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Assessing Stress in College Students After Breathing Meditation With and Without Music

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To the Dean of the Graduate School:

We are submitting a thesis written by Joshua LeClerg entitled Assessing Stress in College Students After Breathing Meditation With and Without Music. We recommend acceptance in partial fulfillment of the requirements for the degree of Master of Science in Biology.

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ASSESSING STRESS IN COLLEGE STUDENTS AFTER BREATHING

MEDITATION WITH AND WITHOUT MUSIC

A Thesis

Presented to the Faculty

Of the

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ABSTRACT

College students face increased levels of stress due to the COVID-19 pandemic, which can adversely affect their academic performance. Therefore, it is critical for students to have access to practices that reduce stress, such as breathing meditations and listening to calming music, which are cost effective and require minimal time commitment. This study aimed to examine the efficacy of combining breathing meditation and listening to music for five minutes a day, five days a week, for two weeks. Fifteen undergraduate students completed the study and were randomly assigned to a control group who completed the breathing meditation without music (n=8) and a treatment group who completed the breathing meditation with music (n=7). Participants completed surveys before and after the meditation program, which included the Perceived Stress Scale (PSS), the 15-Item Five-Facet Mindfulness Questionnaire (FFMQ-15), questions about COVID-19 experience, and demographic information. Additionally, participants wore a Fitbit Inspire 2 for the duration of the study to collect physiological data including sleep, activity minutes, steps, and heart rate. Participants who completed breathing meditation for two weeks reported a significant reduction in stress and a significant increase in overall mindfulness at post-treatment compared to baseline, independent of whether music was included. However, there were no significant differences in Fitbit measures of physiology. This study lays the foundation for future research into combined stress-reduction practices for college students.

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1. INTRODUCTION

1.1 Overview

Stress can severely impact student retention and success in higher education. Among U.S. college students surveyed in the spring of 2021, 80.8% reported moderate or high stress levels, 38.4% reported that stress negatively impacted their class performance, and 5.4% reported a delay in degree progress (American College Health Association 2021). Additionally, 44.8% of students reported that the COVID-19 pandemic has significantly increased their level of stress (American College Health Association 2021). Furthermore, college students self-reported increased symptoms of both anxiety and depression during the Winter 2020 semester compared to prior semesters (Huckins et al. 2020). Similarly, Wang et al. (2020) found that as many as 71% of student participants reported an increase in stress or anxiety during the COVID-19 pandemic, with 39% of those respondents listing academics in a pandemic as the biggest contributor to their stress. Lastly, 47% of participants in a different study reported moderate to extreme worry regarding the pandemic, and these students were more likely to report poor sleep quality than their less stressed peers (Ulrich et al. 2021).

Despite high stress and anxiety, many college students will not pursue traditional mental health support, such as counseling, due to financial barriers (Miranda et al. 2015), because they consider stress a normal part of higher education, or because they don’t have the time to pursue traditional forms of mental healthcare (Eisenberg et al. 2007). Both music and breathing meditation may each individually help reduce stress in individuals, and they are cost effective and require minimal time to implement (Yehuda 2011; Saoji et al. 2019). However, 68.9% of students reported no involvement in meditation or meditative practices in a typical week (American College Health Association 2021). Therefore, this study aims to explore the combined impact of breathing meditation and music on stress levels in college students and assess whether it could be used as an accessible tool for managing students' mental health.

1.2 Stress

Physiological responses to stress include increases in heart rate, blood pressure, and cortisol hormone levels, causing activation of the sympathetic nervous system (Yehuda 2011). Perceived stress can be measured using the Perceived Stress Scale (PSS) (Cohen et al. 1983), and a brief outline of the General Adaptation Syndrome (GAS) (Selye 1936; 1951) summarizes the relevant physiology of stress. In stage one, alarm, the body responds to the stressor, commonly with sympathetic activation. In the second stage, resistance, the body restores many physiological changes caused by sympathetic activation to maintain homeostasis while defending against a prolonged stressor. An example of this is the activation of neural and hormonal pathways that raise blood pressure. In addition, cortisol, known as the stress hormone, is released. This leads to many of these changes as it helps regulate the body's stress response by increasing plasma glucose levels, which provide extra fuel for the body. In the presence of extreme, prolonged stress, stage three is achieved. Stage three is the "exhaustion" stage, wherein essential systems begin to shut down (Selye 1936, 1951).

