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THE ANXIOLYTIC EFFECTS OF EXERCISE AND MINDFULNESS

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THE ANXIOLYTIC EFFECTS OF EXERCISE AND MINDFULNESS

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ABSTRACT

Problem Statement and Background: Anxiety is prevalent and associated with high comorbidity and reduced quality of life. The efficacy of disseminable, inexpensive methods of anxiety management need to be studied. Such methods, including exercise (EX) and mindfulness practice (MP), have been shown to be effective compared to traditional treatments such as Cognitive Behavioral Therapy or pharmaceuticals. However, there is limited work investigating these methods, or their combination, in an anxious population.

Methods: Females (N = 970) were screened from the university population to identify those with high levels of anxiety (≥ 3 on GAD-2 screen). Fifty-six anxious females (M age = 19.3 yrs) were recruited to participate in one of four randomized 20-min conditions in a 2x2 design using acute bouts of mindfulness (MP) and/or exercise (EX). The conditions included: EX+MP; EX+distraction video (noMP); noEX+MP and noEX+noMP. The STAI-Y was used to measure state and trait anxiety. A 2x2 repeated measures ANOVA was used to test the effects of EX, MP, and their interaction on state anxiety at baseline, and immediately-, 5-, 10-, and 20 mins post-task. Follow-up ANCOVAs were used to test differences between groups at each time point, while controlling for baseline anxiety.

Results: There were no evident interaction effects, but there were significant main effects of MP [$F(2.73,142)=7.71$, $p<.05$, partial $\eta^2=.13$], EX [$F(2.73,142)=5.03$, $p<.05$, partial $\eta^2=.09$], and time [$F(2.73,142)=18.71$, $p<.05$, partial $\eta^2=.27$] on state anxiety. Follow-up ANCOVAs showed that the MP groups had significantly lower anxiety than the noMP groups immediately after the task [$M=30.14$, $SD=7.05$ vs. $M=35.07$,

SD=9.77; $F(1,53)=16.71$, $p<.001$, partial $\eta^2=.24$], and 5 min post-task [*M*=30.12, *SD*=7.55 vs. *M*=34.29, *SD*=9.94; $F(1,53)=11.23$, $p=.001$, partial $\eta^2=.18$]. The EX groups had significantly higher anxiety (*M*=35.17, *SD*=9.58) than the noEX groups [*M*=29.65, *SD* = 6.86; $F(1,53)=6.79$, $p<.05$, partial $\eta^2=.11$].

Conclusions: Overall, mindfulness practice had the greatest anxiolytic effect. Although there were reductions in state anxiety in the EX groups, the effects were notably stronger immediately post-task in those who did not exercise (noEX+MP and noEX+noMP). This was surprising given the previous research, but we did find that those who exercised and watched the video were significantly more anxious than those exercising who engaged in the mindfulness practice immediately and 5 minutes after exercise. Future studies should investigate exercise and mindfulness treatments over more variable timeframes, and at different intensities to further explicate the dynamics of these disseminable anxiety management strategies.

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PREFACE

This thesis is written to comply with the University of Rhode Island graduate school Manuscript Thesis Format. This thesis contains one manuscript: *The Anxiolytic Effects of Acute Bouts of Mindfulness Practice and Aerobic Exercise*. This manuscript has been written in a form suitable for publication in the *Journal of Alternative and Complementary Medicine*.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

MANUSCRIPT

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This manuscript was formatted and prepared for publication in the *Journal of Alternative and Complementary Medicine*.

ABSTRACT

Objectives. Anxiety is prevalent and associated with high comorbidity and reduced quality of life. The efficacy of disseminable, inexpensive methods of anxiety management need to be studied. Such methods, including exercise (EX) and mindfulness training (MT), have been shown to be effective compared to traditional treatments, such as Cognitive Behavioral Therapy or pharmaceuticals. However, there is limited work investigating these methods, or their combination, in an anxious population.

Methods. Females (N = 970) were screened from a university population to identify those with high levels of anxiety (≥3 on GAD-2 screen). Fifty-six anxious females (M age=19.3 yrs) were recruited to participate in one of four randomized 20-min conditions in a 2x2 design. The conditions included: EX+MP; noEX+MP; EX+distraction video (noMP); and noEX+noMP. State anxiety was measured using the STAI-Y at baseline, and again 5, 10, and 20 min post-task. A 2x2 repeated measures ANOVA was used to test the effects of EX, MP, and their combination on state anxiety each time point.

Results. There were no evident interaction effects, but there were significant main effects of MP [$F(2.73,142)=7.71$, $p<.05$, partial $\eta^2=.13$], EX [$F(2.73,142)=5.03$, $p<.05$, partial $\eta^2=.09$], and time [$F(2.73,142)=18.71$, $p<.05$, partial $\eta^2=.27$] on state anxiety. Follow-up ANCOVAs showed that the MP groups had significantly lower anxiety than the noMP groups immediately after the task [$M=30.14$, $SD=7.05$ vs. $M=35.07$, $SD=9.77$; $F(1,53)=16.71$, $p<.001$, partial $\eta^2=.24$], and 5 min post-task [$M=30.12$, $SD=7.55$ vs. $M=34.29$, $SD=9.94$; $F(1,53)=11.23$, $p=.001$, partial $\eta^2=.18$]. The EX

groups had significantly higher anxiety (*M*=35.17, *SD*=9.58) than the noEX groups [*M*=29.65, *SD* = 6.86; *F*(1,53)=6.79, *p*<.05, partial η^2=.11].

Conclusions: Overall, MP had the greatest anxiolytic effect. Although there were reductions in state anxiety in the EX groups, the effects were notably stronger immediately post-task in those who did not exercise; however, 20 min post-task anxiety in the EX groups remained low, while the noEX groups returned to levels comparable to baseline. Future studies should investigate exercise and mindfulness treatments over more variable timeframes to further explicate the dynamics of these disseminable anxiety management strategies.

INTRODUCTION

As a group, anxiety disorders are among the most common mental health conditions, and are known to cause significant functional impairment[1]. Anxiety is characterized by excessive worry and is often accompanied by increased stress. In 2010, the American Psychological Association (APA) reported that women were more likely than men to declare having a great deal of stress (28% vs. 20%), and 49% of the women surveyed said their stress had increased over the past five years[2].

Standard treatments for anxiety include pharmacotherapy, psychotherapy, or a combination of the two[3]. However, pharmaceuticals are associated with unpleasant side effects and high cost, which may promote early withdrawal from treatment[3,4]. Psychotherapy can also be costly, and many patients have difficulty adhering to the adequate number of sessions required for any treatment effects to transpire[5]. Therefore, the efficacy of potentially less expensive, aversive, and more disseminable methods of anxiety treatment need to be investigated and evaluated.

Alternative methods of anxiety treatment, including mindfulness, and aerobic exercise, have been investigated and shown to be effective in comparison to traditional treatments, such as cognitive behavioral therapy (CBT)[6] and pharmaceuticals[4]. Research has shown that aerobic exercise decreases levels of anxiety in both normal and high-anxious individuals[7]. There is also strong evidence of a relationship between low physical activity levels and increased levels of anxiety[8,9]. Likewise, interventions that include the component of mindfulness, defined as the practice of focusing attention and awareness on the present moment without judgment, have also produced significant anxiolytic effects[10].

Mindfulness

Mindfulness practice, sometimes known as mindfulness meditation, is a form of non-judgmental attention and awareness characterized by keeping a conscientious focus on internal and external experiences in the present moment[11,12]. This includes bringing awareness to sensations, thoughts, bodily states, consciousness, and the environment, while simultaneously encouraging openness, curiosity, and acceptance[10,13–15]. The cognitive aspects of mindfulness, such focusing on breathing, may create changes in cognitive processes associated with anxiety that are distinct from other validated stress-management approaches[10,16].

Two well-known mindfulness-based therapy interventions are mindfulness-based stress reduction (MBSR)[15] and mindfulness-based cognitive therapy (MBCT)[17]. Both have become very popular forms of treatment in contemporary psychotherapy[10,18–21]. The main feature of MBSR is the cultivation of mindfulness, and the accepted standard format is a sequence of eight weekly 2 1/2-hour classes, plus a 6-hour all-day class at week 6, totaling 26 hours of class time[18,22]. In an analysis investigating the optimal length of an MBSR program, Carmody and Baer found no evidence that shortened versions of MBSR are less effective than the standard protocol in reducing psychological distress[22].

In spite of the robust evidence in support of the anxiolytic effects of MBSR programs on mental and physical outcomes[13,16,23–25], few studies have investigated the effects of an acute bout of mindfulness practice. One study compared three interventions, mindfulness meditation, sham mindfulness (not given the guided instructions pertinent to the practice of mindfulness), and quiet rest, given in 20

minute sessions on three consecutive days in groups of five to eight[26]. Results showed a significant decrease in state anxiety from the baseline to the end of the intervention in both the mindfulness meditation and sham groups, but not the control. This brief intervention supports the idea that practicing mindfulness in short bouts can positively affect psychological variables, both in traditional and non-traditional form, and both of which were more effective than quiet rest.

Exercise

Aerobic exercise, another alternative approach to anxiety treatment, has been shown to have anxiolytic effects on subjects with both clinical and subclinical levels of trait anxiety, as well as individuals with normal levels of anxiety[7,27,28]. The physiological responses of an acute bout of exercise regulate negative psychological states, including neuroendocrine changes, increases in body temperature, changes in central serotonergic systems, and increases in endorphin production[7,29].

Experiencing a sense of mastery and increased self-efficacy following a bout of physical activity may also help reduce anxiety by decreasing experiences of psychological distress[30,31]. Increased positive affect and tranquility responses, and reduced negative affect and fatigue responses are also proposed consequences of aerobic exercise, especially in subjects with higher levels of exercise experience and self-efficacy[32]. However, others have reported discomfort at the beginning of an exercise regimen, which may increase negative affect[33]. To prevent potential negative affect due to exercise discomfort, it has been suggested to start out individuals at low intensities to enhance psychological benefits[34].

Several meta-analyses[7,35–377,35–37] and reviews[29,38] have contributed to what we know about the effects of exercise on anxiety. In 1991, Petruzzello and colleagues published results of a meta-analysis that reviewed 124 studies reporting effects of acute and chronic exercise on either self-reported state and/or trait anxiety[7]. There were significant effect sizes for state anxiety for acute exercise (ES = 0.23) and chronic exercise (ES = 0.25). When state anxiety of participants were compared before and after a treatment the effect size was larger (ES = 0.47) than studies that compared exercise to a motivational control (ES = 0.26), and a no-treatment control group (ES = 0.22). There were also significant differences between aerobic and nonaerobic exercise (ES = 0.26, and ES = -0.05, respectively). With respect to length of exercise session, bouts lasting 0 to 20 minutes yielded significantly lower effect sizes (ES = 0.04) versus bouts lasting between 21 and 30 minutes (ES = 0.41). The largest effect size were observed for intensities of 60-69% (ES = 0.27) and >80% of the individual's maximal effort (ES = 0.33).

Contrary to the empirical support that exercise has a positive effect on anxiety, a more recent meta-analysis of studies including clinically anxious subjects found that aerobic exercise was only beneficial when compared to a placebo or waitlist control conditions, but not in comparison to other evidence-based treatments (i.e. CBT or pharmaceuticals)[35]. A better understanding of how exercise may be employed as a behavioral treatment for anxiety in a normal to high-anxious population needs to be reached.

To our knowledge, only one study has been published that tests the psychological effects of an acute mindfulness practice session and compared it to

aerobic exercise and a quiet rest control in healthy males (N = 75, mean age = 51 years)[39]. Results showed a significant decrease over time for the three groups. Subjects were further split into two groups, high and normal levels trait anxiety based on baseline scores, and anxiety still significantly decreased over time for both groups. These results suggest that a 20-minute bout of aerobic exercise, meditation, or quiet rest will reduce anxiety to the same degree. However, the form of meditation used for this intervention, the Benson Relaxation Response[40], does not encompass all components of mindfulness, as previously defined. The literature still lacks a fair comparison between a traditional mindfulness practice and aerobic exercise, nor has it explained if there is an additive effect when the two methods are combined, or what the effects would be for females.

The purpose of the present study was to compare the anxiolytic effects of acute bouts of mindfulness and aerobic exercise, as well as the combined effects in a sample of high-anxious females. This data may be useful in designing future interventions for normal to high-anxious individuals. The hypothesized outcomes were (1) that participants who engaged in an acute bout of moderate-intensity aerobic exercise would have lower levels of state anxiety post-exercise than those who did not engage in exercise[7,28,41–44]. (2) Participants in the mindfulness practice conditions would have lower levels of anxiety post-practice than those in the video distraction group[45]. (3) There would be an additive effect when the two treatments were given at the same time, such that state anxiety would be significantly lower compared to the other groups.

