**Research Strategy**

**A. Significance**

**A1. Adolescent Mental Health Problems: A Serious Public Health Concern**

One in five U.S. adolescents meets criteria for a mental health disorder with severe impairment.15 Common mental health problems such as anxiety and depression have increased over the past decade and cost the U.S. approximately $247 billion annually.1 Adolescent anxiety and depression, even at sub-clinical thresholds, are significant risk factors for suicide, which is now the second leading cause of death among adolescents.16,17 In addition, adolescent mental health problems are also known to contribute to other long-term stress-related physical health problems such as cardiometabolic disease and type 2 diabetes.3,5,18,19 Unfortunately, adolescents who are exposed to chronic stressors such as financial instability and interpersonal violence have an increased risk of developing mental health problems: chronic stress exposure is a well-documented risk factor for the development of anxiety and depression.20 Research suggests that there are chronic-stress induced changes that occur in neurobiological and behavioral constructs such as impairments in emotion regulation (i.e., emotion regulation difficulties), which contribute to the development of depression and anxiety.6 Emotion regulation is defined as a process of influencing the intensity, duration and type of emotional expression.21 The capacity for emotion regulation and broader self-regulation increases across adolescence, corresponding with development of the prefrontal cortex, the brain region most responsible for coordinating and regulating emotional processes.22 Chronic stress exposure can have negative impacts on this developing neural circuitry, which may then contribute to the onset of mental health problems and related physical health issues. Despite knowledge about risk factors and the long-term consequences of adolescent mental health problems, the increasing rates of adolescent anxiety and depression suggest that there is an unmet need for additional research on effective ways to prevent and treat adolescent mental health problems, especially among adolescents exposed to chronic stress.

**A2. Mindfulness and Emotion Regulation: Tools for Change**

Mindfulness, one’s present moment attention and non-judgmental stance towards sensations and experiences, has been consistently associated with lower emotion regulation difficulties, depression, anxiety, insulin resistance (a precursor to type 2 diabetes) and maladaptive eating behaviors (a risk factor for obesity) among adolescents.4,23,24 According to the mindfulness stress buffering hypothesis, greater mindfulness among adults protects individuals from the impacts of stress and contributes to greater emotion regulation.9,25 Research from our team suggests that adolescents, however, may have a difficult time remaining mindful and capable of regulating their emotions in the face of life stressors when mindfulness is untrained (**Figure 1**).10 This pattern may be evident because regions in the brain that are necessary for supporting mindfulness such as the prefrontal cortex are still developing.26,27

Life stressors

Mindfulness

Emotion Regulation

Difficulties

+\*

-\*

**Figure 1.** Conceptual model of presence of life stressors contributing to significantly (\*) worse mindfulness and emotion regulation difficulties. This relationship will be tested at the momentary level within this proposal (Aim 1).

However, the mindfulness training that participants receive in mindfulness-based interventions (MBIs) has been shown to reduce emotion regulation difficulties and increase mindfulness as well as contribute to improvements in mental and physical health among adolescents.4,8,28 For example, the manualized adolescent MBI curriculum, Learning to BREATHE, has been linked with improvements in mindfulness and reductions in depressive symptoms in several adolescent samples29–31 as well as reduced insulin resistance among adolescents at risk for developing mental and physical health problems immediately after the intervention and up to one year post-intervention.4 Mindfulness training helps to improve the depletion of state emotion regulation among college students when experiencing various daily life stressors.11 Mindfulness training for adults has also been shown to improve momentary reports of depression, anxiety, positive and negative affect, and mindfulness.32–34 Work from our team has also demonstrated that without mindfulness training, adolescents have a difficult time maintaining mindfulness in the face of life stressors and therefore may benefit from targeted training to disrupt those momentary processes.10 MBIs may therefore be particularly well-suited for improving momentary, state-level processes that allow adolescents to remain mindful and emotionally regulated even when coping with life stressors (**Figure 2**). However, literature on MBI mechanisms of change for adolescents relies mostly on between-subjects, cross-sectional measurements that are subject to low ecological validity and recall bias, which limits our ability to generalize these results to real life experiences.12

