



A Non-randomized Trial of Kundalini Yoga for Emotion Regulation within an After-school Program for Adolescents

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Accepted: 24 January 2021 / Published online: 12 February 2021

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Abstract

Adolescence is a critical age for developing difficulties with emotion regulation and other psychosocial problems. Yoga programs implemented in schools may be a promising method of intervention, as previous research suggests that they improve emotion regulation and other psychological outcomes in adolescents. This study examined the effects of the Kundalini Yoga-based Y.O.G.A for Youth (Y4Y) after-school program on adolescents' self-reported emotion dysregulation and psychological functioning. A sample of 119 students, ages 11–14, was recruited through after-school programs for middle school students in the North Carolina school system. Within four public schools, participants participated in 6 weeks of either the Y4Y after-school program ($n = 52$), or an alternate activity ($n = 66$) and completed self-report measures of emotion dysregulation, anxiety, depression, stress and mindfulness before and after the 6 weeks. Results from this study suggest that the students who participated in the Y4Y program reported significant decreases in emotion dysregulation over the 6-week program. They also reported significant decreases in anger, depression and fatigue over one yoga session. Students in the comparison condition only reported significant decreases in fatigue over one session of the program but reported no significant changes in any of the other outcomes. Results from exploratory between-subject analyses also suggested that the Y4Y program's impact on depression, stress and anxiety depended on the school setting in which they were implemented. These findings suggest that the Y4Y program improved emotion dysregulation in adolescent students. However, some of its benefits may be influenced by the school environment.

Keywords Yoga intervention · YOGA for Youth · Kundalini · Socio-emotional learning · Emotion regulation · Adolescents

Highlights

- We studied the effects of the Kundalini yoga program on adolescents' emotion dysregulation and psychological functioning.
- A sample of 119 adolescents from four public schools participated in either the yoga program or an alternate activity.
- Students who participated in the yoga program reported significant decreases in emotion dysregulation across the program.
- Students in the yoga program also reported significant decreases in anger, depression and fatigue over one yoga session.
- Students in the comparison condition only reported decreases in fatigue over one session of the alternative activity.

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1007/s10826-021-01911-9>.

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Adolescence is a particularly critical age for psychological health development as children learn how to navigate and cope with new emotional challenges over this period of cognitive, emotional, social, and physiological change (Dahl, 2004; Silvers et al., 2012; Steinberg, 2005). Because many debilitating forms of psychopathology can develop during adolescence (Beauchaine, 2015; Kessler & Wang, 2008; Roberts et al., 2009), intervention and prevention efforts must target processes underlying such dysfunction in order to promote healthy psychological development.

Emotion regulation, the ability to manage one's emotional experiences, has received increasing attention from developmental researchers, educators, and health providers for its crucial role in healthy child development and mental well-being (Adrian & Veits, 2011; Gross & Muñoz, 1995; Weinberg & Klonsky, 2009). Difficulties managing emotions, or *emotion dysregulation*, have been linked to a wide range of emotional and behavioral problems in children, such as conduct problems and aggression (Compas et al., 2001; Eisenberg, 2000; Eisenberg et al., 1996; Frick & Morris, 2004; Modecki et al., 2017). Emotion dysregulation may even lead to more serious forms of psychological dysfunction, such as anxiety (Mathews et al., 2016; Suveg & Zeman, 2004) and depression (Garnefski et al., 2003; Silk et al., 2003; Yap et al., 2007). In addition, adolescents from low socioeconomic communities are often exposed to life stressors, such as childhood maltreatment, neighborhood violence, and lower residential quality, that may increase the risk of developing emotion dysregulation (Raikes & Thompson, 2005; Raver, 2004). Therefore, there is a pressing need for developmental interventions to help adolescents develop healthy psychological functioning.

The National Center for Complementary and Integrative Health (2011) considers yoga a mind-body intervention that usually incorporates physical postures, relaxation, meditation, and breathing exercises. Yoga programs have recently been implemented in school settings and may be a promising form of intervention for psychosocial problems in adolescence. A recent review found that school-based yoga programs improved several psychological problems, such as tension, anxiety, and mood (Khalsa & Butzer, 2016). Some studies have investigated the effects of school-based yoga programs on emotion regulation (Daly et al., 2015; Kokinakis, 2011). One study found that a yoga program that incorporated postures, breathing, relaxation, and guided meditation improved students' emotion regulation significantly more than a comparison program of physical education (Daly et al., 2015). Other studies found that a yoga-based social-emotional wellness promotion program that includes yoga postures, breathing techniques, centering meditation, and lessons on social-emotional health improved emotion regulation, emotional arousal, and coping strategies in response to stress in urban youth (Frank et al., 2014; Frank et al., 2017). Therefore, these findings suggest that school-based yoga programs have potential beneficial effects on psychological health and emotion regulation in adolescents, yet more empirical research is needed to determine these effects.