METHODOLOGY

Participants were recruited from undergraduate classes at the University of Rhode Island. A screening questionnaire was distributed by research staff to filter the population for individuals meeting the inclusion criteria. Of the screening questionnaires collected (N = 970), the females between the ages of 18 and 25 who scored 3 or higher on the generalized anxiety disorder screen (GAD-2), which is the recommended cut-off for potential anxiety disorder[46]. Those who qualified and indicated interest in participating in the study (N = 62) were contacted and asked to schedule an orientation session. In return for their participation, subjects were entered into a raffle for a $25 gift card. Individuals were excluded if they indicated that they smoke since that subjects were required to refrain from smoking several hours before the treatment which may induce anxiety in a smoker[41,47]. Subjects completed a medical history questionnaire to ensure their safety during exercise, and those with asthma were asked to bring an inhaler. The protocol was approved by the University of Rhode Island's Institutional Review Board, and the participant flow is displayed in Figure A.

Sixty-two females (mean age = 19.3 years) agreed to participate in the study and attended an orientation session, and 56 completed both the orientation and experimental sessions. At the start of the experimental session, participants were randomly assigned using a random number generator to one of four conditions: exercise-mindfulness (EX-MP, N = 16), exercise-video distraction (EX-noMP, N = 14), no exercise-mindfulness (noEX-MP, N = 12), and no exercise-video distraction

(noEX-noMP, N = 14). Table 1 compares the participants in each of the four groups on demographic variables and all baseline measures.

Orientation session. All participants attended a 15-minute orientation session where they provided informed consent and were assured that all information collected was completely confidential and that they may quit at any time. A medical history questionnaire screened for potential medical reasons the individual should not exercise. Demographics, including an exercise frequency questionnaire, height and weight were collected as well as exercise and mindfulness meditation self-efficacy. A trait and state anxiety inventory (STAI-Y1 and Y2) was administered to compare scores to population norms and determine level of trait anxiety. The researcher explained to participants that during the experimental session they may be asked to complete different tasks depending on which condition they were randomly assigned to, and asked to come dressed appropriately for exercise in the event they were chosen for that task. Subjects were asked to refrain from eating for at least one hour before the session, consuming alcohol for 48 hours, and asked to refrain from consuming any caffeine (i.e. tea, caffeinated soda, energy drinks) for at least 72 hours before the session; previous research has shown that caffeine may have effects on mood and anxiety[48]. The remainder of the session was spent familiarizing subjects with the heart rate (HR) monitor and exercise bike.

Interventions

Upon arrival to the lab, subjects were seated at a table and given a state anxiety inventory (STAI-Y1) questionnaire. Participants were then given a HR monitor to wear for the duration of the experiment, followed by random assignment to one of the

four conditions (described in detail below). Subjects spent 20 minutes in their respective conditions; state anxiety questionnaires were given immediately following the assigned task, then again at 5 minutes, 10 minutes, and 20 minutes post-task. The session ended with a manipulation check to verify attention was influenced as intended for each condition.

Aerobic exercise. Participants randomly assigned to the exercise conditions (EX-MP and EX-noMP) began by being fitted to the Precor 846i recumbent bike (Precor USA, Woodinville, WA, U.S.). The researcher selected the manual option on the bike, and the subject spent 5 minutes in a warm-up stage with the resistance on the bike set to "1", which is the easiest setting. After the warm-up, the researcher either began the mindfulness recording to induce mindful attention during the exercise (EX-MP), or played a video to dissociate attention from the exercise (EX-noMP). The target HR was between 60-69% of the subject's age-predicted HR_{max}; the researcher monitored HR and alerted the subject if it was above or below the target HR range, at which point the subject was asked to adjust the intensity accordingly. This intensity was selected because previous research has shown moderate and high intensity aerobic exercise has the greatest anxiolytic effect; however, the high intensity option was eliminated as it may induce negative affect in participants who are not regularly active[7,33]. After 20 minutes of exercise, participants transitioned to a 5 minute cool-down phase at a resistance of "1", while immediately given the first post-task survey. After the cool-down, subjects were seated at a table for the remaining duration of the experiment.

In the EX-MP condition, subjects were informed of their target HR range and asked to self-monitor the intensity during the exercise by watching the HR display on the bike, and adjust the intensity as necessary by changing the resistance or the speed. This was intended to further elucidate the mindfulness state by bringing the focus to bodily sensations[20,49]. The researcher also monitored the subjects' HR to ensure the target range (60-69% HR_{max}) was maintained.

In the EX-noMP condition, the exercise data displayed on the bike (i.e. time, distance, pace, HR) were covered, so the only thing in direct view of the subject was the video-displaying device. The researcher was solely responsible for monitoring subjects' HR, and informed subjects when it was necessary to adjust the intensity; they self-selected the method by either changing the resistance or speed accordingly.

Subjects randomly assigned to the non-exercise conditions (noEX-MP and noEX-noMP) remained seated at the table for the mindfulness and dissociation tasks (described below), and were given post-task surveys at the same time points as the exercise conditions.

Mindfulness practice. Participants assigned to the mindfulness conditions (EX-MP and noEX-MP) were asked to listen and follow along with a recording of a female voice cueing the subject to focus attention on the present moment for 20 minutes. These cues included bringing attention to the breath, body awareness, acknowledging thoughts without judgment and then letting them go, and attending to other senses, such as what they see, smell, taste and feel. This basic mindfulness meditation exercise included defining features of the mindfulness process[20,49], and is consistent with procedures of other studies[18,50].

Distraction video. The EX-noMP and noEX-noMP conditions were intended to avert the participant's focus from the internal and external stimuli related to the present moment. To accomplish this, participants chose one of three 20-minute episodes of "TED Talks", an educational video series. The three episodes were void of content related to exercise, mindfulness, stress, or anxiety. The video was viewed on an Apple iPad 2.0 (Foxconn, Shenzhen, China).

Manipulation check. After filling out the last survey, subjects in all conditions were asked to describe what they were thinking about during the experiment in as much detail as possible. These were reviewed by the researchers to ensure subjects were attending to the appropriate task (i.e. listening to the mindfulness recording or watching the video).

Measures

Demographic data. Demographic data collected included the age, height, weight, race and ethnicity, degree-seeking level, employment status, and previous experience with mindfulness meditation. Height and weight were self-reported on the screening questionnaire and measured objectively during the experimental procedures. Height was measured with the participant's feet together and flat on the floor, head, neck and buttocks against a standard wall-mounted stadiometer (Seca S-216, Hanover, MD). Participants were weighed without excess clothing (i.e. no shoes, jewelry, jacket) with a digital scale (Health-O-Meter H-349KLX, Boca Raton, FL). Height and weight were used to calculate body mass index (BMI), a measure used to estimate body composition and used to categorize individuals as underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), or obese (>30)[51].

Leisure-Time Exercise Questionnaire (LTEQ). The LTEQ is used to assess the frequency of 20 minutes of mild, moderate, and strenuous exercise performed in a 7-day period. The weekly exercise frequency is then calculated into arbitrary units. This instrument has been tested and validated to be used to measure how active a person is in a typical week[52]. This measure was used to ensure homogeneity of regular physical activity habits across experimental groups.

Generalized Anxiety Disorder (GAD) *Screener*. The GAD-7 is a screening tool used in clinical psychology for GAD, and also has reasonable operating characteristics for three other common anxiety disorders: panic disorder, social anxiety disorder, and post-traumatic stress disorder[46,53]. The GAD-2 is a shorter version, also valid and reliable measure with good operating characteristics, and consists of the two core DSM-IV items for GAD. Scores on the GAD-2 are calculated by assigning scores of 0, 1, 2, and 3, to the response categories of not at all, several days, more than half the days, and nearly every day, respectively. Scores on the GAD-2 range from 0 to 6; the recommended cut-point when used as a screener is a score of 3 or greater, indicating the potential presence of disorder[46].

Medical history questionnaire. The medical history questionnaire is a standard survey to check participants for health risk factors and morbidities (i.e. heart problems, family history of sudden death before age 50, etc.), or other possible reasons why the individual should not participate in physical activity. In addition, the questionnaire was used to identify existing psychological disorders and use of any medication or other psychological treatment. No subjects were excluded based on responses to this questionnaire.

State and Trait Anxiety Inventory - Form Y. The STAI-Y is a commonly used measure of trait (Y2) and state anxiety (Y1) used both in clinical settings and for research purposes[54]. Considerable evidence supports the internal consistency, test-retest reliability, and concurrent validity of the scale[55]. The form Y is the most popular version; it consists of 20 items that are rated on a 4-point scale (e.g., from "Almost Never" to "Almost Always"), with higher scores indicating greater anxiety. The STAI is the most cited anxiety instrument in the context of exercise[7,56].

Heart Rate (HR). Heart rate was used to monitor intensity during the bout of exercise, and ensure intensity was at the desired percentage range of the subjects' age-predicted HR_{max} (60-69%). All participants wore a Polar E600 HR monitor (Polar Electro Inc., Lake Success, NY, U.S.) throughout the experiment.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 22.0 was used to analyze results. Results from analyses are presented in text, in Tables as mean (M) ± standard deviation (SD), and in Figures as M ± standard error of the mean (SE). Independent sample t-tests were used to check if the subjects who dropped out (n = 6) were statistically different from those who participated for any variable measured. One-way ANOVAs were performed to test differences between groups for potential covariates.

A 2 (EX and noEX) x 2 (MP and noMP) repeated measures ANOVA was used to test the effects of exercise, mindfulness, and their interaction on state anxiety at baseline, immediately post-task, 5, 10, and 20 minutes post-task. Follow-up ANCOVAs were conducted for both mindfulness (MP and noMP) and exercise (EX

and noEX) conditions to examine differences at each time point, while controlling for baseline anxiety. In addition, we ran paired sample t-tests to identify significant changes from baseline to each post time point for each group.

To further elucidate these results, we ran a series of ANCOVAs to test differences between individual conditions (EX-MP, EX-noMP, noEX-MP, noEX-noMP), while controlling for baseline anxiety. These analyses were followed-up with pairwise comparisons to identify specific differences between groups. There were no violations of the sphericity assumption or homogeneity of variance as indicated by Mauchly's test of sphericity and Levene's test, respectively. Apha was set at $p \leq 0.05$ for all analyses.

RESULTS

Demographics

Demographic information and baseline scores for all measured variables are presented for each group in Table 1. There were no apparent group differences on any of the demographic variables, baseline measures, or variables identified potential covariates (meditation experience, leisure-time exercise frequency, existing psychological disorder, treatment for psychological treatment). Subjects who dropped out of the study after the orientation session (N = 6) were not statistically different from those who participated (N = 56) in any variable measured. As expected, the average trait anxiety scores for each group were higher than reported norms for female college students (40.4)[55]. The manipulation check verified that participants' reported thoughts included components of respective conditions.

Interaction Effects

In the 2 x 2 repeated measures ANOVA, there was no significant interaction between MP and EX groups; therefore, we proceeded to interpret the main effects.

Mindfulness

The 2 x 2 repeated measures ANOVA showed significant main effects of mindfulness [$F(2.73, 142) = 7.71$, $p < .05$, partial $\eta^2 = .13$], and time [$F(2.73, 142) = 18.71$, $p < .05$, partial $\eta^2 = .27$] on state anxiety. Results from the ANCOVAs showed that the MP groups had significantly lower anxiety than the noMP groups immediately after the task [M=30.14, SD=7.05 vs. M=35.07, SD=9.77; $F(1,53)=16.71$, $p<.001$, partial $\eta^2=.24$], and 5 min post-task [M=30.12, SD=7.55 vs. M=34.29, SD=9.94; $F(1,53)=11.23$, $p = .001$, partial $\eta^2=.18$].

Paired sample t-tests indicated that for MP groups, anxiety scores were significantly lower immediately post-task [$t(27)=8.07$, $p < .001$], 5 minutes post-task [$t(27)=7.91$, $p < .001$], 10 minutes post-task, [$t(27)=5.81$, $p < .001$], and 20 minutes post-task [$t(27)=4.83$, $p < .001$] in comparison to baseline anxiety scores. For the noMP groups, anxiety was significantly lower 10 minutes post-task compared to baseline [$t(27)=2.10$, $p = .05$]. See Figure 2.

Exercise

The 2 x 2 repeated measures ANOVA showed a significant main effect of exercise [$F(2.73, 142) = 5.03$, $p < .05$, partial $\eta^2 = .09$] on anxiety. The EX groups had significantly higher anxiety (M=35.17, SD=9.58) scores than the noEX groups [M=29.65, SD = 6.86; $F(1,53)=6.79$, $p<.05$, partial $\eta^2=.11$].