**A4. Ecological Momentary Assessments and Study Significance**

The use of ecological momentary-assessments (EMA), which captures information about momentary, state-level processes and is high in ecological validity, is ideally suited to investigate therapeutic mechanisms of change,35 but it has never been used within an adolescent MBI.13,14 EMA involves real-time repeated sampling of an individual’s experiences within their natural environment.35 These repeated measurements can reduce recall bias and maximize ecological validity. EMA also allows for the investigation of microprocesses that give rise to behaviors; therefore, they are ideally suited to investigate mechanisms of change such as mindfulness and emotion regulation difficulties.35 In addition, research suggests that EMA has greater sensitivity to detect changes in depression, anxiety and mindfulness after an MBI clinical trial when compared to the standard retrospective pen-and paper approach.32 Notably, EMA has been used to examine mechanistic changes that may occur during and after an MBI among college students.11 Specifically, it was discovered that college students who were involved in an MBI compared to a control were more likely to maintain healthy emotion regulation when faced with family-related stressors.11 Although these results are promising, research on mechanistic changes that occur among adolescents involved in an MBI is limited; studies with adults may not be generalizable for adolescents who are still experiencing rapid physical and neurodevelopmental changes. Without the evaluation of MBI mechanisms of change using ecologically valid measurement methods, the MBI theoretical models of change for adolescents remain in question. **This proposal represents the first test of the theorized mechanisms of change using EMA in the context of an adolescent MBI**.

Given the importance of clarifying adolescent MBI theoretical models of change, this proposal will incorporate EMA measurements of mindfulness, emotion regulation difficulties, and life stressors among 80 adolescents exposed to chronic stressors and involved in a larger randomized controlled trail where adolescents within a mentoring program are randomized to receive either a 10-week mentoring program with an MBI, Learning to BREATHE (MBI+Mentoring), or mentoring-as-usual (Mentoring). **The proposed study is significant because it will provide critical new information about how MBIs target mindfulness and emotion regulation at that the momentary, state-level***.* This knowledge can be used to inform further research on how improving state mindfulness and emotion regulation through an adolescent MBI can improve integrative mental and physical health problems among adolescent exposed to chronic stress. Consistent with the mission of NCCIH, this project aims to identify how MBIs target mechanisms of change and help adolescents to maintain mindfulness and emotion regulation in moments where they are faced with a life stressor.

**Figure 2.** Conceptual model of Aim 2. MBI+Mentoring will ameliorate the impacts of life stressors on momentary, state-levels of mindfulness (a1ns), and emotion regulation difficulties (a2ns), by rendering the relationships non- significant (*ns*). For Mentoring, relationships between the variables for will remain significant (a1\*, a2\*). Burst represents pre (0), mid (1) and post-intervention (2) EMA measurements.

*For MBI+Mentoring: a2* ***ns***

*For Mentoring: a2****\****

Mindfulness

MBI+Mentoring (1) vs. Mentoring(0) X Burst (0=pre-intervention)

Life stressors

Emotion Regulation Difficulties

a3\*

a4\*

*For MBI+Mentoring: a1* ***ns***

*For Mentoring: a1****\****

**B. Innovation**

This F31 proposal is innovative in its approach, methodology, and research question. This proposal will be the first to utilize ecological momentary assessment (EMA) to investigate theorized mechanisms of change within the context of an adolescent MBI. Although EMA can be successfully implemented with adolescents, it has not been utilized within the context of an adolescent mindfulness-based intervention (MBI).13,14 Further, the research question is unique and innovative as *no research exists* on how adolescent MBIs are effective at targeting mindfulness and emotion regulation at the momentary, state level. By answering the question “does participation in an MBI compared to a control allow adolescents to be more mindful and regulated in moments when there is a stressor?”, we will gain *entirely new information* about how MBIs impact the theorized mechanisms of change, which will be used to inform mechanistic research on how to best improve mental and physical health problems among adolescents exposed to chronic stress.