One such program, called Your Own Greatness Affirmed dba Y.O.G.A. for Youth (Y4Y), teaches Kundalini yoga to students in elementary, middle, and high schools within predominantly African American and Latino communities

(Sarkissian et al., 2018). Kundalini yoga is a type of yoga that utilizes particular sequences of physical postures and emphasizes breathing and meditation. Kundalini yoga incorporates *kriyas*, specific combinations of exercises that are intended to improve physiological, mental, and emotional functioning. The Y4Y program utilizes Kundalini yoga because of accessibility to people of different ages as it requires no special equipment or particular physical flexibility. In addition, previous evidence has demonstrated its benefits on psychological functioning. For example, Kundalini yoga emphasizes cultivating self-awareness and has demonstrated effectiveness in treating depression (Devi et al., 1986), stress (Granath et al., 2006), and several other types of psychiatric disorders, such as obsessive-compulsive disorder, anxiety disorders, and substance use disorders (Shannahoff-Khalsa, 2004). The Y4Y program prioritizes serving youth who can benefit from learning how to cope with behavioral and emotional problems (Sarkissian et al., 2018) by providing a series of classes that follow a standardized curriculum of Kundalini yoga with explicit instruction of yogic principles to enhance students' understanding of the practice. One study found that this program significantly improved students' self-reported stress, affect, and resilience (Sarkissian et al., 2018). This research suggests that the Y4Y program may lead to benefits in managing stress and emotional challenges in students in urban, high-minority school settings. This study, conducted in schools in Southern California, was the first to investigate the effects of this program on students' emotional well-being (Sarkissian et al., 2018). However, it is not yet known if this school-based yoga program can improve emotion dysregulation in adolescents.

There are also limitations in the previous studies that can be improved on in further empirical research. First, although stress, resiliency, and mood are certainly related to emotion regulation, there is a need to capture changes in emotion dysregulation with rigorous, valid measures validated in child and adolescent populations (Zeman et al., 2007). Second, it is yet unknown if the Y4Y program has different effects across various school settings. For example, more research is needed to evaluate the effects of the Y4Y Kundalini yoga classes beyond the urban communities in Southern California, which may have more awareness of or access to yoga practices than in other parts of the United States. This research could greatly inform dissemination and implementation efforts across the nation and help us interpret the generalizability of the previous study's findings (Sarkissian et al., 2018). Third, this previous study provided only preliminary findings with a small sample and without a comparison group. Therefore, the present study aims to build on these preliminary findings while addressing these limitations in study design by including a non-randomly formed comparison group.

Using a non-randomized trial design with a comparison group would make an important contribution to the literature on the psychological effects of yoga in adolescents. Many previous studies in this topic did not incorporate a comparison group in their research design (Khalsa & Butzer, 2016), which makes it difficult to interpret whether the findings can be attributed to the effects of the yoga or effects of other potentially confounding factors, such as time or engagement in an activity. Findings from non-randomized trials can make useful contributions to empirical research (Axelrod & Hayward, 2006; Rubin, 1974) and as a result, researchers have recently used this type of design to study the psychological effects of yoga in adults (Bragard et al., 2017; Cho et al., 2015) and children (Jeitler et al., 2020; Khalsa et al., 2013; Razza et al., 2015). Non-randomized trials can be particularly useful for providing preliminary evidence in the early stages of development of new interventions before investing the resources into a full randomized clinical trial. In addition, findings from this type of trial can be highly ecologically valid, as they can generalize to yoga programs implemented in real school settings that give students the choice to enroll. The present study builds on this previous research because, to our knowledge, it is the first to investigate a Kundalini yoga program in adolescents with a non-randomized trial design.

In sum, yoga programs implemented in schools have the potential to improve psychological health and emotion regulation in adolescents. The current study investigated the effects of the Y4Y program on middle school students' emotion dysregulation and related psychological constructs across four public schools in North Carolina using a non-randomized trial design. Based on previous research (Khalsa & Butzer, 2016), we hypothesized that the Y4Y program would improve students' self-reported emotion dysregulation, depression, anxiety, stress, and mindfulness. We also explored within-subject effects of the alternative activity and potential between-subject group differences on the changes in these constructs.

Material and Methods

Participants

Students participating in the research study were enrolled in after-school programs at four public schools (i.e., School A, School B, School C, and School D) in Orange County and Chapel Hill-Carrboro school systems, North Carolina. Historically, these after school programs were administered by the non-profit organization Communities in Schools of Orange County (CIS), and were offered free of charge, targeting students having academic and/or behavioral challenges. In the CIS afterschool programs, teachers from

the schools were hired to supervise and staff the after-school programming. Students had the opportunity to choose one program among several different types of after-school programs. The Your Own Greatness Affirmed dba Y.O.G.A. for Youth (Y4Y) program was a series of Kundalini yoga classes that the students could choose as their after-school program. Other after-school programs included outdoor play or tutoring. The after-school programs were open to all students but prioritized enrolling those who were considered those most at risk of academic and behavioral challenges by the schools and CIS. During the years of data collection (2016–2017), students had to be recommended by a parent, teacher, social worker, or counselor in order to participate in the program. For example, parents recommended students if they needed childcare, a counselor could recommend students if they needed social or emotional remediation, or a teacher recommended students if they needed academic help. For further context regarding the school communities, 23.9% of all students in School A, 25.2% of all students in School B, 30.5% of all students in School C, and 26.6% of all students in School D were economically disadvantaged, according to the standards of State Board of Education's report on public schools of North Carolina.

Participants in our total sample were 118 adolescents. Demographics for the entire sample are provided in Table 1.