For the EX groups, paired sample t-tests indicated that anxiety was significantly lower immediately [$t(29)=3.10$, $p < .001$], 5 minutes [$t(29) = 4.71$, $p < .001$], 10 minutes, [$t(29) = 5.30$, $p < .001$], and 20 minutes post-task [$t(29) = 4.81$, $p < .001$] in comparison to baseline scores. For the noEX groups, anxiety was lower immediately [$t(25) = 4.90$, $p < .001$], 5 minutes [$t(25)=3.48$, $p < .001$], and 10 minutes post-task [$t(25) = 2.75$, $p < .05$], but not at 20 minutes-post in comparison to baseline scores. See Figure 3.

Mindfulness & Aerobic Exercise

To further explore the relationships between conditions, we performed a series of ANCOVAs to test differences in anxiety scores between the four conditions at each post-task time point, while controlling for baseline anxiety. Scores varied significantly between conditions immediately after the task [$F(3, 51) = 10.24$, $p < .05$, partial $\eta^2 =$

.38] and five minutes after the task [$F(3, 51) = 3.98$, $p < .05$, partial $\eta^2 = .19$]. Immediately after the task, pairwise comparisons indicated that anxiety was higher in the EX-noMP condition than the other three conditions, and the noEX-MP group was also significantly lower than the other three. Five minutes after the task, the EX-noMP group was higher than the EX-MP and noEX-MP groups, and the noEX-MP group was also lower than the noEX-noMP group. There were no significant differences between groups after 10 minutes, and at 20 minutes post-task the EX-MP group had lower scores than the noEX-noMP group. Means, standard errors, and significant time points are presented in Figure 4.

DISCUSSION

The results from this study indicate that acute bouts of mindfulness and aerobic exercise each have a positive effect on state anxiety, and after 20 minutes the combined group had lower anxiety than the group who did not engage in either task. In support of the hypothesis, subjects who participated in the mindfulness task had significantly lower anxiety than those who were instructed to watch the distraction video, but only immediately and five minutes after the task. Contrary to the hypothesis, the participants who did not exercise reported lower self-reported anxiety than those who did exercise immediately after the task, but scores were similar 10 minutes post, and by 20 minutes the group that did not exercise was no longer significantly less anxious than baseline.

Mindfulness

Our results support that a brief mindfulness practice may be effective for reducing anxiety. Those in the mindfulness condition had lower anxiety immediately after the task than the video distraction group, and scores remained lower throughout the other time points. These results are consistent with literature supporting that mindfulness training may reduce anxiety by diverting attention from threatening stimuli, or stressors, as both conditions could theoretically distract participants from whatever makes them anxious[10,16]. If a mere distraction is all that is necessary to reduce anxiety, then theoretically both the mindfulness and a video conditions should have the same effect. However, anxiety was reportedly lower for those who engaged in mindfulness compared to those who watched the video.

Bahrke and Morgan implemented a similar acute mindfulness meditation treatment in a sample of males (N = 75)[39]. The mindfulness meditation condition was delivered via a recording of the Benson Relaxation Response[40] while seated in a comfortable recliner. A relaxation control group sat in the recliner and was provided a current issue of *Reader's Digest*. The STAI was used to assess trait anxiety at baseline, and state anxiety at baseline, immediately after, and 10 minutes following each session. Results showed a significant decrease over time for each group, consistent with the results of the present study; however, the two groups were statistically similar immediately following the task. The form of meditation used for the intervention, the Benson Relaxation Response, does not include all components of a mindfulness practice as previously described, which could be why there was no difference in anxiety between the mindfulness and relaxation groups. In addition, this study included only males, whereas the present study included only females.

In a longer, but still brief, mindfulness intervention, Zeidan and colleagues implemented a 3-day, 20-minute session intervention in which subjects (N = 82, 48 females) were randomly assigned to either mindfulness training, sham mindfulness, or a seated control[26]. The mindfulness meditation group received training modeled from basic meditation skills by a trained facilitator. The sham mindfulness meditation group were not given guided instructions pertinent to the practice of mindfulness meditation, but simply told to take deep breaths as they sat in meditation. The participants in the control group sat in a chair for 20 minutes without doing homework or falling asleep, but they were permitted to speak to each other. Results showed a significant decrease in state anxiety from the beginning to the end of each session in both the mindfulness

meditation and sham meditation groups, but not for the control. It is possible that there was a decrease in the sham condition because there was cuing directed towards the breath, which could be considered intentionally paying attention to moment-by-moment experience[20]. The decline in anxiety scores from baseline to post-intervention supports the findings of the present study; however, the authors did not report analyses from pre- to post-meditation or sham meditation for individual 20 minute sessions. In addition, Zeidan et al. only measured anxiety immediately post-task, and had no additional follow-up time points.

While the results from this study cannot be directly compared to those of MBSR interventions, it does add to the support that varying lengths of mindfulness interventions may be effective for reducing anxiety. In an analysis investigating the optimal length of an MBSR program, Carmody and Baer found no evidence that shortened versions of MBSR were less effective than the standard protocol in reducing psychological distress[22]. This finding combined with evidence of acute effects[39], and short-term interventions[26] support the concept that brief mindfulness practice may help manage anxiety.

When analyzing the conditions individually, we found that in the mindfulness conditions those who exercised were significantly more anxious than those who were seated immediately after the mindfulness practice, but not at 5, 10, and 20 minutes post-training. This could be because subjects were able to relax their bodies, or engage in a quiet rest which has also been shown to reduce anxiety[57,58]. It is also possible that anxiety appeared higher in the group that exercised because the measurement tool

(STAI-Y1) also captures constructs that relate to anxiety, such as arousal, which has been a proposed issue with studies investigating anxiety post-exercise[59].

Aerobic Exercise

It was unexpected that those who exercised were more anxious than those who did not. However, as time went on after the task, the self-reported anxiety of the participants that did not exercise or engage in mindfulness gradually increased, and by 20 minutes post-task, anxiety was no longer significantly different from baseline. Conversely, participants in the exercise condition reported lower anxiety as time progressed, and remained significantly different than baseline.

A potential explanation as to why we did not see the anticipated difference between those who exercised and those who did not immediately after the task could be because of the between-subject design. Results from a meta-analysis indicate that exercise has a higher effect size in within-subject design studies (ES = 0.47) than when compared to a no treatment control (ES = 0.22)[7]. If this were a cross-over design and each participant engaged in each condition, results may have varied. This discrepancy could also be due to the other treatment variable of mindfulness in the mix: the meta-analysis also indicated that, compared to another anxiety-reducing interventions, there were no differences between groups. As touched upon previously, some researchers have proposed that using a measure to assess state anxiety, such as the STAI, may be counterintuitive because exercise increases some of the negative constructs (i.e. arousal) associated with anxiety, but does not necessarily translate to high anxiety[59]. This also supports the steady decline in anxiety observed as time elapsed after the bout of exercise.

Cox et al. investigated differences between moderate (60% VO_{2max}) and high intensity (80% VO_{2max}) aerobic exercise conditions on a treadmill and compared them to a no exercise control[60]. Measures of state anxiety were taken at baseline and again 5, 30, 60, and 90 minutes post-condition. Results also showed a significant decrease in anxiety from baseline to each time point in all conditions. The high intensity group had significantly lower anxiety than the control group 30, 60, and 90 minutes post-exercise, and the moderate intensity group was significantly lower than the control at 90 minutes post. This trend in anxiety scores is consistent with results from the present study at 10 minutes post-task, and suggests that if we continued to measure anxiety after 20 minutes, the exercise groups may have been significantly lower than the no exercise control. Anxiety may be higher immediately after exercise compared to the other time points because individuals experience residual arousal from the bout of exercise[61]. In addition, since the sample had varying scores on the leisure-time exercise questionnaire, it is possible that those with more exercise experience were not challenged enough by the exercise intensity to experience the anxiolytic effect.

The finding that as time went on the group that did not exercise also did not experience lasting effects on anxiety (no longer significantly different from baseline at 20 minutes-post), but the exercise group's anxiety continued to decrease and remained so until the 20 minute mark. This suggests there may be a greater benefit from exercise extended periods after. In a study of females (N = 25) with multiple sclerosis, Petruzzello et al. assessed anxiety at time points beyond 20 minutes after exercise also found significant reductions in scores[27]. Subjects were divided into low and high trait-anxious groups as determined by the STAI: scores greater than one

standard deviation above the population mean were considered higher trait anxious (N = 8, mean age = 37 years), the rest were considered lower trait anxious (N = 17, mean age = 44 years). After filling out baseline measures of state anxiety, participants warmed-up for 5 minutes with no resistance, followed by 20 minutes of cycling at 60% of the individual's measured VO_{2max}, and finished with a 5 minute cool-down. Measures of anxiety were taken again 5, 20, and 60 minutes after the bout of exercise. Results showed a statistically significant reduction in state anxiety between baseline and 5, 20 and 60 minutes after exercise in the higher trait anxious subjects, but not the low anxious subjects. These results support the findings of the present study given that the average trait anxiety scores our sample were above average. It also suggests that we could have potentially seen a reduction if we continued to measure anxiety after 20 minutes, because even subjects considered low trait-anxious showed significantly lower anxiety at 60 minutes post-exercise. This is also consistent with Cox et al., who found that anxiety continued to drop between 5 and 30 minutes post-exercise, and either continued to drop (high intensity) or maintained (moderate intensity) until the last reading at 90 minutes post[60].

When breaking down the results by condition, we found that in the exercise conditions those who watched the video were significantly more anxious than those in the mindfulness condition, and this trend continued 10 and 20 minutes post-exercise. This supports the idea that there may be a difference in anxiolytic effects depending on if the exerciser's attention is either associated (i.e. engaging in mindfulness) or dissociated (i.e. watching distraction video) in regard to the activity[62].

Mindfulness & Aerobic Exercise

Contrary to the hypothesis, there was not a significant additive effect of mindfulness and exercise compared to all other conditions at all post-task time points. However, the last measured time point of 20 minutes did show the exercise plus mindfulness group reporting significantly lower anxiety than the seated group watching the video, with the latter showing a gradual increase over time. To our knowledge, there is no published literature to date that has tested these methods in a similar design to compare results to. Furthermore, it is possible we did not observe the anticipated additive effect because both treatments were acting on similar mechanisms, another reason these treatments need to be investigated further and over time.

Limitations

As with other studies of this nature, conditions carried on in a laboratory setting may produce different results when done in a natural environment, such as at a fitness center or in someone's home. In addition, the exercise intensity was estimated based on an age-predicted equation, and could have been more accurate if individual's cardiorespiratory fitness level was measured using more accurate procedures (i.e. VO_{2max} testing).

The mindfulness recording was intended to be generic so it could be interpreted by those seated and those exercising. If the mindfulness recording were relevant to a specific exercise (i.e. cycling), perhaps the two treatments would have better complemented each other. The video groups were intended to include the opposite of mindfulness; it may have also served to have a control group because the

video condition also had an anxiolytic effect, perhaps because of the "time-out" hypothesis[41].

The 20 minutes between the immediate-post and final measurements the subjects were not permitted to read, use their electronic devices, or do homework, and this type of "down time" is uncommon for the average college student which may also have impacted the generalizability of the results.

CONCLUSIONS

The results of this study contribute to the body of literature aiming to identify and improve methods of alternative medicine for anxiety management. This study supports the theory that acute bouts of both mindfulness and exercise are successful at reducing anxiety, and when used in combination, exercise plus mindfulness yielded lower anxiety scores than exercise while watching a video at the end of the experiment. To better understand the mechanisms of exercise as an anxiolytic intervention, further research on exercise characteristics, such as focused attention should be done. Future research should also compare different dose-response relationships between mindfulness coupled with various times, types, and intensities of aerobic exercise, and the chronic effects of these combined methods.