**C. Preliminary Data**

Our team has carried out a number of steps to ensure the feasible and acceptable completion of the parent randomized controlled trial study and the inclusion of the ecological momentary assessment (EMA) measures added for the unique aims of the proposed F31 project:

1. ***Learning to BREATHE adaptations***: In Fall 2019, the PI and the Sponsor met with the leadership team of the mentoring program called Campus Connections to discuss ways of adjusting the mindfulness-based intervention, Learning to BREATHE, to fit within the context of the mentoring program. The Learning to BREATHE program was planned to be facilitated over 10 sessions for 35 minutes a session during the Spring of 2020 to pilot test the feasibility and acceptability of the program. During this pilot test, adolescents received four sessions of Learning to BREATHE before COVID-19 caused university and global closures. Although the pilot test was stopped due to COVID-19, this data suggests that conducting an MBI within the context of a mentoring program is feasible.
2. ***Feasibility of recruitment***: The recruitment goal of the current proposal is to enroll 80 adolescents exposed to chronic stressors. The feasibility of these numbers is supported by data which suggests that Campus Connections serves approximately 250 adolescents per year. In the spring of 2020, Campus Connections provided trained staff to consent 118 (87% of all participants) for the spring semester. In addition, the parent study aims to enroll 80 adolescents during fall 2021 and 80 during spring 2022; therefore, the current proposal will only need to enroll ~50% of participants who are enrolled in the parent study. Conservative estimates were made to account for the impact that COVID-19 may have on enrollment.
3. ***Acceptability of Campus Connections***: Adolescents were surveyed two months after Campus Connection ended (~June 2020) to access for feasibility and acceptability. On average, adolescents involved in MBI+Mentoring stated that they ‘greatly enjoyed’ the program, which did not significantly differ from those involved in Mentoring (p=.92). The parent RCT will resume in the Fall of 2021 and continue through the Spring of 2021 with the intention of enrolling a total of 160 adolescents. This data suggests that the inclusion of the MBI was acceptable and did not disrupt the regular mentoring program as most adolescents stated that they greatly enjoyed the program as a whole.
4. ***Feasibility of EMA***: We have utilized our past research to explore whether EMA is feasible to conduct with adolescents in Campus Connections. Our prior research suggests that when prompted, adolescents complete daily diary measurements at relatively high rates (~88%). For example, when adolescents were prompted to report mindfulness and emotions over the course of 7 days, adolescents completed an average of 6.2 days of measurements. We have also designed the EMA portion of this study to follow the recommendations for compliance that were outlined in a meta-analysis of EMA research with adolescents.36 These recommendations include promoting adolescents 2-3 times a day as opposed to 4-5 times a day. The reviewed research also suggests that incentives are standard, but that compliance doesn’t depend on the amount of compensation provided. It also suggests that most EMA studies utilized smartphones; therefore, our proposal will do the same.36,37

**D. Approach**

**D1. Participants**

The target sample size for this proposal is N=80 adolescents (ages 11-18 years) referred to a community-based mentoring program, Campus Connections, for being “at-risk for not reaching their full potential” (e.g., department of human services [DHS] involvement, behavioral/emotion concerns). Based on estimates from the spring of 2020, approximately 47% of adolescents had some type of DHS involvement, 63% of parents did not have a college degree, 63% of the families reported making less than $50,000 per year and 25% of the families lived below the poverty line. Collectively, these socio-demographic features suggests that adolescents served by Campus Connections are at risk for chronic stress exposure. 40 adolescents will be randomized to receive MBI+Mentoring and 40 will be randomized to receive Mentoring (**Table 1**). Campus Connections occurs over two nights per week for 12 weeks each academic semester where different adolescents are served on different nights. Randomization will be completed by night to ensure that adolescents do not receive both conditions.

|  |  |  |  |
| --- | --- | --- | --- |
| Table 1. Participants | | | |
|  | Fall 2021 | Spring 2022 | Total by Group |
| MBI+Mentoring | 20 | 20 | n=40 |
| Mentoring | 20 | 20 | n=40 |
| Total by Cohort | n=40 | n=40 | **N=80** |