Table 1 Demographics for entire sample

Gender	
Male <i>N</i> (%)	55 (46.6)
Female <i>N</i> (%)	63 (52.5)
Grade	
6th <i>N</i> (%)	63 (53.3)
7th <i>N</i> (%)	30 (25.0)
8th <i>N</i> (%)	25 (20.8)
Race/ethnicity	
African-American <i>N</i> (%)	51 (42.5)
Latino <i>N</i> (%)	29 (24.2)
White <i>N</i> (%)	18 (15.0)
Asian <i>N</i> (%)	12 (10.0)
Multi-racial <i>N</i> (%)	7 (5.8.0)
Did not specify <i>N</i> (%)	1 (0.01)
Academic achievement	
Math 2014 percentile (SD)	40.04 (30.95)
Reading 2014 percentile (SD)	38.78 (32.79)
Math 2015 percentile (SD)	34.53 (30.39)
Reading 2015 percentile (SD)	37.11 (31.92)
Math 2016 percentile (SD)	37.80 (31.67)
Reading 2016 percentile (SD)	35.25 (31.36)

Academic achievement is assessed by state-wide "End-of-Grade tests" administered to grades 3–8 in North Carolina public schools. Age ranges for grade 6 are 11–12 years, grade 7 are 12–13 years, and grade 8 are 13–14 years

End-of-Grade tests of reading comprehension and mathematics were administered to grades 3–8 as part of an assessment program in North Carolina. Percentile rank compares students' performance to that of all North Carolina students who took the test in the norming year, with higher percentiles indicating higher levels of achievement (see Table 1). Participants in this study were primarily students of ethnic minority backgrounds (i.e., African-American and Latino) and of lower than average academic achievement by statewide standards. Fifty-two students were included in the yoga condition, and 66 were included in the comparison condition. Our power analyses indicate that with a Type-I error rate of 5% and 34 participants per condition, we would have at least 80% power to detect a medium effect size with paired-sample *t*-test analyses. With a Type-I error rate of 5% and a total sample size of 128, we would have at least 80% power to detect a medium effect size with analyses of variance. Therefore, we were adequately powered for paired-sample *t*-test analyses to detect within-subject changes in our outcomes separately for the yoga and comparison conditions.

Study Procedures

The after-school programs (including the Y4Y program and the alternate programs) took place in four public middle schools in North Carolina over 6-weeks, with two 40 min classes per week (Monday/Wednesday or Tuesday/Thursday). Two schools had the after-school programs in the Fall semester of 2016 and the other two in the Spring of 2017.

Participants were recruited for the study from the after-school programs through a passive, opt-out consent procedure. Y4Y North Carolina teachers and one of the study's principal investigators visited each school at the start of the semester to provide orientation sessions for students and staff. These sessions were held to explain the purpose and benefits of a yoga practice, the elements of a Y4Y class, expectations for behavior during yoga classes, and to answer any questions. After the orientation, students at each school were given the choice of participating in the Y4Y yoga program or the other after-school activities such as homework, free time, and outdoor play. All students who enrolled in the after-school programs, as well as their parents/guardians, were informed by a parental notification letter that they could participate in a study on the psychological effects of the Y4Y program. The study had no exclusion criteria and the research protocol was approved by the Institutional Review Board of Duke University. Students who provided assent to our study and chose the Y4Y program for the after-school program were included in our yoga condition and students who provided assent to our study and chose an alternate activity for the after-school program (e.g., homework, outdoor play, etc.) were included in our comparison condition.

For all data collection procedures, the research team administered the measures to all participants in paper format during scheduled data collection sessions at the schools. In these sessions, students participating in the study gathered in a large classroom, where members of the research team distributed the questionnaire packets and gave detailed instructions for answering questionnaires with examples. Extra instructions were given for reverse-scored measures, such as the Mindful Attention and Awareness Scale for Adolescents (see below). The research team answered any questions from the students while they filled out the questionnaires (i.e., if they had difficulty understanding the language of the items). The main questionnaires (The Difficulties in Emotion Regulation Scale-Short Form, the Depression, Anxiety and Stress scale, and the Mindful Attention and Awareness Scale for Adolescents) were administered to all student participants at two timepoints: once during the week before the programs started (time 1) and once during the week after the program finished (time 2). Furthermore, the Profile of Mood States for Adolescents was administered at two other timepoints: once before (time 1a) and once after (time 2a) one class for both the yoga and comparison conditions (i.e., at the beginning and at the end of one Y4Y yoga class or one single session of the alternative after-school program) midway through the 6-week program. Students were given snacks at the conclusion of each session of data collection to compensate for their participation.

Intervention: The Y.O.G.A. for Youth Program

The non-profit Your Own Greatness Affirmed dba Y.O.G.A. for Youth (Y4Y) organization provided a series of two weekly yoga classes for 6 weeks, offered as one of the after-school programs. Y4Y classes teach Kundalini Yoga as taught by Yogi Bhañan[®] (Bhañan, 2007), adapted for educational settings. Y4Y teachers are Yoga Alliance-certified 200 h teachers who have also undergone Y4Y's 40 h specialty training and have been mentored as Teaching Assistants by a Lead Teacher before becoming Lead Teachers themselves. Each yoga class was taught by a Y.O.G.A. for Youth Lead Teacher, assisted by a Y4Y teacher assistant. At each of the four school locations, classes were divided by students' gender identification (there was a girls' class and a boys' class at each school) and were offered simultaneously. A total of five Lead Teachers and five teacher assistants taught at the four sites (see Supplementary Table 1). Three of the five Lead Teachers and three of the five Teacher Assistants taught at more than one school in different pairings.