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Table 1. Means and Standard Deviations for Descriptive and Baseline Variables

Baseline mean (SD)	EX-MP N=16	EX-noMP N=14	noEX-MP N=12	noEX-noMP N=14	*F*	*P*
Age	20 (1.9)	19 (1.3)	19 (1.2)	19 (1.5)	1.83	.154
White (%)	81.3	85.7	75.0	78.6	0.29	.834
No Psychological Disorder (%)	75.0	71.4	83.3	85.7	0.25	.861
No Treatment for Disorder (%)	81.3	71.4	100.0	92.9	0.91	.443
No Meditation Experience (%)	62.5	35.7	58.3	35.7	1.76	.166
Unemployed (%)	25.0	42.9	41.7	64.3	1.59	.202
BMI	25 (4.9)	24 (3.0)	27 (8.0)	25 (4.8)	0.50	.686
Activity Level	39 (27.1)	47 (22.1)	55 (31.5)	66 (44.0)	1.88	.144
Trait Anxiety	51 (8.7)	45 (11.1)	47 (11.3)	44 (7.6)	1.73	.172
State Anxiety	43 (9.6)	38 (8.8)	42 (13.9)	36.9 (9.7)	1.29	.287

SD, standard deviation; BMI, body mass index; Activity Level, arbitrary units calculated from LTEQ. One way ANOVAs confirm homogeneity of baseline characteristics across conditions, $p < .05$

Figure 1. Flow of Participant Recruitment and Allocation

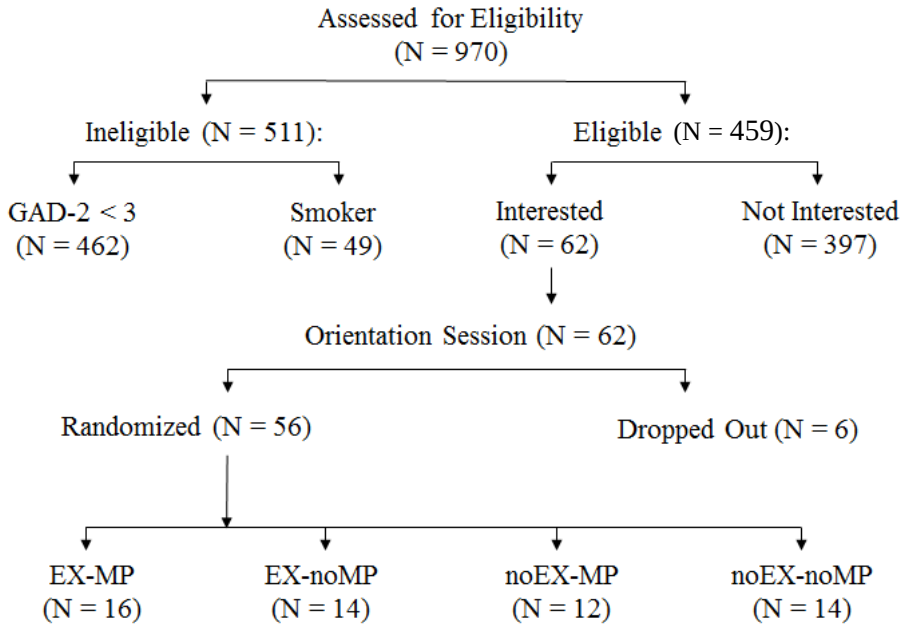
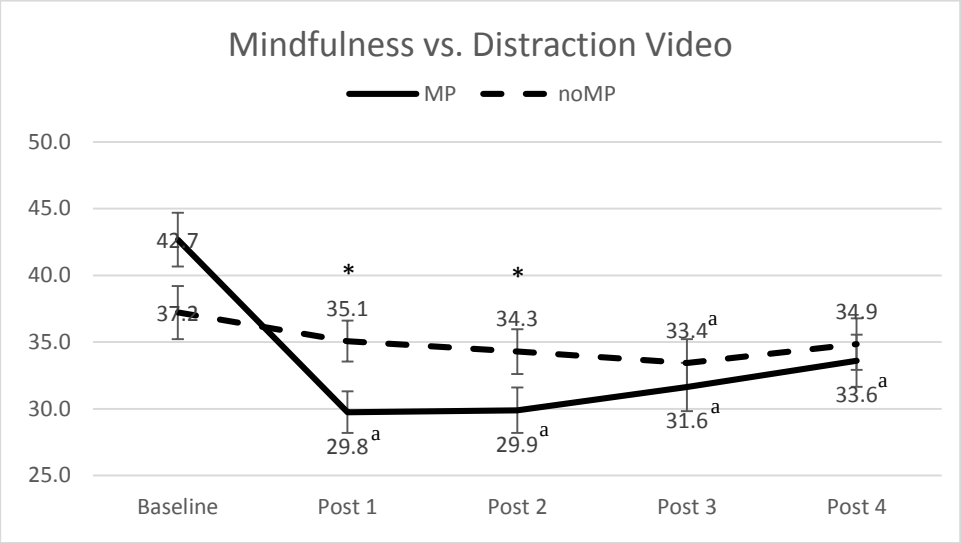


Figure 1. Flow of subject recruitment and allocation.

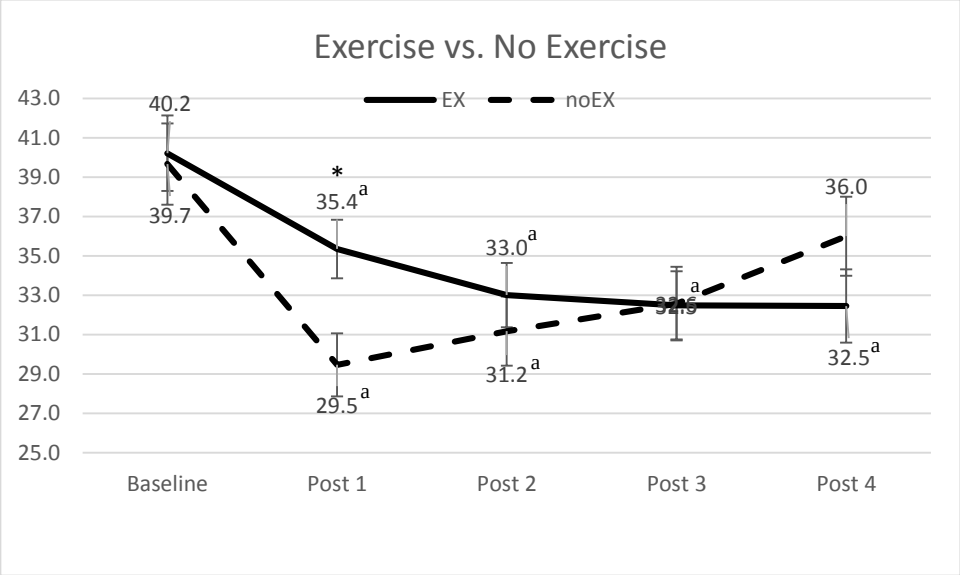
Figure 2. Change in State Anxiety for Mindfulness



*Means significantly different, $p < .05$.

[a]Statistically different from baseline.

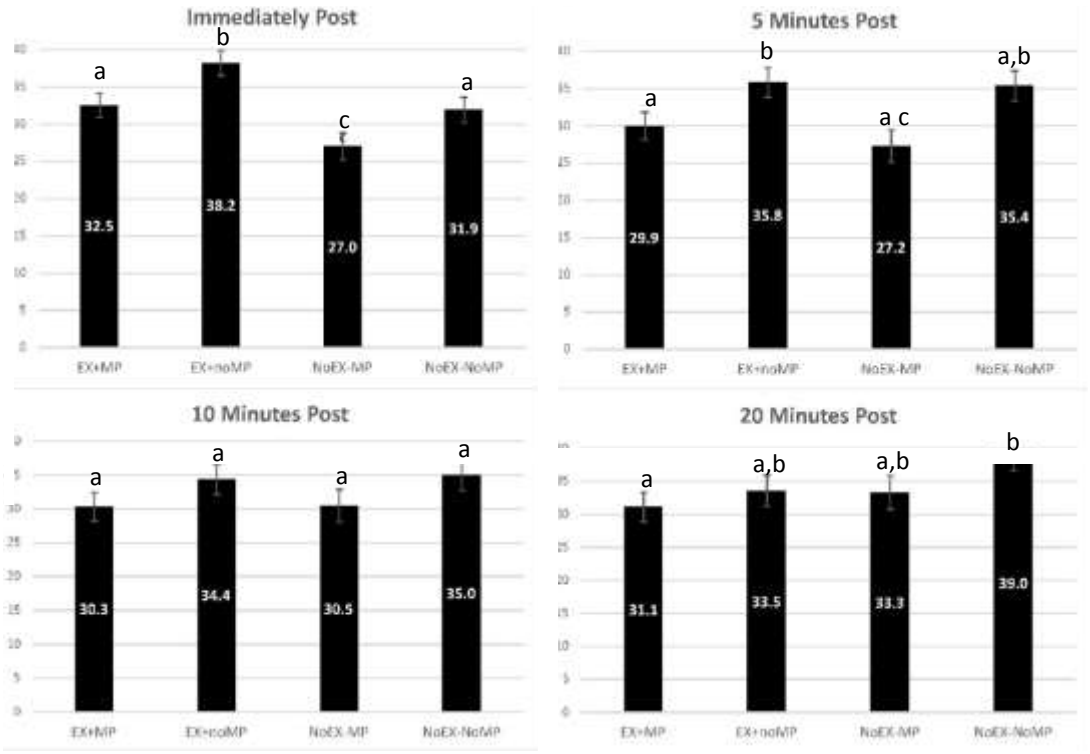
Figure 3. Change in State Anxiety for Exercise



*Means significantly different, $p < .05$.

[a]Statistically different from baseline.

Figure 4. Change in State Anxiety Between Conditions at Post Time Points



Pairwise comparisons with baseline state-anxiety included as a covariate.

[a,b,c] Letters indicate statistical difference from groups with different letters, $p < .05$.

APPENDIX A

REVIEW OF LITERATURE

Introduction

As a group, anxiety disorders are among the most common mental health conditions, and are known to cause significant functional impairment (Ravindran & Stein, 2010). Anxiety is characterized by excessive worry and is often accompanied by increased stress. The American Psychological Association (APA) report that women are more likely than men to declare having a great deal of stress (28% vs. 20%), and 49% of the women surveyed said their stress had increased over the past five years (Anderson & et al., 2010).

A large, nationally represented survey (N = 9,282; mean age ≥ 18 years) reported on one year of mental health cases, 41.1% of which were receiving treatment, of which the majority visited mental health professionals rather than general medicine (Wang et al., 2011). Of those who sought mental health treatment in the last 12 months, 12.3% were treated with psychotherapy, 16% consulted with other types of mental health specialists, 22.8% were treated by general medical providers, and 6.8% treated with complementary and alternative medicine; some receive treatment from more than one source. Standard treatments for anxiety disorder include psychotropic medication, psychotherapy, or a combination of the two (Baldwin, Woods, Lawson, & Taylor, 2011; Hofmann & Smits, 2008). However, pharmaceuticals are associated with unpleasant side effects and high cost (Black, 2006), which may promote early withdrawal from treatment (Baldwin et al., 2011; Broocks et al., 1998); psychotherapy can also be costly, and many patients have

difficulty adhering to the adequate number of sessions required for treatment effects to transpire (Merom et al., 2008). Only 46.1% of the patients seeking treatment for anxiety disorders received at least minimally adequate treatment. Therefore, the efficacy of potentially less expensive, aversive, and more disseminable methods of treatment need to be investigated and evaluated for anxiety disorders, especially at subclinical levels, to prevent the debilitating symptoms of chronic anxiety.

This review of literature will briefly discuss the issue of high levels of anxiety, and the need for alternative methods for anxiety management. Alternative to traditional medicine, mindfulness-based and physical exercise treatments will be discussed. Finally, a review of the literature on the effects of these treatments independently and in combination on anxiety.

Anxiety

Anxiety is an emotional state or condition that includes experiential, physiological, and behavioral components (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Individuals with high trait anxiety regularly experience high state anxiety because they tend to interpret a wider range of situations as threatening. Anxiety disorders are characterized by excessive stress and pervasive worry about multiple topics that are difficult to control, and associated with symptoms of muscle tension, restlessness, difficulty concentrating, increased fatigue, irritability, and sleep disturbance (Andrews et al., 2010). They are also associated with high comorbidity, reduced quality of life, and significantly increased health care utilization (Hayes-Skelton, Roemer, & Orsillo, 2013).

Alternative methods of anxiety treatment, including mindfulness training and aerobic exercise, have been investigated and shown to be effective in comparison to traditional treatments, such as cognitive behavioral therapy (CBT; McEntee & Halgin, 1999) and pharmaceuticals (Broocks et al., 1998). Research has shown that aerobic exercise decreases levels of state and trait anxiety in both normal and high-anxious individuals. Furthermore, there is strong evidence of a relationship between low physical activity levels and increased levels of anxiety (Adams, Moore, & Dye, 2007; Ströhle, 2009). Likewise, interventions that include the component of mindfulness, which is the practice of focusing attention and awareness on the present moment without judgment, have also been shown to produce promising anxiolytic effects (Baer, 2003). Research has yet to determine which alternative treatment has the strongest effects on anxiety, or if there is an additive effect when the two methods are combined.