**D2. Procedure**

Adolescents will be consented at least two months before Campus Connections begins. Learning to BREATHE will begin the second week of Campus Connections and take place over the following 10 weeks for 35 minutes a night. Smartphone-based EMA measurements will be administered across 3 evenly spaced bursts (pre-intervention, mid-intervention, post-intervention), each lasting for 10 days. Adolescents will receive semi-random signals outside of school hours (3-9pm) to complete an EMA report and they will have 30 minutes to reply (See **Table 2** for general overview). EMA methodology was selected based on past research, which suggests that EMA can be successfully implemented with adolescents and does not act as an effective intervention, but rather as an assessment of momentary processes.13,38 EMA bursts were selected to represent pre-, mid- and post-intervention change and were evenly spaced across the intervention as modeled in previous EMA mindfulness research.11 EMA measurements will be delivered to adolescents’ smartphones through the TigerAware Software.39

**Table 2.** General Procedures for One Cohort

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| EMA Pre-  Intervention 3x per day | Campus  Connections Starts | MBI+Mentoring vs. Mentoring Begins | EMA Mid-  Intervention 3x per day | MBI+Mentoring vs. Mentoring Ends | Campus  Connections Ends | EMA Post-  Intervention 3x per day |

**D3. Measures and Variables.** EMA measurements will include items for momentary reports of life stressors, mindfulness, and emotion regulation difficulties. I will also include demographic variables and a question about previous mindfulness experience at baseline.

1. ***Life stressors*** (independent variable). Following a protocol outlined by Hankin, Fraley, and Abela,40 participants will respond to the questions, “Since the last time you answered these questions, have you experienced at least one stressful life event?” Adolescents will then be asked to write down up to three stressful events that have occurred since the last response period and then rate each event’s severity on a scale from 1 (‘not at all severe’) to 5 (‘extremely severe’). Severity scores will be summed for each moment, with higher scores indicating greater severity of life stressors. Life stressors will be used as an independent, continuous variable.
2. **Momentary mindfulness** (dependent variable). Participants will complete items assessing two key dimensions of momentary mindfulness: mindful attention/awareness and mindful non-judgment. Two dimensions of mindfulness were selected based on prior research on daily reports of mindfulness among adolescents.12 Items will be drawn from reliable and valid measurements of mindfulness, and modified to correspond to the momentary assessment timeframe.41,42 Both mindful attention and non-judgment will be evaluated separately as continuous dependent variables.
   1. ***Mindful attention and awareness.*** Participants will complete thefive-item Mindful Attention and Awareness Scale.41 Participants will rate the extent to which they were currently (i.e., at the moment of data collection) having each experience (e.g., “I am preoccupied with the past or future”) on a 7-point Likert scale from 0 (‘not at all’) to 6 (‘very much’). Items will be revere scored and then averaged for each EMA measurement, such that higher scores will indicate greater levels of momentary mindful attention and awareness.
   2. ***Mindful non-judgment.*** Participants will complete the five-item mindful non-judgment subscale from the Five-Facet Mindfulness Questionnaire-Short Form.42 Participants will rate how much they are currently having each experience (e.g., “I tell myself that I shouldn’t be feeling the way I’m feeling”) on a 5-point Likert scale from 1(‘not at all’) to 5(‘very much’). Items will be revere scored and then averaged for each EMA measurement, such that higher scores will indicate greater levels of mindful non-judgment.
3. ***Momentary emotion regulation difficulties*** (dependent variable). Participants will complete the six-item non-acceptance subscale of the State-Difficulties in Emotion Regulation Scale (S-DERS).43,44 Participants will rate how much each item applies to their emotional experience in the current moment (e.g., “I am embarrassed for feeling this way”) on a 5-point Likert-type scale from 1 (“not at all”) to 5 (“completely”). Items for each EMA measurement will be averaged, such that higher scores will indicate greater emotion regulation difficulties. The original DERS has been validated for use among adolescents45 and the S-DERS is a valid and reliable adaptation of this measure intended to capture state-based emotion regulation difficulties.43 The non-acceptance subscale was selected based on prior research on mindfulness and emotion regulation, which suggests that non-acceptance was a particularly important dimension to consider.46 Momentary emotion regulation difficulties will be used as a dependent, continuous variable.
4. ***Intervention Arm*** (predictor/moderator). Adolescents will be randomized to receive MBI+Mentoring or Mentoring. Participation will be coded as 1 for MBI+Mentoring and 0 for Mentoring. Intervention Arm will be used as a categorical predictor (i.e., moderator) of the relationship between life stressors and mindfulness and emotion regulation difficulties. This variable will only be used to test Aim 2.
5. ***EMA Burst*** (predictor/moderator)***.*** Adolescents will complete three bursts of EMA measurements: pre-intervention, mid-intervention and post-intervention. Bursts will be dummy coded to determine if mid-intervention and post-intervention participation differs from baseline participation (dummy code=0). An interaction term will be created for intervention arm x EMA burst to determine if this predicts the relationship between life stressors, mindfulness and emotion regulation difficulties. This variable will only be used to test Aim 2.
6. ***Demographic variables*** (controls)***.*** Adolescents will report on their age, ethnicity and gender identity at baseline. Parents of adolescents will complete questions about income and highest level of education. These variables will be controlled for in all analyses.