The Y4Y training targets the teaching of underserved youth and covers the Y4Y curriculum structure and content, trauma-informed yoga practices, and classroom management. Each class consists of chanting an opening mantra, breath practice, physical warm-ups, a kriya (specific sequence of

physical postures that may incorporate specific breath patterns, eye focus, and hand positions), meditation, relaxation, and a closing song. Additionally, a Y4Y class includes learning based on eight principles derived from the practices of the Eightfold Buddhist path (Vetter, 1988): Right Understanding, Right Intention, Right Speech, Right Action, Right Livelihood, Right Attitude, Right Mindfulness, Right Concentration. These principles are often taught through group discussion or additional explanation throughout the class to enhance students' understanding of the yogic principles underlying these different activities. In this program, specific breath practices are utilized and each posture or movement in Kundalini Yoga are intended as physical exercise, meditation, and a method of increasing self-awareness (Bhajan, 2007). Postures are used to isolate specific muscles and put pressure on specific points or areas of the body. Meditation in Kundalini Yoga utilizes specific hand positions, specific eye foci, as well as a specific breath pattern or sound/mantra. The same class curriculum was applied in each of the four schools. A sample class curriculum is provided in Supplementary Table 2. For the students in the yoga condition, School A had 62.2% attendance, School B had 40% attendance, School C had 42.3% attendance, and School D had 69.8% attendance on average for each yoga class.

Outcome Measures

Difficulties in Emotion Regulation Scale-Short Form (DERS-SF; Kaufman et al., 2016)

The DERS-SF is an 18-item self-report measure of difficulties to regulate emotions effectively. Items are rated on a Likert scale ranging from 1 (*almost never*) to 5 (*almost always*). The DERS-SF has high internal consistency within adolescent samples, ranging from 0.79 to 0.91 (Kaufman et al., 2016). In the present study, the Cronbach's alphas for the total score were 0.91 at time 1 and 0.87 at time 2. This measure yields a total score that assesses general emotion dysregulation and six subscales (3 items each) that capture different facets of emotion dysregulation, including (1) *nonacceptance*, difficulty accepting negative emotions (Cronbach's alphas in the present study were 0.82 at time 1 and 0.66 at time 2); (2) *goals*, difficulty in emotional situations with pursuing goal-directed behaviors (Cronbach's alphas in the present study were 0.83 at time 1 and 0.79 at time 2); (3) *impulsivity*, difficulty controlling impulses, (4) *strategies*, lack of regulation strategies (Cronbach's alphas in the present study were 0.88 and 0.83 respectively); (5) *awareness*, problems with emotional awareness (Cronbach's alphas in the present study were 0.56 at time 1 and 0.77 at time 2); (6) *clarity*, problems with understanding and discriminating emotions clearly (Cronbach's alphas in the present study were 0.66 at time 1 and 0.67 at time 2).

Mindful Attention Awareness Scale-Adolescent (MAAS-A; Brown et al., 2011)

The MAAS-A is a 14-item scale designed to assess dispositional mindfulness, defined as a tendency to be in a receptive state of mind of present-moment awareness. Items are rated on a Likert scale from 1 (*almost always*) to 6 (*almost never*) and the measure is calculated as the average score across all items. The MAAS-A has been validated for use with community and clinical adolescent populations from ages 14 to 18 years old (Brown et al., 2011). The MAAS-A has demonstrated high internal consistency (above 0.80), test-retest reliability, and both concurrent and incremental validity. In the present study, the Cronbach's alpha was 0.89 at time 1 and 0.91 at time 2, which indicate high internal consistency.

Depression Anxiety Stress Scale-21 (DASS-21; Lovibond & Lovibond, 1995)

The DASS-21 is an abbreviated version of the full self-report measure of depression, anxiety and stress. This measure has shown strong psychometric properties, as internal consistencies range from 0.82 to 0.93 in large, non-clinical samples (Henry & Crawford, 2005). In this measure, participants rate 21-items on a Likert Scale of 0 (*did not apply to me at all*) to 3 (*applied to me very much, or most of the time*) and yields a total score and three subscale scores (7 items each) for (1) anxiety (Cronbach's alphas in the present study were 0.79 at time 1 and 0.75 at time 2); (2) depression (Cronbach's alphas in the present study were 0.87 at time 1 and 0.87 at time 2); and (3) stress (Cronbach's alphas in the present study were 0.80 at time 1 and 0.73 at time 2). In the present study, the Cronbach's alpha for the total score was 0.92 at time 1 and 0.90 at time 2.