Mindfulness and Anxiety

Mindfulness practice, sometimes known as mindfulness meditation, is a form of non-judgmental attention and awareness characterized by keeping a conscientious focus on internal and external experiences in the present moment (Kabat-Zinn et al., 1992; Marlatt & Kristeller, 1999). This includes bringing awareness to sensations, thoughts, bodily states, consciousness, and the environment, while simultaneously encouraging openness, curiosity, and acceptance (Baer, 2003; Bishop et al., 2004; Hofmann, Sawyer, Witt, & Oh, 2010; Kabat-Zinn, 2003). Mindfulness relates to anxiety because anxious individuals often focus their attention toward threatening information in the environment over non-threatening stimuli. This bias, referred to as

an attention bias toward threat, is implicated in the development and maintenance of anxiety (Brown & Ryan, 2003; Suway et al., 2013). The cognitive aspects of mindfulness, such focusing on breathing, may create changes in cognitive processes associated with anxiety that are distinct from other validated stress-management approaches (Baer, 2003; Edenfield & Saeed, 2012). Mindfulness may be important in disengaging individuals from automatic thoughts, habits, and unhealthy behavior patterns which may play a key role in fostering informed and self-endorsed behavioral regulation (Brown & Ryan, 2003).

Brown and Ryan investigated the role of mindfulness in psychological well-being using the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003). A sample of students enrolled in a psychology course (N = 92, 74% female, mean age = 19.5 years) and adults from a northeastern U.S. community (N = 74, 55% female, mean age = 37.6 years) successfully completed the study. Each were recruited to assess associations of the MAAS with other validated measures of other psychological variables. The scale showed positive associations between mindfulness and clarity of emotional states, mood repair, attention to emotions, openness and receptivity to experience and behavior, and positive affect. The MAAS was associated with low levels of neuroticism, which has been consistently related to poorer psychological well-being, anxiety, negative mood states, self-monitoring, public self-consciousness, and social anxiety. Interestingly, MAAS was inversely related to the number of visits made to medical professionals in past 21 days. The capacity for self-awareness is an important component of mindfulness as a construct, therefore, highly mindful individuals are theorized to be more attentive to

psychological and physical processes than less mindful individuals (Brown & Ryan, 2003).

Mechanisms

A recent review on mindfulness meditation (Edenfield & Saeed, 2012) suggests the neurophysiological changes in the brain may contribute to improvements in attention regulation, awareness, and emotional reactivity (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Brown, Ryan, & Creswell, 2007; Shapiro, Carlson, Astin, & Freedman, 2006). Mindfulness may also help reduce anxiety by inducing a sense of well-being; research has shown that being in a mindful state, even momentarily, is associated with a greater sense of well-being (Lau et al., 2006). On a secondary level, poor sleep quality is regularly comorbid with high anxiety, and some research suggests mindfulness interventions may alleviate this symptom (Brand, Holsboer-Trachsler, Naranjo, & Schmidt, 2012).

Decentering, which involves viewing internal experience with increased objectivity, is a potential mechanism of mindfulness-based intervention studies by facilitating a tendency to respond to internal and external experiences with less emotional reactivity (Shapiro et al., 2006). Undergraduate college females (N = 190) were randomly assigned to one of three 15-minute conditions: mindful breathing, progressive muscle relaxation, and loving-kindness meditation. The mindfulness breathing exercise guided participants to become aware of physical sensations, to notice thoughts in an accepting and non-judgmental way, and return focus to the breathe when the mind starts to wander. This encompasses the central features of mindfulness practice, which is intentionally paying attention to moment-by-moment

experience with an attitude of acceptance (Kabat-Zinn, 1994; Shapiro et al., 2006). Relative to other stress-management strategies, mindful breathing better facilitated decentering, a component found to increase pre- to post-session in mindful-based interventions.

Mindfulness-Based Interventions

Evidence presented in a systematic review of 52 studies investigating the neurobiological and clinical features of mindfulness meditation suggests that mindfulness training is useful in many psychiatric and physical disorders, and also in healthy individuals (Chiesa & Serretti, 2010). A well-known mindfulness-based therapy intervention derived from ancient Buddhist and Yoga practice is mindfulness-based stress reduction (MBSR; Kabat-zinn, 2003). This intervention has become a popular form of treatment in contemporary psychotherapy (Baer, 2003; Hayes, Masuda, Bissett, Luoma, & Guerrero, 2004; Kabat-Zinn, 1994; Lau et al., 2006; Salmon, Lush, Jablonski, & Sephton, 2009). Mindfulness-based stress reduction interventions have shown efficacy for treatment of certain psychiatric disorders (i.e. anxiety disorders, mood disorders, and depression), and there is evidence for reducing psychological distress in patients with cancer and chronic pain, improving many physical conditions, and for reducing stress levels in healthy subjects (Hofmann et al., 2010).

The early studies of MBSR used slightly varying formats, but the primary feature has always been the cultivation of mindfulness. A sequence of eight weekly 2 1/2-hour classes, and a one day 6-hour class at week 6, totaling 26 hours of class time, has come to be the accepted standard format (Carmody & Baer, 2009; Lau et

al., 2006). The calculated effect size of traditional MBSR interventions in a meta-analysis of 20 studies is 0.54 for psychiatric disorders, and 0.53 for physical disorders (Grossman, Niemann, Schmidt, & Walach, 2004). In an analysis investigating the optimal length of an MBSR program, Carmody and Baer (2009) found no evidence that shortened versions, as few as 6 total hours, of MBSR are less effective than the standard protocol to reduce psychological distress. This finding combined with other empirical evidence of acute effects of mediation (Bahrke & Morgan, 1978), and short-term interventions (Zeidan, Johnson, Gordon, & Goolkasian, 2010) support the concept that brief mindfulness practice interventions can be beneficial for normal to high-anxious individuals.

Acute Mindfulness

In spite of the vast evidence in support of the anxiolytic effects of MBSR programs on mental and physical outcomes (Chiesa & Serretti, 2010; Chiesa & Serretti, 2009; Edenfield & Saeed, 2012; Grossman et al., 2004; Hofmann et al., 2010), few studies have investigated the effects of an acute bout of mindfulness practice. Minor et al. (2006) reported that the length of the MBSR program was a potential reason for some participants to decline an MBSR group for caregivers of children with chronic illnesses. Similarly, recruitment data from a recent clinical trial of the 8-week MBSR program showed that of the eligible potential participants who declined to participate (N = 131) when contacted by the recruiter, 59 (45%) gave a reason related to the time required for the classes (Carmody & Baer, 2009). Because time commitment of the MBSR intervention may be a barrier to practicing

mindfulness, it is imperative to determine if shorter bouts of are also effective, both acute and chronic.

Bahrke and Morgan (1978) implemented an acute mindfulness meditation treatment in a sample of males (N = 75, mean age = 51.9 years). The mindfulness meditation condition was delivered via a recording of the Benson Relaxation Response (Benson, Greenwood, & Klemchuk, 1975) while seated in a comfortable recliner. A relaxation control group sat in the recliner and was provided a current issue of *Reader's Digest*. The State-Trait Anxiety Inventory (STAI; Spielberger, Gorusch, Lushene, Vagg, & Jacobs, 1983) was used to assess trait anxiety at baseline, and state anxiety at baseline, immediately after, and 10 minutes following each session. Results showed a significant decrease over time for each group ($p <$ .05), but no significant difference between groups. However, the form of meditation used for the intervention, the Benson Relaxation Response, does not encompass all components of mindfulness training as previously defined, which could be why there was no difference in anxiety between the mindfulness and relaxation groups. These results cannot necessarily be generalized to females, whose anxiety norms are generally a bit higher than their male counterparts (Spielberger et al., 1983).

In a longer, but still brief, mindfulness intervention, Zeidan and colleagues (2010) randomized a sample of psychology students (N = 82, 48 females, median age = 19 years) who received one of three 20-minute interventions, given on three consecutive days. The groups received either mindfulness training, sham mindfulness, or a seated control. The mindfulness meditation group received training of basic meditation skills from a trained facilitator. The sham mindfulness meditation group

were not given guided instructions pertinent to the practice of mindfulness meditation, but simply told to take deep breaths as they sat in meditation. The participants in the control group sat in a chair for 20 minutes without permission to do homework or fall asleep, but they were permitted to speak to each other. Anxiety was measured using the STAI, which was given before and after the intervention. Results showed a significant decrease in state anxiety from the beginning to the end of each session in both the mindfulness meditation and sham meditation groups ($p < .05$), but not the control. It is possible that there was a decrease in the sham condition as well because there was cuing directed towards the breath, which could be considered intentionally paying attention to moment-by-moment experience (Kabat-Zinn, 1994). This brief intervention supports the idea that practicing mindfulness training in short bouts can positively affect psychological variables, both in traditional form and with the perception of meditation with a focus on breath. However, the authors did not report analyses from pre- to post-meditation or sham meditation for the individual 20-minute sessions, so conclusions cannot be drawn from single bouts of mindfulness. Also, lasting effects were not measured at any other length of time after the last session, other than immediately, something future studies should include.

Exercise and Anxiety

Regular physical activity is associated with lower levels of stress and anxiety: cross-sectional evidence from a large cohort (N = 5,061) support that regular exercise is associated lower levels of anxiety, neuroticism, and depression (De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006). Exercise is also an alternative approach to anxiety treatment, shown to be effective in subjects with both clinical (Morrissey,

1997) and subclinical levels of anxiety, as well as individuals with normal levels of trait anxiety (Petruzzello, Snook, Gliottoni, & Motl, 2009; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991). Several meta-analyses (Bartley, Hay, & Bloch, 2013; Long & Stavel, 1995; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991; Wipfli, Landers, Nagoshi, & Ringenbach, 2011) and reviews (Asmundson et al., 2013; Byrne & Byrne, 1993) have contributed to what we know about the effects of exercise on anxiety.

In 1991, Petruzzello and colleagues published results of a meta-analysis that reviewed 124 studies reporting effects of acute and chronic exercise on self-reported state and trait anxiety (Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991). The overall mean effect size for state anxiety was 0.23 for acute exercise, and 0.25 for chronic exercise. Without a control group, within-subject designs yielded a higher effect size of 0.47, but reduced to 0.26 for studies using a motivational control group, and to 0.22 in studies including a no-treatment control group. Effect sizes were significant for normal (ES = 0.26), psychiatric (ES = 0.21), and obese subjects (ES = 0.26), but, interestingly, not for high-anxious or cardiac rehabilitation subjects.

Other meta-analyses with more select inclusion criteria have also been published. Wipfli et al. (2008) ran an analysis that included 49 studies that implemented an exercise intervention and reported an overall effect size of 0.48, indicating larger reductions in anxiety among exercise groups than control groups. Exercise groups also showed greater reductions in anxiety compared with groups that received other forms of anxiety-reducing treatment, such as relaxation (ES = 0.19).

Because only randomized controlled trials were included, these results provide top tier evidence for using exercise in the treatment of anxiety.

Contrary to the empirical support that exercise has a positive effect on anxiety, a more recent meta-analysis focused only on clinically anxious subjects and found aerobic exercise was beneficial when compared to placebo or waitlist-control conditions, but not in comparison to other evidence-based treatments of anxiety disorders (CBT and pharmaceuticals; Bartley et al., 2013). A better understanding of how exercise may be employed as a behavioral treatment for stress and anxiety in a normal to high-anxious female population is still needed.

Aerobic Exercise vs. Resistance Training

Resistance training has also been shown to improve anxiety. However, meta-analysis shows significant differences between aerobic and nonaerobic exercise, favoring aerobic (effect sizes of 0.26 and -0.05, respectively; Petruzzello et al., 1991). Bibeau and colleagues (2010) investigated effects of different intensities and rest periods on anxiety in a sample of undergraduate students (N = 104, 46 female) enrolled in a resistance training class. There were five groups (low intensity, short rest between sets; low intensity, long rest between sets; high intensity, short rest; high intensity, long rest; and a control) tested for anxiety at baseline, immediately after the 30-minute treatment, and again 5, 20, and 40 minutes post-treatment. There was a main effect for time, with anxiety being significantly lower than baseline at 20 and 40 minutes post-exercise. The only significant difference seen between groups was at 5 minutes post-treatment, showing that those in the high intensity-short rest group had significantly higher anxiety than the control. While these results look promising, this

group of participants who were already familiar with and engaging in this form of physical activity on a regular basis.

Comparisons between effects of aerobic exercise and resistance training on anxiety have been explored in the literature. One study compared the effects of resistance training and step aerobics on anxiety at weeks 1, 4, and 8 of an exercise class in a sample of undergraduate college students (N = 42, 26 female; Hale & Raglin, 2002). Anxiety was measured using the STAI at baseline and 5 minutes post-exercise session at weeks 1, 4, and 8. Subjects in the step aerobics condition were encouraged to maintain a HR of 70% of their age-predicted HR_{max} by use of a HR monitor. Initially, analyses revealed a significant overall change in anxiety over time, but with no differences between groups, so subjects were separated between high and low anxious groups based on baseline trait anxiety scores. Although both groups were significantly lower after an acute 50-minute session, there was a significant decrease in state anxiety for participants in the step aerobics condition for both high and low anxious individuals, but for the resistance training condition there was a only a decrease in anxiety in the high-anxious group. Therefore, both modalities are potentially effective, but aerobic exercise may be a more appropriate form of exercise when working with varying levels of anxious individuals when the goal is to reduce anxiety.