**D4. Analyses/expected outcomes and statistical plan.** Multilevel structural equation modeling will be used for all analyses. Multilevel structural equation modeling is extremely flexible and capable of handling missing data and intensive repeated measurements across multiple levels of data.47–49 The study design of the current proposal is a 2-level multilevel structural equation model with momentary assessment as level 1 and individual as level 2, which is in line with past EMA research.49,50 Intervention arm, burst, and demographic control variables are between-subjects’ variables that fall within level 2. Demographic variables will be controlled for in all models.

**Specific Aim 1**. The goal of aim 1 is to characterize the real-time, dynamic relationships between life stressors, state mindfulness and state emotion regulation difficulties in N=80 adolescents exposed to chronic stressors. We will use multilevel structural equation modeling to evaluate this aim. It is expected that at baseline (pre-intervention), greater severity of life stressors will be associated with lower mindfulness in the same moment and the next moment. Greater severity of life stressors is also expected to be associated with greater emotion regulation difficulties in the same moment and the next moment.

**Specific Aim 2.** The goal of aim 2 is to investigate the extent to which adolescents’ participation in MBI+Mentoring (n=40) vs. Mentoring (n=40), changes the real-time, dynamic relationships between life stressors, state mindfulness and state emotion regulation difficulties. We will use multi-level structural equation modeling to test this aim. It is expected that for adolescents involved in MBI+Mentoring at mid-intervention and post-intervention compared to pre-intervention, there will be non-significant relationships between life stressors and mindfulness in the same moment and in the next moment. There will also be non-significant relationships between life stressors and emotion regulation difficulties in the same moment and in the next moment for adolescents involved in MBI+Mentoring. For adolescents involved in Mentoring, the control group, the relationships between life stressors, mindfulness and emotion regulation difficulties in the same moment and in the next moment will remain significant.

**D5. Power analyses.** For Aim 1, all data will come from baseline (pre-intervention) EMA measurements. At baseline, 80 participants will complete 30 momentary measurements. This will yield an estimated 2,400 total measurements at baseline. Intraclass correlations (ICC) for all variables are expected to be medium to large based on previous research and data from our lab.11 Accordingly, we will have 80% power to detect small, medium and large effect sizes according to a simulation study conducted by Arend and Shaffer.51 For Aim 2, all EMA data will be utilized. 80 participants will complete 90 moments of data, which will result in an estimated 7,200 total measurements. Although previous literature on random slope variance is sparse, Arend and Schäfer recommend estimating random slope variance to be approximately medium when previous literature is not available.51 In line with the tables provided by Arend and Schäfer,51 this proposal goes above and beyond the power estimates tables, which suggests that we will have power to detect medium and large effect sizes.

**D6. Potential problems and alternative strategies**. One potential problem is that some adolescents may not have smartphones to complete EMA data collection measurements. Any adolescent without a smartphone will be provided with one by the research team. Additionally, some adolescents may become complacent when responding to EMA measurements across all three bursts. Any adolescent that has low responses rates (<50%) within the first two days of each burst will be contacted for trouble shooting. Adolescents will also be provided with incentives for answering each EMA measurements. Adolescents will receive $1 for the first measurement per day and then an additional 50 cents for each measurement after that. In addition, adolescents will only be prompted to answer questions 3 times a day, which is in line with compliance recommendations from a meta-analysis of EMA research studies conducted with adolescents.36