Profile of Mood States-Adolescents (POMS-A; Terry et al., 1999)

The POMS-A is a 24-item scale in which participants rate 24 emotion words on a Likert scale ranging from 1 (*not at all*) to 5 (*extremely*) based on how strongly they feel that emotion in that moment. The POMS-A has shown strong psychometric properties in adolescent samples (Terry et al., 1999). This scale measures six dimensions of current mood (4 items each): 1. anger (Cronbach's alphas in the present study were 0.77 at time 1 and 0.78 at time 2), confusion (Cronbach's alphas in the present study were 0.78 at time 1 and 0.65 at time 2), depression (Cronbach's alphas in the present study were 0.77 at time 1 and 0.78 at time 2), fatigue (Cronbach's alphas in the present study were 0.85 at time 1 and 0.87 at time 2), tension (Cronbach's alphas in the present study were 0.79 at time 1 and 0.83 at time 2), and

vigor (Cronbach's alphas in the present study were 0.64 at time 1 and 0.58 at time 2).

Analytic Plan

The primary aim of the study was to test whether there are changes in emotion dysregulation, depression, anxiety, stress, and mindfulness from before (time 1) to after (time 2) reported by the students in the yoga program. A secondary aim was to assess these changes in those enrolled in the alternative after-school programs. For all the following analyses, the alpha level was set a-priori at 0.05, two-tailed. Secondary aims were to assess these changes in those enrolled in the alternative after-school programs and to explore differences in the changes demonstrated by these two groups on key outcome variables. Due to the low internal reliability of the DERS-SF subscales, we used the total score as the measure of emotion dysregulation. On the other hand, the stress, anxiety, and depression subscales of the DASS-21 all demonstrated acceptable internal reliability, so these three subscales were used to measure these constructs. The total score for the MAAS-A was used as the measure of mindfulness, as the reliabilities were also acceptable for this scale. The assumption of normality was not violated, as assessed by an inspection of Q-Q plots. Given that the lack of randomization in the study design may lead to problems with selection bias, we also conducted analyses of variance (ANOVA) to examine whether there were baseline group differences between the students in the yoga and comparison conditions. Results from these analyses revealed no significant group differences in emotion dysregulation ($p = 0.979$), stress ($p = 0.135$), depression ($p = 0.592$), anxiety ($p = 0.618$), and mindfulness ($p = 0.622$) at time 1. We also conducted Pearson Chi-Square tests to determine if there were group differences in ethnicity or gender. These results revealed no significant differences between the yoga and comparison conditions in either ethnicity ($p = 0.998$) or gender ($p = 0.609$).

To address our primary aim, paired samples t -tests were used to determine whether there were statistically significant mean differences between the main outcomes across the after-school programs, from time 1 to time 2. For our secondary aim, we conducted the same analyses within the comparison condition. For all of these analyses, we addressed the issue of missing data with multiple imputation for missing data with five imputations using the Markov chain Monte Carlo method (Schafer, 1997) to preserve power. Out of the full sample, 32 students in the yoga program completed this measure at both timepoints, and 39 students in the comparison condition completed the measure at both timepoints. (60.2% of the full sample). See Fig. 1 for a flow chart of enrollment and attrition for main outcome measures. Results from Little's MCAR test

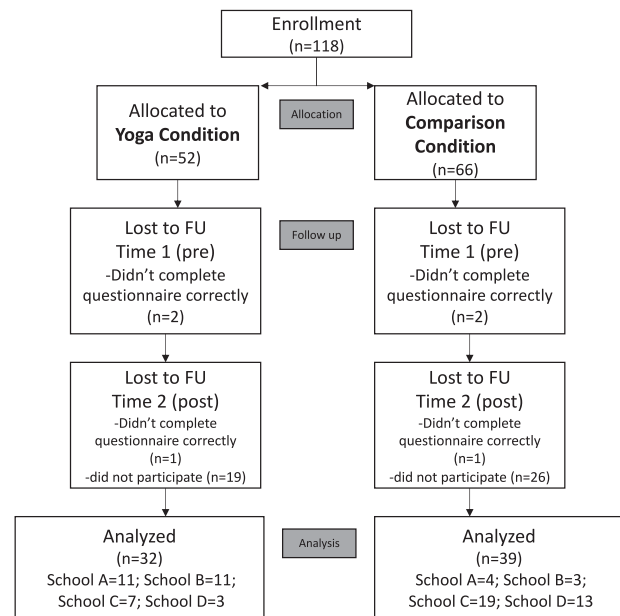


Fig. 1 Flow Chart of Enrollment and Attrition for the Main Outcome Measures of Emotion Dysregulation, Depression, Anxiety, Stress, and Mindfulness. Note: This figure shows the number of students out of the full sample of 118 participants who completed the main outcome measures, including the Difficulties in Emotion Regulation Scale-Short Form (DERS-SF; Kaufman et al., 2016), Depression Anxiety Stress Scale-21 (DASS-21; Lovibond & Lovibond, 1995), and Mindful Attention Awareness Scale-Adolescent (MAAS-A; Brown et al., 2011). Note that allocation to the two conditions were based on participants' selection of after-school programs

suggested that missing data is missing at random ($\chi^2 (103, N = 118) = 94.3, p = 0.718$). There were no significant outliers in the imputed data.

To explore group differences between the yoga and comparison conditions across the different school settings, we also conducted supplementary analyses investigating the effect of condition on these outcome measures with two-way analyses of covariance (ANCOVA) in the original data. Separate ANCOVA analyses were conducted for each outcome measure, with condition (yoga vs. comparison) and school (School A, School B, School C, and School D) as the between-subject fixed factors, and the score from time 2 was the dependent variable, controlling for the score on time 1.