Another study compared resistance and aerobic exercise, but instead had subjects cycle on an ergometer with both exercise conditions set to 70-80% of the individual's maximum intensity (Hale & Raglin, 2002). Results also showed a main effect of time for aerobic exercise on anxiety, and significantly lower scores at 60

minutes post-exercise. Not only was there a lack of anxiolytic effect for the resistance training group, but scores were significantly higher than baseline immediately after exercise, comparable to baseline 20 minutes post, and below baseline at 60 minutes post-exercise. Given these and previous results, the evidence points to aerobic training as the more effective mode of exercise to reduce anxiety.

Duration of Exercise Session

In regards to length of an exercise session, bouts lasting zero to 20 minutes yielded significantly lower effect sizes (ES = 0.04) compared to bouts lasting between 21 and 30 minutes (ES = 0.41; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991). However, when studies comparing bouts of less than 20 minutes of exercise to other known anxiolytic treatments, such as relaxation, the effect size increased to 0.22. With this additional finding, the authors concluded that any duration of exercise results in reduced self-reported anxiety. Multiple studies that have published results indicating significant reductions in anxiety following aerobic exercise have had participants warm-up for five minutes, exercise at various target intensities for 20 (Breus & O'Connor, 1998; Cox, Thomas, Hinton, & Donahue, 2004; Petruzzello et al., 2009) or 30 (Smith, 2013) minutes, and then cool down for five minutes.

Intensity of Exercise

There are several different ways to measure an individual's maximum heart rate (HR_{max}) to prescribe appropriate intensity during exercise. One well-known method is a VO_{2max} test, in which the subject pedals on a cycle ergometer or walks/runs on a treadmill until volitional fatigue. During the test, the individual is connected to a metabolic cart, which measures ventilation to determine peak oxygen

uptake. A less accurate, but easier and less invasive, method is calculating HR_{max} based on the age of the subject (age-predicted HR_{max}). For both methods, exercise intensity is prescribed based on percentages of that maximum value. Levels of exercise intensity were not significantly different from each other in meta-analysis, however, the largest effect sizes were observed for intensities of 60-69% HR_{max} or VO_{2max} (ES = 0.27) and >80% HR_{max} or VO_{2max} (ES = 0.33; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991).

There is evidence showing support that cycling at 50% HR_{max} can reduce anxiety in patients diagnosed by psychiatrists as having anxiety disorders and/or depression (90% received two diagnoses; Knapen et al., 2009). Knapen and colleagues tested effects of cycling in three exercise conditions on state anxiety in male (N = 19, mean age 40.68 years) and female (N = 29, mean age = 34.61) subjects. The conditions were self-selected intensity with HR feedback, self-selected intensity without HR feedback, and prescribed intensity of 50% HR_{max}. There were significant reductions in the group that worked at 50% HR_{max} (M = 45.54±14.16 to M = 39.23±16.18), those at a self-selected intensity with HR feedback (M = 42.91±13.1 to M = 38.98±11.97), and those at a self-selected intensity without HR feedback (M = 47.72±13.22 to M = 41.30±12.46). Another interesting finding was participants in the self-selected intensities conditions felt more fatigued than those in the prescribed intensity group, although the average work load was not significantly different between groups. These results show further support that moderate intensity can benefit both normal and high-anxious individuals, there was an anxiolytic effect regardless if assigned to the self-selected or prescribed intensity exercises.

Cox et al. (2004) investigated differences between moderate (60% VO_{2max}) and high intensity (80% VO_{2max}) aerobic exercise on state anxiety in younger (N = 12, ages 18-20 years) and older (N = 12, ages 35-45 years) regularly active women. Both conditions were performed on a treadmill, and measures of state anxiety were taken at baseline and again 5, 30, 60, and 90 minutes post-exercise. Results showed a significant decrease in anxiety from baseline to each time point in all conditions, and the high intensity group had significantly lower anxiety than the control group 30 (26.29±4.98 vs. 29.17±7.32), 60 (26.79±6.31 vs. 29.29±7.24), and 90 (25.92±5.35 vs. 30.17±7.55) minutes post-exercise, and there were no differences between the age groups. The moderate intensity group had significantly lower anxiety than the control at 90 minutes post-exercise. While these results allude to higher intensity being more efficacious, other research suggests that high-intensity exercise may be aversive to those inexperienced or confident in exercise.

Ekkekakis and colleagues reported that experienced discomfort at the beginning of an exercise regimen may increase negative affect (Ekkekakis, Backhouse, Gray, & Lind, 2008). To prevent potential negative affect due to exercise discomfort, it has been suggested to start out individuals at low intensities to enhance psychological benefits (Ekkekakis, Hall, & Petruzzello, 2004).

Time points following exercise

Several studies have investigated the lasting effects after an acute bout of aerobic exercise, and effect sizes have been calculated indicating significant reductions from baseline anxiety to measurements 0 to 5 minutes (ES = 0.21), 5 minutes (ES = 0.36), 10 minutes (ES = 0.27), 20 minutes (ES = 0.49) and greater than

20 minutes (ES = 0.27). Petruzzello et al. (2009) saw reductions in a sample of females (N = 25) with multiple sclerosis; separated subjects into high (N = 8, mean age = 37 years) and low (N = 17, mean age = 44 years) trait-anxious levels as determined by the STAI. Scores greater than one standard deviation above the population mean were considered high, the rest were considered low trait-anxious. Participants were administered the STAI at baseline, then warmed up for 5 minutes followed by 20 minutes of cycling at 60% of the individual's measured VO_{2max}, and finished with a 5 minute cool-down. Measures of anxiety were taken again 5, 20, and 60 minutes after the bout of exercise. Results showed a statistically significant reduction in state anxiety between baseline and 5, 20 and 60 minutes after exercise in the higher trait anxious subjects, but not the less anxious subjects. These results suggest that it can be expected for anxiety to be lower up to 60 minutes after the bout of exercise in high-anxious females, because even subjects considered low trait-anxious showed significantly lower anxiety at 60 minutes post-exercise. This, however, is a specific clinical population which may present other influencing factors.

Issues with Anxiety Measurement During and After Exercise

Some researchers have proposed that using a measure to assess state anxiety, such as the SAI, may be counterintuitive because exercise increases some of the negative constructs (i.e. arousal) associated with anxiety, but does not necessarily translate to high anxiety (Katula, Blissmer, & McAuley, 1999). In a sample of 80 older, inactive adults (mean age = 67 years), subjects were randomly assigned to light-, moderate-, and high-intensity aerobic exercise. Results showed significant

decreases in anxiety in the light-intensity condition, a non-significant decrease in the moderate condition, and a significant increase in the high-intensity condition. To further investigate these results, individual item responses on the SAI were analyzed. Results confirmed that in the high-intensity condition subjects reported increased scores of "overexcited," and reduced scores of "relaxed," "calm," "at ease," and "comfortable," yet subjects reported less anxiousness. Based on these responses, it is evident that researchers must to be cautious when interpreting results from measures, such as the SAI, when assessing effects on anxiety post-exercise.

Aerobic Exercise vs. Mind-Body Focused Exercise

Some studies have explored comparisons between aerobic exercise interventions and exercise focused on mind-body connections. In a randomized control trial of 12 (7 females) clinically depressed subjects, Bodin and Martinsen (2004) tested two forms of exercise on anxiety. The conditions were 45 minutes of aerobic exercise on a stationary bike set at a standard resistance, and 45 minutes of Tae Kwon-Do movement sequences, and both with intensities increasing every 15 minutes. Measures of state anxiety were taken using the STAI after the first 15-minute period during exercise and after the last stage of exercise. Interestingly, there were larger anxiety reductions in the Tae Kwon-Do group compared to the waitlist control group, and a trend for greater decreases compared to the aerobic exercise condition. However, this was a small sample of clinically depressed patients, and results cannot necessarily be generalized to normal or high-anxious populations.

Another study compared groups of aerobic exercise (swimming and aerobic dance) and low-exertion mindful activities [yoga and Feldenkrais (awareness through

movement)], and a computer class as a control group, with students in an enrichment program (N = 42; 26 undergraduate females; Netz & Lidor, 2003). Post-measures of anxiety were taken after 14 weeks, and showed a significant improvement in state anxiety when measured pre- and post-session for one single bout of swimming, yoga, and Feldenkrais. Scores from these groups were also significantly lower than anxiety in the dance aerobics, and computer groups at post-testing. This suggests some forms of exercise that involve a component of mindfulness are equivalent to some form of aerobic exercise.

Streeter et al. (2010) randomly assigned participants (N = 34, 22 female) to a 12-week intervention of either yoga (N = 19) or walking (N = 15) for three 60-minute sessions per week. State anxiety was measured at baseline and at weeks 4, 8, and 12. Intensities of both activities were matched using metabolic equivalents (METs). Results showed a significant change in anxiety over time, and the greatest effects were in the yoga group. Being that the metabolic demands of both activities were evenly matched, there is a mechanism other than the physical exercise component of yoga that may be contributing to the effects, and needs to be further studied.

Mindfulness and Exercise

To our knowledge, only one study has been published that tests the psychological effects of an acute mindfulness training session in comparison to aerobic exercise (Bahrke & Morgan, 1978). Participants (N = 75 males) were randomized into groups to participate in 20 minutes of either exercise, meditation, or a relaxation control group. The bout of exercise performed was on a treadmill at an intensity of 70% of each subject's self-imposed HR_{max}. The meditation group listened

to a recording of the Benson Relaxation Response (Benson et al., 1975) while seated in a comfortable recliner. The control group sat in the same recliner, and was provided a current issue of Reader's Digest that was unrelated to relaxation, exercise, or cardiovascular health. The STAI was used to assess trait anxiety, and state anxiety at baseline, immediately after, and 10 minutes following each session. Results showed a significant decrease over time for the three groups. When subjects from each condition were combined, subjects were split into two groups, high trait-anxious (N = 10) and low trait-anxious (N = 10) based on trait anxiety at baseline. Scores in each condition were significantly lower after the intervention ($p < .05$), and scores did not differ significantly between conditions. With all subjects combined and split between high- and low-anxious, there was a significant decrease for both the high-anxious group (41.7 to 31.8, $p < 0.05$), and low-anxious group (27.4 to 22.0, $p < 0.05$). These results suggest that a 20-minute bout of aerobic exercise, meditation, or quiet rest will reduce anxiety to the same degree. However, the form of meditation used for this intervention does not encompass all components of a mindfulness practice, as previously defined. The literature still lacks a fair comparison between a traditional mindfulness practice and a bout of aerobic exercise, or if there is an additive effect when the two methods are combined.

Conclusion

Anxiety is prevalent in the U.S. population, and is partially responsible for increased healthcare utilization, while traditional treatments can be expensive and challenging to adhere to (Wang et al., 2011). Other alternative methods need to be explored that reduce anxiety, and aid in stress management for populations at-risk for

anxiety disorder. Mindfulness-based stress reduction interventions have been widely used for anxiety treatment, but little research exists on acute bouts of mindfulness training that do not require a trained facilitator. Likewise, extensive research has been done to study the anxiolytic effects of various modes and intensities of exercise, but none have compared it to or combined it with mindfulness practice. Future research needs to address the gap in the literature to elucidate the potentially efficacious treatment method. Practitioners treating anxious individuals may benefit from such information, as well as individuals seeking ways to manage their own anxiety.

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APPENDIX B

FULL METHODOLOGY

Participants were recruited from undergraduate classes at the University of Rhode Island. A screening questionnaire was distributed by research staff to filter the population for individuals meeting the inclusion criteria. Of the screening questionnaires collected (N = 970), the females between the ages of 18 and 25 who scored 3 or higher on the generalized anxiety disorder screen (GAD-2), which is the recommended cut-off for potential anxiety disorder (Kroenke, Spitzer, Williams, Monahan, & Löwe, 2007), and indicated interest in participating in the study, (N = 162) were contacted and asked to schedule an orientation session. In return for their participation, subjects were entered into a raffle for a $25 gift card. Individuals were excluded if they indicate that they smoke on the screening questionnaire on the basis that subjects were required to refrain from smoking several hours before the treatment which may have induced anxiety in a smoker (Breus & O'Connor, 1998; Streeter et al., 2010). Subjects answered a medical history questionnaire to ensure they were safe to exercise, and those with asthma were asked to bring an inhaler. The protocol was approved by the University of Rhode Island's Institutional Review Board, and the participant flow is displayed in Figure A.

