularly a challenge for facilitators to conclude Abby's group within the allotted hour given the competing the needs of allowing for relationship building and asking questions

that allow for deeper understanding of content. While the manualized program for Abby's group followed a specific research protocol, the Learning to BREATHE curriculum as used outside of the research context allows a menu of activity options that allow for flexibility in facilitation giving facilitators liberty to adapt to the needs of the group.

Considerations and Future Directions

The current case study highlights considerations for clinicians intervening with adolescents at risk for T2D, including the potential utility of a mindfulness training component for adolescents who have overweight or obesity, a family history of diabetes, and co-occurring elevated depressive symptoms. Abby's results fit well with theoretical explanations for the potential utility of mindfulness training, yet there are alternative explanations that warrant research. Larger RCT studies to further the study of specific mechanism connecting depressive symptoms and insulin resistance and the role of mindfulness are needed to test some of the hypotheses generated by this case study. While mindfulness-based intervention may offer an important component to prevention for adolescents at risk for T2D with depressive symptoms, there remain barriers to implementation. Adolescents are difficult to engage in prevention efforts, specifically because of multiple demands on time, requirements on families to invest in the process, and peer influence. Future research is essential to evaluate the optimal venue for reaching adolescents who may benefit most from prevention efforts.

This case study suggests that there may be some benefit to the use of mindfulness-based programs for prevention of T2D in adolescent girls. While this study and the majority of current T2D prevention research has evaluated mindfulness separately from lifestyle-based programs, future evaluation of the combination of the two approaches may provide helpful insight for clinicians interested in implementing a holistic approach to T2D prevention.

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