Broadly, mental health can have significant impacts on student success and retention, with as many as 64% of students who leave college before graduation attributing their attrition to mental health concerns (Gruttadaro 2012). During the COVID-19 pandemic, as many as 89% of students surveyed were worried about academic progress, and 85% were worried about academic performance (Wang et al. 2020). Previous reports suggest that there is an inverse relationship between student stress and academic performance (Grimes and Binder 2021).

1.3 Mindfulness

Mindfulness can be described as "moment-to-moment non-judgmental awareness" and can help reduce stress (Kabat-Zinn 2013). One well-studied program is Mindfulness-Based Stress Reduction (MBSR) (Kabat-Zinn 2013), an eight-week course that incorporates 45-60 minutes of daily mindfulness practice, such as body scan meditation, yoga, and breathing. Review of MBSR in college students found that 73% of the studies resulted in significant reductions in overall stress scores (Bamber and Schneider 2016). More recently, one study found that a 4-week mindfulness-based intervention (MBI) significantly reduced stress in undergraduate students compared to students who completed a coloring activity (active control) and compared to a traditional negative control group (Dark-Freudeman et al. 2020). Furthermore, college students who reported more mindfulness also engaged in more exercise (Lentz and Brown 2019). Working undergraduate students who participated in an 8-week mindfulness-based strengths practice (MBSP) reported a significant improvement to overall well-being and a non-significant increase in retention over the two subsequent semesters (Wingert et al. 2020).

1.4 Yoga Breathing

One mindfulness practice is yoga breathing, otherwise known as *Pranayama* (in Sanskrit), which includes a variety of techniques that may beneficially affect “neurocognitive, psychophysiological, respiratory, biochemical, and metabolic functions,” as well as several clinical conditions (Saoji et al. 2019). In individuals with hypertension, a specific type of yoga breathing called *Nadishodhana*, or alternate nostril breathing, reduced systolic and diastolic blood pressure after 10 minutes, compared to simple breath awareness, which only reduced systolic blood pressure, and a control activity that had no impact on blood pressure (Telles et al. 2013). Similarly, hypertension patients in a different study who practiced alternate nostril breathing for 10 minutes, twice a day, for five days alongside routine treatment reported a significant reduction in blood pressure, heart rate, and rate pressure product (a measure of the energy demand of the heart found by multiplying heart rate by systolic blood pressure) relative to a control that only received typical treatment (Kalavaini et al. 2019).

Another *pranayama* practice, left uninostril breathing, involves inhalation and exhalation through only the left nostril, while the right nostril is occluded. Six weeks of left uninostril breathing caused an increase in parasympathetic activity, and just 20 minutes of alternate nostril breathing also increased parasympathetic activity (Saoji et al. 2019). Raghurai (2008) compared left uninostril breathing to other nostril manipulations and reported a significant increase in heart rate after 30 minutes of practice across five days, and a significant decrease in systolic and mean blood pressure. While these blood pressure results are in line with previous discussions, the heart rate data are not, suggesting that the impact to physiology is more complex than simple sympathetic or parasympathetic activation. Other studies report reductions in blood pressure, heart rate, and breathing rate (Bargal et al. 2022, Saoji et al. 2019). A review of relevant literature also found that while there was no change in blood oxygen levels, different types of yogic breathing could change oxygen consumption patterns (Saoji et al. 2019) Therefore, left uninostril breathing is a technique in yoga breathing that shows promise for stress management. Additionally, yoga breathing, like left uninostril breathing, and general mindfulness interventions may be considered low-intensity and have not been associated with significant risks. Even the more intense practices, such as *Kapalabhati* were only infrequently associated with adverse effects. Mindfulness practices had comparable risks to current best practices in psychotherapy, including counseling and pharmacological interventions (Johnson and Tierney 2004; Cramer et al. 2013; Britton et al. 2021).