Sixty-two females (mean age = 19.3 years) agreed to participate in the study and attended an orientation session, and 56 completed both the orientation and experimental sessions. At the start of the experimental session, participants were randomly assigned using a random number generator to one of four conditions: exercise-mindfulness (EX-MP, N = 16), exercise-video distraction (EX-noMP, N =

14), no exercise-mindfulness (noEX-MP, N = 12), no exercise-video distraction (noEX-noMP, N = 14). Table 1 compares the participants in each of the four groups on demographic variables and all baseline measures.

Orientation session. Participants attended a 15-minute orientation session. First, an informed consent was signed, and subjects were assured that all information collected was completely confidential and that they may quit at any time. A medical history questionnaire screened for potential medical reasons the individual should not exercise. Demographics, including an exercise frequency questionnaire and height and weight were collected, as well as exercise and mediation self-efficacy questionnaires. An anxiety inventory (STAI-Y2) was administered to compare scores to population norms and determine level of trait anxiety. The researcher explained to participants that during the experimental session they may be asked to complete different tasks depending on which condition they are randomly assigned to, and asked to come dressed appropriately for exercise in the event they are chosen for that task. Subjects were asked to refrain from eating for at least one hour before the session, consuming alcohol for 48 hours, and asked to refrain from consuming any caffeine (i.e. tea, caffeinated soda, energy drinks) for at least 72 hours before the session; previous research has shown that caffeine may have effects on mood and anxiety (Lieberman, Wurtman, Emde, & Coviella, 1987). The remainder of the session was spent familiarizing subjects with the heart rate (HR) monitor and exercise bike.

Interventions

Upon arrival to the lab, subjects were seated at a table and given a state anxiety inventory (STAI-Y1) and positive and negative affect survey (PANAS-X). In addition,

participants had been familiarized with the lab and exercise procedures during the orientation session, so there was no reason to suspect subjects would be unusually tense. Participants were then given a HR monitor to wear for the duration of the experiment, followed by random assignment to one of the four conditions (described in detail below). Subjects spent 20 minutes in their respective condition; state anxiety and affect questionnaires were given again immediately following the assigned task, then again at five minutes, 10 minutes, and 20 minutes post-task. The last series of questionnaires included another exercise and mindfulness self-efficacy assessment, and the session ended with a manipulation check to verify attention was influenced as intended for each condition.

Aerobic exercise. Participants randomly assigned to the exercise conditions (EX-MP and EX-noMP) began by being fitted to the Precor 846i recumbent bike (Precor USA, Woodinville, WA, U.S.). The researcher selected the manual option on the bike, and the subject spent five minutes in a warm-up stage with the resistance on the bike set to "1", which is the easiest setting. After the warm-up, the researcher either began the mindfulness recording to induce mindful attention during the exercise (EX-MP), or played a video to dissociate attention from the exercise (EX-noMP). The researcher monitored HR and alerted the subject if it was above or below 60-69% of the subject's age-predicted HR_{max}, at which point the subject was asked to adjust the intensity accordingly to remain in that range. This intensity was selected because previous research has shown moderate and high intensity aerobic exercise has the greatest anxiolytic effect, however the high intensity option was eliminated as it may induce negative affect in participants who are not regularly active (Ekkekakis, Hall, &

Petruzzello, 2008; Petruzzello, Landers, Hatfield, Kubitz, Salazar, 1991). After 20 minutes of exercise, participants transitioned to a five minute cool-down phase at a resistance of "1", while immediately given the first round of post-task surveys. After the cool-down, subjects were seated at a table for the remaining duration of the experiment.

In the EX-MP condition, subjects were informed of the target HR range and asked to self-monitor the intensity during the exercise by watching the HR display on the bike, and adjust the intensity as necessary by changing the resistance or the speed. This was intended to further elucidate mindfulness state by bringing the focus to bodily sensations (Kabat-Zinn, 1994; Shapiro, Carlson, Astin, & Freedman, 2006). The researcher monitored the subjects' HR to maintain the target range (60-69% HR_{max}).

In the EX-noMP condition, the exercise data displayed on the bike (i.e. time, distance, pace, HR) was covered, so the only thing in direct view of the subject was the video-displaying device. The researcher was solely responsible for monitoring subjects' HR, and informed subjects when it was necessary to adjust the intensity; they were permitted to self-select the method to do so by either changing the resistance or speed accordingly. Subjects randomly assigned to the non-exercise conditions (noEX-MP and noEX-noMP) remained seated at the table for the mindfulness and dissociation tasks (described below), and given post-task surveys at the same time points as the exercise conditions.

Mindfulness training. Participants assigned to the mindfulness conditions (EX-MP and noEX-MP) were asked to listen and follow along with a recording of a female

voice cueing the subject to focus attention on the present moment for 20 minutes. These cues include bringing attention to the breathe, body awareness, acknowledging thoughts without judgment and then letting them go, and attending to other senses, such as what they see, smell, taste and feel. This basic mindfulness meditation exercise represents defining features of mindfulness process (Kabat-Zinn, 1994; Shapiro et al., 2006), and is consistent with procedures of other studies (Lau et al., 2006; Thompson & Waltz, 2007).

Distraction video. The EX-noMP and noEX-noMP conditions were intended to avert the participant's focus from the internal and external stimuli related to the present moment. To accomplish this, participants chose one of three 20-minute episodes of "TED Talks", an educational video series. The three episodes were void of content related to exercise, mindfulness, stress, or anxiety. The video was viewed on an Apple iPad 2.0 (Foxconn, Shenzhen, China).

Manipulation check. After filling out the last round of surveys, subjects in all conditions were asked to describe what they were thinking about during the experiment in as much detail as possible. These responses were reviewed by the researchers to ensure subjects were attending to the appropriate task.

Measures

Demographic data. Demographic data collected included the age, height, weight, race and ethnicity, degree-seeking level, employment status, and previous experience with mindfulness meditation. Height and weight were self-reported on the screening questionnaire and measured objectively during the experimental procedures. Height was measured with the participant's feet together and flat on the floor, head,

neck and buttocks against a standard wall-mounted stadiometer (Seca S-216, Hanover, MD). Participants were weighed without excess clothing (i.e. no shoes, jewelry, jacket) with a digital scale (Health-O-Meter H-349KLX, Boca Raton, FL). Height and weight were used to calculate body mass index (BMI), a measure used to estimate body composition and used to categorize individuals as underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), or obese (>30; Heyward, 2006).

Leisure-Time Exercise Questionnaire (LTEQ). The LTEQ is used to assess the frequency of 20 minutes of mild, moderate, and strenuous exercise performed in a 7-day period. The frequency is then calculated into arbitrary units of physical activity levels. This instrument has been tested and validated to be used to measure how active a person is in a typical week (Godin, Jobin, & Bouillon, 1986). This measure was used to ensure homogeneity of regular physical activity habits across experimental groups.

Generalized Anxiety Disorder (GAD) Screener. The GAD-7 is a screening tool used in clinical psychology for GAD, and also has decent operating characteristics for three other common anxiety disorders: panic disorder, social anxiety disorder, and post-traumatic stress disorder (Kroenke et al., 2007; Spitzer, Kroenke, Williams, & Löwe, 2006). The GAD-2 is a shorter version, also with good operating characteristics, and consists of the two core DSM-IV items for GAD. Scores on the GAD-2 are calculated by assigning scores of 0, 1, 2, and 3, to the response categories of not at all, several days, more than half the days, and nearly every day, respectively. Scores on the GAD-2 range from 0 to 6; the recommended cut-point when used as a screener is a score of 3 or greater.

Medical history questionnaire. The medical history questionnaire is a standard survey to check participants for health risk factors and morbidities (i.e. heart problems, family history of sudden death before age 50, etc.), or other possible reasons why the individual should not participate in physical activity. In addition, the questionnaire was used to identify existing psychological disorders and use of any medication or other psychological treatment.

State and Trait Anxiety Inventory - Form Y. The STAI-Y is a commonly used measure of trait (Y2) and state anxiety (Y1) used both in clinical settings and during research (C. Spielberger, Gorusch, Lushene, Vagg, & Jacobs, 1983). Considerable evidence supports the internal consistency, test-retest reliability, and concurrent validity of the scale (Spielberger, 1989). The form Y is the most popular version; it consists of 20 items that are rated on a 4-point scale (e.g., from "Almost Never" to "Almost Always"), with higher scores indicating greater anxiety. The STAI is the most cited anxiety instrument in the context of exercise (Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991; Wipfli, Rethorst, & Landers, 2008).

Affective response. The general dimension scales of the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988) were used to assess positive and negative affect before and after the conditions. Participants were to rate 10 items measuring positive affect (active, alert, attentive, determined, enthusiastic, excited, inspired, interested, proud, strong), and 10 items measuring negative affect (afraid, scared, nervous, jittery, irritable, hostile, guilty, ashamed, upset, distressed) in terms of the degree to which they felt "right now." The PANAS-X was developed and

validated on undergraduate college samples, and has been widely used in studies involving mood (Bibeau, Moore, Mitchell, Vargas-Tonsing, & Bartholomew, 2010).

Self-efficacy. A modified version of the Exercise Self-Efficacy Scale (McAuley & Jacobson, 1991) was used to assess participants' confidence in ability to cycle on an exercise bike at a moderate intensity for increasing lengths of time. Participants were asked to indicate their confidence on a 100-point percentage scale with 10-point increments; zero indicates 0% and not at all confident, and a score of 100 indicates 100%, signifying high confidence. Similar methods of self-efficacy assessment have been used in physical activity studies (Katula, Blissmer, & McAuley, 1999). Likewise, to assess subjects' self-efficacy to engage in mindfulness meditation, they were asked to indicate their confidence in ability to practice meditation for increasing lengths of time. There were a total of 7-items for each exercise and meditation self-efficacy.

Heart Rate (HR). Heart rate was used to monitor intensity during the bout of exercise, and ensure intensity was at the desired percentage range of the subjects' age-predicted HR_{max} (60-69%). All participants wore a Polar E600 HR monitor (Polar Electro Inc., Lake Success, NY, U.S.) throughout the experiment.

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APPENDIX C

Name: _____

Date:_____

Age:_____

Gender (circle): Male Female

Do you smoke? (circle): YES NO

Are you willing to participate in a study about exercise, mindfulness

Over the last 2 weeks, how often have you been bothered by the following problems? *(Use a "✓" to indicate your answer)*	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Feeling nervous, anxious or on edge	0 ☐	1 ☐	2 ☐	3 ☐
2. Not being able to stop or control worrying	0 ☐	1 ☐	2 ☐	3 ☐

and mood? (circle):

YES **NO**

If yes, please provide contact information:

Phone:_____

Email:_____

APPENDIX D

The University of Rhode Island
Department of Kinesiology
25 West Independence Way
Kingston, RI 02881
Anxiolytic effects of exercise and mindfulness

CONSENT FORM FOR RESEARCH

You have been invited to take part in a research project described below. The researcher will explain the project to you in detail. You should feel free to ask questions. If you have more questions later, Dr. Bryan Blissmer, the person mainly responsible for this study, (401) 874-5435, will discuss them with you. You must be at least 18 years old to be in this research project.

Description of the project:
The purpose of this research is to evaluate effects of two types of activities, aerobic exercise and mindfulness training, separately and together on anxiety and mood. Those who participate will be entered into a raffle for a $25 visa gift card; the winner will be drawn and contacted by the student investigator after all data has been collected, which will be by May 1, 2014 at the latest.

What will be done:
If you take part in this study, you will first come in for an orientation session where your height and weight will be measured, answer surveys, including a medical history questionnaire and you will be familiarized with the study procedures and equipment involved. You will be asked to dress appropriately for physical activity, refrain from consuming caffeine for 72 hours, alcohol for 48 hours, and food for at least 1 hour before the experiment. During the experiment, you will wear a heart rate monitor, and will be assigned randomly to a task. You may be asked to pedal on an exercise bike at a low to moderate intensity for a total of 30 minutes or remain seated for 30 minutes while either participating in guided mindfulness training recording or watching an educational video of your choosing. Your involvement in any of these tasks will be random, like the flip of a coin. You can expect the whole experiment to take about 1 hour.

Risks or discomfort:
Aerobic exercise may make you feel tired, and may result in muscle soreness. Every effort will be made to minimize risks and the risk of injury by medical history screening and monitoring procedures that are designed to anticipate and exclude the rare individual for whom exercise might be injurious. All these risks are no greater than those that may occur during the normal course of training. The Investigator does not have a plan to cover the cost of any injuries in the course of participation. If you are injured during your participation in any way, you will be given first aid and evaluated by the University of Rhode Island Health Services and referred to your

personal doctor, if needed. If you have any difficulty completing the protocol because of muscular soreness, illness, or another injury unrelated to the study, the exercise protocol will be terminated for that day. Although there are no known psychological risks associated with this study, in the event you need the aid of a counselor, you may contact the campus Counseling Center at (401) 874-2288, or visit them at 217 Roosevelt Hall, 90 Lower College Road, University of Rhode Island, Kingston, Rhode Island.