Finally, we conducted within-subject analyses to investigate changes in mood over one session of the programs, assessed by the difference between participants' POMS-A scores before one session of the after-school program started (time 1a) and their scores after the session completed (time 2a). Out of the full sample, 32 students in the yoga program completed this measure at both timepoints, and 18 students in the comparison condition completed the measure at both timepoints. See Fig. 2 for a flow chart of enrollment and attrition for the mood measure. We used paired sample t -test analyses to test the differences between self-reported mood assessed at time 1a and scores at time 2a

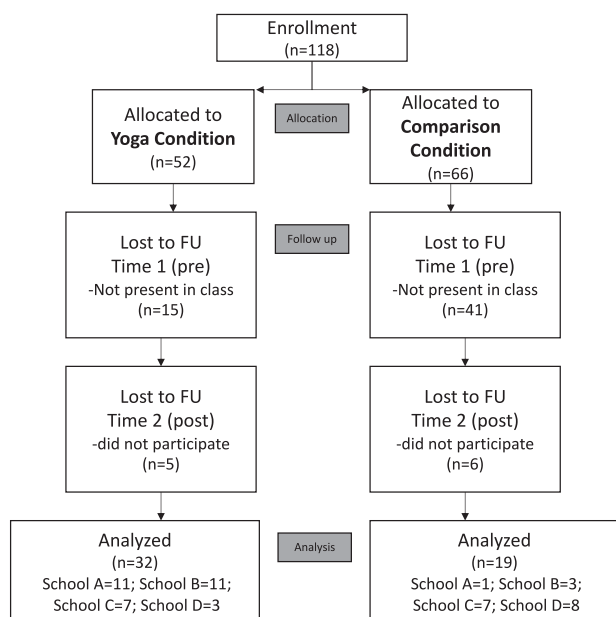


Fig. 2 Flow Chart of Enrollment and Attrition for the Mood Scale. Note: This figure shows the number of students out of the full sample of 118 participants who completed the mood scale, the Profile of Mood States-Adolescents (POMS-A; Terry et al., 1999). Note that allocation to the two conditions were based on participants' selection of after-school programs

separately for the yoga and comparison conditions. Due to the low internal reliability of the confusion and vigor subscales, we only used anger, depression, fatigue, and tension subscales in our analyses. The assumption of normality was not violated, as assessed by an inspection of Q-Q plots. We detected outliers with boxplots by condition and Winsorized these outliers by reducing them to the closest value. Due to the high proportion of missing data in this measure, multiple imputation was not appropriate for these analyses so missing values were excluded from these analyses. Given that selection bias may also be a consideration with mood, we also conducted analyses of variance (ANOVA) to examine whether there were baseline group differences in mood between the students in the yoga and comparison conditions. Results from these analyses revealed no significant group differences in anger ($p = 0.567$), depression ($p = 0.111$), fatigue ($p = 0.968$), and tension ($p = 0.591$) at time 1a, before the session.

Results

Primary Analyses in Yoga Condition

Main outcome measures

Results from the paired sample t -test analyses of changes in emotion dysregulation (assessed by the DERS-SF) from before to after the after-school programs are displayed in

Table 2. Within the students in the yoga program, there was a significant decrease of 4.98 in emotion dysregulation from time 1 to time 2, $t(25) = 2.48$, $p = 0.021$. Results from the paired sample t -test analyses of differences in depression, anxiety, and stress (assessed by the DASS-21) before and after the after-school programs are displayed in Table 2. There were no significant changes in depression, anxiety or stress in either condition (all $p > 0.05$). Results from the paired sample t -test analyses of differences in mindfulness (assessed by the MAAS-A) before and after the after-school programs are displayed in Table 2. There were no significant changes in (all $p > 0.05$).

Mood

Results from the paired sample t -test analyses of changes in mood from before to after a single session of the after-school program are displayed in Table 3. Within the students in the yoga program, there was a significant decrease in anger (mean difference = 0.34), depression (mean difference = 0.30), and fatigue (mean difference = 0.63) from time 1 to time 2.

Secondary Analyses in Comparison Condition

Main outcome measures

Within students in the comparison condition, there was no significant change in emotion dysregulation $t(11) = 0.691$, $p = 0.504$. There were no significant changes in depression, anxiety, stress or mindfulness in this condition (all $p > 0.05$). Results from the paired sample t -test analyses of differences are displayed in Table 2.

Mood

Results from the paired sample t -test analyses of changes in mood from before to after a single session of the after-school programs are displayed in Table 3. Within students in the comparison condition, there was only a significant decrease of 0.46 in fatigue from time 1 to time 2 over one session of the alternate after-school activity.