1.5 Music and Relaxation

Over 50 studies have explored the use of music to reduce stress that were cited in a 2011 review of the topic (Yehuda 2011). Music can impact the brain through entrainment, a process where one rhythm or frequency is aligned to another, which leads to brain waves matching the musical rhythm. There are two brain waves associated with relaxation, alpha waves (6-12 Hz) and theta waves (4-7 Hz), and music can alter these brain waves (Yehuda 2011). Yoga breathing can also lead to changes in brain wave activity, including an increase in alpha activity (Kaushik et al. 2020). Research is still exploring the connections between brain wave activity and music’s ability to reduce stress in individuals (Yeduda 2011). By contrast, Liu et al. (2013) investigated the use of music to increase alertness while driving and identified three factors of music that impacted how "refreshing" it was. The most refreshing music had three factors: a high average pitch with lots of variation, measured via pitch entropy and pitch interval entropy (Liu et al. 2013). Additionally, music may modulate neurotransmitters in the brain, including norepinephrine, dopamine, and serotonin (Evers and Suhr 2000; Yehuda 2011), which are most notably associated with the fight-or-flight response, the brain's reward system, and mood regulation (among many other things), respectively.

Given its role in stress regulation, several studies have explored changes in cortisol levels as it relates to stress. Notably, hair cortisol concentrations (HCC) have been found to increase in undergraduate students more over 10 weeks during a stressful time (fall semester) than during a low stress time (summer break) (Stetler and Guinn 2020). Additionally, greater exposure to traumatic or stressful events was associated with increases in hair cortisol levels during pregnancy (Schreier et al. 2016). However, music may lower cortisol levels, particularly classical music and music in a major key compared to a minor key (Khalfa et al. 2003; Yehuda 2011). Interestingly, techno music may be a notable exception to the effect of music as it seemed to increase cortisol levels (Gerra et al. 1998). This suggests that certain types of music may be able to produce adverse effects.

Music may also promote relaxation via physiological or psychological entrainment, during which similar resonance frequencies adjust to match each other (Yehuda 2011). This can apply to several physiological processes, including heart rate and blood pressure. For example, the tempo of music can alter heart rate via entrainment. High-tempo music can increase heart rate, and low-tempo music, close to a resting heart rate, can lower heart rate, inducing a relaxed state. In line with this principle, music used for entrainment-based therapy should have a tempo at or below resting heart rate (around 70 bpm), predictable dynamics, pleasing harmonies, and a regular rhythm. Furthermore, music seems to be more effective when it is "self-selected," or a style of music that study participants would listen to in their day-to-day life, or that they chose themselves for the study. In some instances, participants prefer silence over prescribed music (Yehuda 2011).

1.6 Music and Sleep

Music may help improve the quality of sleep in students (Harmat et al. 2008). There are several mechanisms by which music may impact sleep, including its ability to reduce sympathetic nervous system activity and decrease anxiety, as well as decrease blood pressure, heart rate, and respiratory rate, all of which decrease during sleep. More specifically, listening to "relaxing classical music" for 45 minutes before bed significantly improved sleep quality compared to a similar treatment listening to audiobooks and no intervention, neither of which caused a significant change (Harmat et al. 2008). However, the researchers acknowledged two possible limitations. First, they did little to assess or enforce participant compliance. Second, all participants only experienced moderate degrees of sleep disruption, as experiencing severe sleep disruptions was an exclusion criterion. The authors acknowledge that sleep disruptions of the caliber studied may resolve themselves spontaneously, irrespective of intervention (Harmat et al. 2008).

A similar study included 27 female participants who listened either to music or a control text before taking a 90-minute nap. Participants were assessed based on their "suggestibility index," which is how likely a person is to be susceptible to things like hypnosis and the placebo effect. In this study, the authors investigated whether music could serve as a non-hypnotic effect that could improve sleep quality in high-suggestible people compared to low-suggestible peers. Participants who listened to music reported a nearly 3-minute decrease in the average amount of time in stage 1 sleep (the stage associated with falling asleep) and low-suggestible participants saw a 46% increase in the time spent in deep sleep (stage 3, slow-wave sleep, non-rapid eye movement sleep) (Cordi et al. 2019).

1.7 Yoga Breathing and Music

A few studies have examined the combined impact of yoga breathing and music interventions on stress (Joshi and Kiran 2019; Vajpeyee et al. 2021). However, long-term implications of these practices are not well established, and some of the methodology has not been clearly outlined to allow replication of the work. Therefore, our study begins to address this gap in the literature by exploring a short-term combined music and yoga breathing intervention on stress in college students and developing a potential methodology for future research to expand upon.