Benefits of this study:
There are no direct benefits to you for participating in this study, but your participation will help the researchers in learning more about exercise, mindfulness training and mood.

Confidentiality:
Any information obtained from you during the study will remain confidential and you will not be identified by name in any publication or reports that result from this study. Each subject will receive a random numerical code; all records will be coded and stored by the subject identification codes. Records of codes will be locked and stored in a file cabinet in the Kinesiology department, 25 West Independence Way, Suite P, at the University of Rhode Island. The researchers will be the only people to have access to these records. Records will be kept for 3 years and then destroyed. Any data entered into a computer program will contain only subject codes to ensure anonymity.

In case there is any injury to the subject: (If applicable)
If this study causes you any injury, you should write or call Dr. Bryan Blissmer at the University of Rhode Island at (401) 874-5435. You may also call the office of the Vice President for Research, 70 Lower College Road, University of Rhode Island, Kingston, Rhode Island, telephone: (401) 874-4328.

Decision to quit at any time:
Participation in this study is completely voluntary, and you have the right to quit at any time. Quitting the study will not result in any sort penalty to you as an individual or as a student. If you wish to quit, simply inform Dr. Bryan Blissmer at the University of Rhode Island at (401) 874-5435 of your decision.

Rights and Complaints:
If you are not satisfied with the way this study is performed, you may discuss your complaints with Dr. Bryan Blissmer or with Alyssa Guastella (203) 512-6381, anonymously, if you choose. In addition, if you have questions about your rights as a research participant, you may contact the office of the Vice President for Research, 70 Lower College Road, Suite 2, University of Rhode Island, Kingston, Rhode Island, telephone: (401) 874-4328.

You have read the Consent Form. Your questions have been answered. Your signature on this form means that you understand the information and you agree to participate in this study.

_____	_____
Signature of Participant	Signature of Researcher
_____	_____
Typed/printed Name	Typed/printed name
_____	_____
Date	Date

Please sign both consent forms, keeping one for yourself

APPENDIX E

HUMAN PERFORMANCE LABORATORY MEDICAL HISTORY QUESTIONNAIRE

Date: _____ _____

PLEASE ANSWER ALL OF THE FOLLOWING QUESTIONS AND PROVIDE DETAILS FOR ALL "YES" ANSWERS IN THE SPACES AT THE BOTTOM OF THE FORM.

YES	NO		
☐	☐	1.	Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2.	Has your doctor ever denied or restricted your participation in sports or exercise for any reason?
☐	☐	3.	Do you ever feel discomfort, pressure, or pain in your chest when you do physical activity?
☐	☐	4.	In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	5.	Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	6.	Does your heart race or skip beats during exercise?
☐	☐	7.	Has a doctor ever ordered a test for you heart? (i.e. EKG, echocardiogram)
☐	☐	8.	Has anyone in your family died for no apparent reason or died from heart problems or sudden death before the age of 50?
☐	☐	9.	Have you ever had to spend the night in a hospital?
☐	☐	10.	Have you ever had surgery?

11. Please check the box next to any of the following illnesses with which you have ever been diagnosed or for which you have been treated.

☐	High blood pressure	☐	Elevated cholesterol	☐	Diabetes
☐	Asthma	☐	Epilepsy (seizures)	☐	Kidney problems
☐	Bladder Problems	☐	Anemia	☐	Heart problems
☐	Coronary artery disease	☐	Lung problems	☐	Chronic headaches

YES	NO		
☐	☐	12.	Have you ever gotten sick because of exercising in the heat? (i.e. cramps, heat exhaustion, heat stroke)
☐	☐	13.	Have you had any other significant illnesses not listed above?
☐	☐	14.	Do you currently have any illness?
☐	☐	15.	Do you know of any other reason why you should not do physical activity?

16. Please list all medications you are currently taking. Make sure to include over-the-counter medications and birth control pills.

Drugs/Supplements/Vitamins	Dose	Frequency (i.e. daily, 2x/day, etc.)

DETAILS: _____

_____

_____

_____

_____

_____

_____

_____

_____

17. Are you currently diagnosed with any of the following?:

			Receiving treatment?				
☐	Depression	_____		☐	Yes	☐	No
☐	Anxiety disorder	_____		☐	Yes	☐	No
☐	Mood disorder	_____		☐	Yes	☐	No
☐	PTSD	_____		☐	Yes	☐	No

18. Please list all allergies you have.

Substance	Reaction
_____	_____
_____	_____
_____	_____
_____	_____

YES	NO			If yes, #/day	Age Started	If you've quit, what age?
		19.	Have you smoked?			
☐	☐		Cigarettes	_____	_____	_____
☐	☐		Cigars	_____	_____	_____
☐	☐		Pipes	_____	_____	_____
☐	☐	20.	Do you drink alcoholic beverages?	If yes, how much? _____		How often? _____

21. Do you have a family history of any of the following problems? If yes, note who in the space provided.

☐	High blood pressure	_____	☐	Heart disease	_____
☐	High cholesterol	_____	☐	Kidney disease	_____
☐	Diabetes	_____	☐	Thyroid disease	_____

22. Please check the box next to any of the following body parts you have injured in the past and provide details.

☐	Head	_____	☐	Hip	_____	☐	Calf/shin	_____
☐	Neck	_____	☐	Thigh	_____	☐	Shoulder	_____
☐	Upper back	_____	☐	Knee	_____	☐	Upper arm	_____
☐	Lower back	_____	☐	Ankle	_____	☐	Elbow	_____
☐	Chest	_____	☐	Foot	_____	☐	Hand/fingers	_____

YES	NO		
☐	☐	23.	Have you ever had a stress fracture?

☐	☐	24.	Have you ever had a disc injury in your back?
☐	☐	25.	Has a doctor ever restricted your exercise because of an injury?
☐	☐	26.	Do you currently have any injuries that are bothering you?

27. Do you consider your occupation as?

- ☐ Sedentary (no exercise)
- ☐ Inactive-occasional light activity (walking)
- ☐ Active-regular light activity and/or occasional vigorous activity (heavy lifting, running, etc.)
- ☐ Heavy Work-regular vigorous activity

ADDITIONAL DETAILS:

APPENDIX F

Age:_____
Height:_____ **Weight:_____** lbs
Ethnicity (circle)**:**

a. Hispanic or Latino
b. Not Hispanic or Latino

Race (circle all that apply)**:**

a. White
b. Black or African-American
c. Asian
d. Native Hawaiian or Other Pacific Islander
e. American Indian or Alaska Native
f. Other

Enrolled in classes (circle)**:** part-time full-time
Graduate student? (circle): Yes No
Academic Major: _____
Employment status (circle): unemployed part-time full-time
I practice some sort of meditation or mindfulness (circle):

a. once per day.
b. once per week.
c. once per month.
d. never.

APPENDIX G

1. During a **typical 7-Day period** (a week), how many times on the average do you do the following kinds of exercise for **more than 15 minutes** during your free time (write on each line the appropriate number).

TIMES PER WEEK

a. STRENUOUS EXERCISE
(HEART BEATS RAPIDLY)
(e.g. running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling) _____

b. MODERATE EXERCISE
(NOT EXHAUSTING)
(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing) _____

c. MILD EXERCISE
(MINIMAL EFFORT)
(e.g. yoga, archery, fishing from a river bank, bowling, horseshoes, golf, snow-blowing, easy walking) _____

1. During a typical **7-Day period** (a week), in your leisure time, how often do you engage in any regular activity **long enough to work up a sweat** (heart beats rapidly)? Check one.

Often	Sometimes	Rarely/Never
☐	☐	☐

APPENDIX H

Cycling Self-Efficacy for Duration

Please indicate below how confident you are that you can successfully carry out each of the activities listed below:

I BELIEVE THAT I CAN CYCLE ON AN EXERCISE BICYCLE:

0 10 20 30 40 50 60 70 80 90 100

NOT AT ALL MODERATELY HIGHLY

CONFIDENT CONFIDENT CONFIDENT

1. For **10 minutes at a moderate intensity** without stopping.

0 10 20 30 40 50 60 70 80 90 100

2. For **20 minutes at a moderate intensity** without stopping.

0 10 20 30 40 50 60 70 80 90 100

3. For **25 minutes at a moderate intensity** without stopping.

0 10 20 30 40 50 60 70 80 90 100

4. For **30 minutes at a moderate intensity** without stopping.

0 10 20 30 40 50 60 70 80 90 100

5. For **35 minutes at a moderate intensity** without stopping.

0 10 20 30 40 50 60 70 80 90 100

6. For **40 minutes at a moderate intensity** without stopping.

0 10 20 30 40 50 60 70 80 90 100

7. For **45 minutes at a moderate intensity** without stopping.

0 10 20 30 40 50 60 70 80 90 100

APPENDIX I

Mindfulness Meditation Self-Efficacy for Duration

Please indicate below how confident you are that you can successfully carry out each of the activities listed below:

I BELIEVE THAT I CAN PRACTICE MINDFULNESS MEDITATION:

0 10 20 30 40 50 60 70 80 90 100

NOT AT ALL CONFIDENT **MODERATELY CONFIDENT** **HIGHLY CONFIDENT**

1. For at least **10 uninterrupted minutes**.

0 10 20 30 40 50 60 70 80 90 100

2. For at least **20 uninterrupted minutes**.

0 10 20 30 40 50 60 70 80 90 100

3. For at least **25 uninterrupted minutes**.

0 10 20 30 40 50 60 70 80 90 100

4. For at least **30 uninterrupted minutes**.

0 10 20 30 40 50 60 70 80 90 100

5. For at least **35 uninterrupted minutes**.

0 10 20 30 40 50 60 70 80 90 100

6. For at least **40 uninterrupted minutes**.

0 10 20 30 40 50 60 70 80 90 100

7. For at least **45 uninterrupted minutes**.

0 10 20 30 40 50 60 70 80 90 100

APPENDIX J

SELF-EVALUATION QUESTIONNAIRE
STAI Form Y-1

DIRECTIONS:
A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I feel strained	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worried over possible misfortunes	1	2	3	4
8. I feel satisfied	1	2	3	4
9. I feel frightened	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel indecisive	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel confused	1	2	3	4
19. I feel steady	1	2	3	4
20. I feel pleasant	1	2	3	4

APPENDIX K

SELF-EVALUATION QUESTIONNAIRE
STAI Form Y-2

DIRECTIONS:
A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel. There no right or wrong answers. Do not spend too much time on one statement but give the answer which seems to best describe how you generally feel.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel pleasant	1	2	3	4
2. I feel nervous and restless	1	2	3	4
3. I feel satisfied with myself	1	2	3	4
4. I wish I could be as happy as others seem to be	1	2	3	4
5. I feel like a failure	1	2	3	4
6. I feel rested	1	2	3	4
7. I am "calm, cool, and collected"	1	2	3	4
8. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
9. I worry too much over something that really doesn't matter	1	2	3	4
10. I am happy	1	2	3	4
11. I have disturbing thoughts	1	2	3	4
12. I lack self-confidence	1	2	3	4
13. I feel secure	1	2	3	4
14. I make decisions easily	1	2	3	4
15. I feel inadequate	1	2	3	4
16. I am content	1	2	3	4
17. Some unimportant thought runs through my mind and bothers me	1	2	3	4
18. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
19. I am a steady person	1	2	3	4
20. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

APPENDIX L

PANAS-X

This scale consists of a number of words and phrases that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. **Indicate to what extent you feel at this moment**.

Use the following scale to record your answers:

1	**2**	**3**	**4**	**5**
very slightly or not at all	**a little**	**moderately**	**quite a bit**	**extremely**

_____	upset	_____	nervous	_____	enthusiastic	_____	alert
_____	guilty	_____	attentive	_____	hostile	_____	scared
_____	excited	_____	inspired	_____	jittery	_____	active
_____	interested	_____	irritable	_____	distressed	_____	determined
_____	proud	_____	afraid	_____	strong	_____	ashamed

APPENDIX M

"TED Talks" video options:

1. Feats of Memory Anyone Can Do.

   Science writer Joshua Foer describes the technique known as "the memory palace" to explain how people can quickly memorize long lists of numbers.

2. Paul Sereno Digs Up Dinosaurs.

   A paleontologist talks about his surprising encounters with prehistory – and a new way to help students join the adventure.

3. Steven Strogatz on Sync.

   Mathematician Steven Strogatz shows how flocks of creatures (birds, fireflies and fish) synchronize and act as a unit, when no one's giving orders.

APPENDIX N

Please describe in as much detail as possible what you were thinking about during the experiment:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____