Supplementary Analyses

Detailed results from two-way Analyses of Covariance exploring group differences between the yoga and comparison conditions across the different schools are provided in Supplementary Materials. See Supplementary Table 3 for means and standard deviations of the main outcome measures by school and condition. Briefly, results from the analyses with the DERS-SF scale (total score) revealed a significant main effect of condition on emotion dysregulation across all

Table 2 Results from *t* test analyses for within-subject changes in emotion dysregulation, stress, anxiety, depression, and mindfulness in the yoga condition and the comparison condition

	Yoga condition						Comparison condition					
	Time 1		Time 2		<i>t</i>	<i>p</i>	Time 1		Time 2		<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
DERS-SF	34.77	11.27	29.96	6.8	2.48	0.021*	39.35	13.09	38.78	10.33	0.691	0.504
DASS-21 Stress	5.52	4.21	4.24	3.79	1.38	0.173	5.83	5.06	5.17	4.48	-0.25	0.807
DASS-21 Depression	4.00	4.23	2.57	3.38	1.03	0.316	4.30	4.99	4.30	5.08	-0.98	0.337
DASS-21 Anxiety	4.08	3.67	3.88	4.48	0.20	0.845	5.11	5.21	4.92	4.27	-1.26	0.215
MAAS-A	4.55	1.12	4.57	1.14	-0.12	0.906	4.25	1.32	4.34	1.11	0.09	0.929

Mean scores and standard deviations from original data. Results from paired *t*-test analyses for the main outcome measures, assessed before the after-school program (time 1) and after the after-school program (time 2) in the imputed data. Measures include the Difficulties in Emotion Regulation Scale-Short Form (DERS-SF; Kaufman et al., 2016), Depression Anxiety Stress Scale-21 (DASS-21; Lovibond & Lovibond, 1995), and Mindful Attention Awareness Scale-Adolescent (MAAS-A; Brown et al., 2011). All statistics are presented separately for the yoga and comparison conditions

* $p < 0.05$

Table 3 Results from *t* test analyses for within-subject changes in mood in the yoga condition

	Yoga condition						Comparison condition					
	Time 1a		Time 2a		<i>t</i>	<i>p</i>	Time 1a		Time 2a		<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Anger	1.88	1.10	1.53	0.89	2.23	0.033*	1.67	0.76	1.52	0.7	0.92	0.369
Depression	1.66	0.90	1.36	0.69	2.40	0.023*	1.31	0.42	1.35	0.62	-0.39	0.699
Tension	1.68	0.96	1.43	0.71	1.97	0.058	1.42	0.48	1.36	0.60	0.42	0.679
Fatigue	2.63	1.25	2.00	1.22	3.26	0.003*	2.57	1.16	2.11	1.24	2.73	0.014*

Mean scores, standard deviations, and results from paired *t*-test analyses for the Profile of Mood States-Adolescents (POMS-A; Terry et al., 1999), assessed before (time 1a) and after (time 2a) one single after-school program session. These statistics are presented separately for the yoga condition with outliers included and without outliers (i.e., excluding the outliers of that particular mood subscale). Note that fatigue had no outliers

* $p < 0.05$

four schools ($p < 0.001$). The analyses with the subscales of the DASS-21 revealed significant interaction effects between school and condition on stress ($p = 0.019$), anxiety ($p = 0.002$) and depression ($p = 0.040$). Specifically, the students in the yoga program at School A reported more significant decreases in anxiety ($p = 0.001$), stress ($p < 0.001$), and depression ($p < 0.001$) than the students in the comparison condition. However, these effects were not significant within the other three schools, School C, School B, and School D (all $p > 0.05$). On the other hand, the students in the yoga program at School C reported significant increases in anxiety compared to students in their comparison condition ($p = 0.036$).

Discussion

For this study, we examined self-reported changes in emotion dysregulation, anxiety, depression, stress, and

mindfulness in students who participated in the Your Own Greatness Affirmed dba Y.O.G.A. for Youth (Y4Y) Kundalini yoga after-school program and in students who participated in an alternative after-school program. Participants in this sample were recruited from four public schools in North Carolina within predominantly African American and Latino communities. The results from our study suggest that students in this yoga program reported significant decreases in emotion dysregulation across the 6-week program. We also found that students reported significant decreases in anger, depression, and fatigue over one single Y4Y class session. The students in the comparison condition reported significant decreases in fatigue across one session of the alternative after-school programs. Taken together, these findings suggest that the Y4Y program improved emotion dysregulation in this adolescent, public-school student population. The effects on depression, anxiety, and stress, on the other hand, varied among different school settings.

In line with our hypotheses and with previous research (Frank et al., 2014, 2017; Kokinakis, 2011), the Y4Y program significantly reduced emotion dysregulation in this population. These results extend findings from the previous study on Y4Y that demonstrated this program's positive effects on students' emotional well-being (Sarkissian et al., 2018). We also found that students in the yoga condition reported significant decreases in anger, depression, and fatigue over one yoga class. Several aspects of the Y4Y program may have contributed to these beneficial effects. The program emphasized different meditation practices, which have been shown to improve healthy regulation of emotions, including awareness of emotions and enhanced goal-directed behaviors (Chambers et al., 2009; Roemer et al., 2015). Beyond the meditation practices, the program's teachings of the yogic principles asked students to reflect on longer-term goals and values, such as what they consider "right actions" or "right livelihoods" and how they want to pursue them. This kind of instruction may encourage students to engage in behaviors informed by long-term goals instead of behaviors driven by short-term emotional reactions. As there are many aspects of yoga that could affect emotion regulation processes (Gard et al., 2014), future research efforts should investigate if specific components or the synergistic effect of all the components of this yoga program contribute to improvements in emotion dysregulation. Future research efforts should also investigate the program's direct effects on mood with larger sample sizes.