1.8 Fitbits

In order to analyze quantitative physiological data while participants completed breathing meditation, this study utilized Fitbit device technology. The rise of wearable fitness technology has opened the opportunity to collect objective measures of data that have traditionally been assessed via self-report, such as physical activity, heart rate, and sleep. For example, Wang et al. (2021) collected Fitbit data to examine the impact of personal, social, and environmental factors on daily physical activity in college students.

Another strength of Fitbit technology is its accuracy when measuring resting heart rate. Both the Apple Watch and Fitbit are more accurate than research-grade wearables with only minimal underestimation of heart rate (Nelson et al. 2020). Additionally, Fitbits are more affordable than research-grade wearables (Nelson et al. 2020). Ultimately, the accuracy and affordability of commercial products make them an effective tool for research, but more studies should be done before applying them to clinical trials (Bent et al. 2020; Nelson et al. 2020).

While Fitbit technology shows much promise in research studies, they are not without error. They use a green LED light sensor to detect pulse rate and extrapolate that to measure heart rate. While this reduces the impact of movement artifacts, green light is more readily absorbed than red light, particularly by darker skin tones. Thus, Fitbits have a lower accuracy of detection during instances of high activity, when worn over a tattoo, and with darker skin tones. Additionally, differences in how the band is worn can impact accuracy of readings, as a loose band can more readily introduce movement artifacts, and differences can arise in whether the band is worn on the dominant or non-dominant hand (Nelson et al. 2020). In this study, detailed instructions were provided to participants to help reduce potential issues with the Fitbit device. Combining objective physiological measures from Fitbit technology with self-reported surveys strengthened the data assessing stress in college students following breathing meditation.

1.9 Objective

The objective of this study was to expand on existing literature examining the benefits of yoga breathing and mindfulness for stress reduction and to investigate whether the beneficial effects could be improved by supplementing the breathing practice with calming music. We hypothesized that there would be a difference between breathing meditation with and without calming music. More specifically, we hypothesized that participants who meditated while listening to calming music would experience greater improvements to their perceived stress and physiological markers of stress, relative to the participants who meditated without calming music.

2. METHODS

2.1 Participants

Eighteen university students were recruited via email announcements through the university student listserv, contact with the research team, and by class announcements. Initial recruitment invited students who were at least 18 years old, and who had not completed mindfulness (yoga or meditation) in the past six months, to participate in a four-week study beginning on the fifth week of the 14-week spring semester. Due to difficulty recruiting enough participants, recruitment was modified to include students who were at least 18 years old and were not currently practicing a daily breathing meditation to participate in a shorter two-week study. Participants were randomly assigned to control and treatment groups. Three of the 18 participants did not complete the study. Therefore, analysis included a total of fifteen participants assigned to control (breathing meditation; n=8) and treatment (breathing meditation with music; n=7) groups (Figure 1). Participants provided written informed consent, and this study was approved by the university's Institutional Review Board (IRB22037).

2.2 Study Design

All participants were asked to complete left uninostril breathing meditation, within an hour of waking or going to bed, for five minutes a day, five days a week, for two weeks. One of the research team members (CG), who is a certified 200-hour yoga teacher (RYT-200, Yoga Alliance), guided participants through the breathing meditation before beginning the study and provided written instructions for reference during the study. In addition, one of the research team members (GB), who is a licensed psychologist with the university, was present to refer participants to counseling services if needed and make them aware of the support resources available. Participants in the treatment group were provided five minutes of music to listen to during their meditation. The music selection was a modern classical composition (Lackner 2021) chosen for its qualities that were consistent with relaxation (Yehuda 2011). Participants in the control group were provided the music after the study was completed, so that they would have the opportunity to receive the same potential benefits as participants in the treatment group. An email was sent to all participants twice a week to remind them to perform their meditation practice. Participants were asked to only complete the breathing meditation once per day and not for additional time while in the study. Additionally, all participants wore a Fitbit throughout the duration of the two-week study, and instructions were provided to participants on using the Fitbit app to log each meditation session.