Results from our supplemental, between-subject analyses revealed that some of the effects of the Y4Y program varied among the different schools. These preliminary findings may suggest that the yoga program may affect stress, anxiety, and depression differently across the different schools. Given that the Y4Y classes followed a standardized curriculum across schools and that teachers received the same training, it is unlikely that our findings can be attributed to variations in the yoga classes in the different schools. However, reporting, recording or monitoring of the integrity of individual yoga sessions was not implemented in this study, and so this possibility cannot be ruled out. Instead, the differences in school environment may partially explain these differences observed across school settings. Even though we recruited student participants from public schools in the same geographic region, the four schools varied greatly in their administration of the after-school program, the alternative activities offered, the approaches to classroom management, and the general school climate. Although Y4Y requested that after school staff actively participate in the yoga programming, actual participation by staff varied between sites. For example, School C tended to have the lowest attendance rates for the yoga classes out of the four schools while School A had among the highest.

However, without further empirical evidence, we can only generate hypotheses about why the effects of the Y4Y program varied among different school settings. Although previous research has demonstrated the psychological benefits of school-based yoga programs in students (Khalsa & Butzer, 2016), these findings highlight the need for future studies to systematically assess different environmental factors that may support the efficacy of such programs, such as management of classroom behavior and student engagement (Sarkissian et al., 2018).

Limitations

This study has several limitations that must be taken into consideration when interpreting these results. The most notable limitation is the lack of randomization in our study design, as students enrolled in the Communities in Schools of Orange County (CIS) after-school programs were allowed to choose their activity (Y4Y classes vs. alternative activities). The most notable limitation of non-randomized interventional study designs is the potential of biased effects (Des Jarlais, Lyles, Crepanz, & TREND Group, 2004; Thiese, 2014). For example, the group differences found in this study may be attributed to specific characteristics of students who were most likely to choose the Y4Y program instead of the effects of the program itself. We have taken several steps to examine potential biases, including demonstrating that there were no significant group differences in important preintervention attributes (e.g., socio-demographics or baseline scores on outcome measures) according to recommendations for analyzing data from non-randomized clinical trials (Axelrod & Hayward, 2006; Shadish et al., 2012). However, the risk of bias still warrants cautious interpretation of group differences between the two conditions, such as potential confounding effects of other unmeasured variables. Although the lack of randomization is a significant limitation of this study design, findings from non-randomized trials that are transparently reported can contribute important data. Therefore, future studies testing the impact of yoga interventions in schools may utilize randomized study designs. Secondly, we did not find significant changes in self-reported mindfulness between the two conditions. This null finding may be attributed to students' difficulty in understanding items on the Mindful Attention Awareness Scale for adolescents (Brown et al., 2011), which asked students to report on abstract, meta-cognitive awareness (e.g., "I could be experiencing some emotion and not be conscious of it until some time later"). Similar to issues raised in previous research evaluating yoga programs in schools (Daly et al., 2015; Sarkissian et al., 2018), some students in our sample had difficulty reading and understanding the questions. Although we also gave detailed instructions about how to complete the

questionnaires, the reverse-scoring on the MAAS-A may have also confused some students and led to inaccurate responses. Research within diverse community settings should use and develop self-report measures that are appropriate for a wide range of reading and comprehension levels. Another limitation of this study is the lack of standardization of the after-school activities in the comparison condition. Students in the comparison condition engaged in a wide range of activities, such as homework, music class, or free outdoor play, which makes it difficult to identify what aspects of the yoga program were most effective. Given these limitations, the design of this study was intended to study the effects of this yoga program with as much empirical rigor as was feasible.

Despite these limitations, our study found that this after-school-based Kundalini yoga program improved emotion dysregulation in adolescents. These findings imply that this type of program may improve adolescents' ability to manage their emotions in healthy ways. Secondly, we found that this program's effect on other related problems, such as anxiety, depression, and stress, varied across different school settings. School-based yoga programs have become increasingly popular in the past two decades, these results suggest that more attention be given to understanding the local context and complexity of school environments which can either enhance or undermine specific interventions. These results have important implications for school-based yoga programs, as some school environments may enhance their benefits more than others.

Data Availability

Data and related experimental details cannot be made openly accessible because the authors do not have the permission to do so.

Acknowledgements We wish to acknowledge many people who helped with this multi-site, applied research study. First, we want to thank the students from University of North Carolina-Chapel Hill and Duke University who participated as team members on the Duke Bass Connections project from Fall 2016-Spring 2017: Sarah Jeffries, Marah Jolibois, Matthew Kaplan, and Sue Leichter. We also want to thank everyone at the North Carolina public schools and the Y.O.G.A for Youth staff that contributed their efforts to the after-school program.

Funding This work was supported by Duke University Bass Connections.

Author Contributions KM: designed and executed the study, conducted the data analyses, and wrote the paper. MB: designed and conducted the study, and edited the paper. KKK: designed and conducted the study, including the yoga class protocol, and wrote several sections of the paper. EH: conducted the study and edited the paper. SBSK: collaborated in the writing and editing of the final manuscript.

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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