2.3 Measures

2.3.1 Questionnaires

Participants completed a baseline questionnaire via Qualtrics that included the 15-Item Five Facet Mindfulness Questionnaire (FFMQ-15) and Perceived Stress Scale (PSS). The FFMQ-15 questionnaire is used to assess mindfulness across five factors: observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience (Baer et al. 2008; Pelham et al. 2019). Items are rated on a 5-point Likert scale (1-5), and seven items are reverse scored. Item scores are summed for the total score, and a higher score indicates greater mindfulness (Gu et al. 2016). In addition, the FFMQ-15 has adequate internal consistency, does not differ significantly from the 39-

item FFMQ, and is sensitive to change resulting from Mindfulness-Based Cognitive Therapy (Gu et al. 2016). Two participants in the control group did not fully complete the FFMQ and their data were omitted from analysis.

The PSS is a 10-item questionnaire that measures perception of stress levels and has been validated previously for reliability and validity (Cohen et al. 1983). Items are rated on a 5-point Likert scale (0-4), and four items are reverse scored. Item scores are summed for the total score, with higher scores indicating higher perceived stress (Cohen et al. 1983). The baseline questionnaire also included questions about participant demographics and COVID-19 experience. Participants completed a second questionnaire right after the two-week study ended that was identical to the baseline questionnaire. The post-study questionnaire included additional questions about the acceptability and feasibility of the study.

2.3.2 Physiological Data

The Fitbit Inspire 2 was used to collect continuous physiological metrics, including heart rate, sleep quality, and physical activity, throughout the duration of the study. Participants were provided with pseudonyms to use with their Fitbit accounts to protect confidentiality. When participants were given their Fitbits, they weighed themselves for more accurate BMI calculations within the Fitbit. Participants were asked to wear the Fitbit on their non-dominant wrist for as close to 24 hours a day as possible, and they were asked to sync their Fitbit accounts with their mobile device at least once a day. Participants used the Fitbit app to record a log of their meditations using the “exercise” feature so that heart rate was recorded during the session.

Participants were excluded from Fitbit data analysis if more than 30% of recorded values were missing, unless otherwise noted. Fitbit data calculation and formats are described below. Daily resting heart rate was averaged across the two-week study, and the difference between day 14 and day 1 resting heart rate was also calculated (one participant was omitted due to incomplete data). Sleep was recorded in minutes and averaged across the two-week study adjusting for the number of days that contained sleep data. Steps were recorded as a daily total, which were averaged across the study according to the number of days recorded. Similarly, activity minutes were recorded as three separate daily totals – minutes lightly active, minutes fairly active, and minutes very active – which were summed for each day. The daily activity totals were then averaged according to the number of days recorded. Adherence to the breathing meditation protocol was determined by a count of the number of meditation sessions logged by each participant in the Fitbit app, and participants were included in analysis regardless of how many sessions they logged. One participant verbally confirmed the number of meditation sessions completed, and this number was used since they did not log the correct number in the app. Change in meditation heart rate was determined by subtracting the final recorded heart rate from a meditation session, as logged by the participant's Fitbit, from the first recorded heart rate of the session, and these were averaged according to the number of meditations a participant completed.

Blood pressure was measured at baseline and study completion using a digital blood pressure monitor (Omron 3 Series, 2019 Omron Healthcare, Lake Forest, IL). Both systolic and diastolic blood pressures were recorded from both arms to assess the impact of any inter-arm differences (Eguchi et al. 2007).

2.4 Statistical Analysis

Data were downloaded from the Fitbit accounts and Qualtrics into Microsoft Excel. Statistical analysis was completed using R (R Version 4.1.0, Vienna, Austria). Fisher's Exact Tests were used to determine if there was an association between treatment and participant demographics, except for age, which was compared between treatment groups with a Kruskal-Wallis test. Fisher's Exact Tests were used to determine if there was an association between participants COVID-19 experience and treatment. For Fisher's Exact Tests with two response groups (e.g., tested positive for COVID-19), the sample estimate odds ratios reported are for the alternative hypothesis that the odds ratio is not equal to one. FFMQ data (including each sub-score (*observing, describing, acting with awareness, non-judging*, and *non-reactivity*) and total score) and PSS data were analyzed using repeated measures ANOVAs with time (baseline and post) being the repeated measures predictor on individual participants and treatment as the between-group factor. The interaction between treatment and time was included in the analyses. In order to obtain normal data, the *observe* baseline and post sub-scores were squared, and the *acting with awareness* baseline and post sub-scores were transformed via an 1/x transformation. Finally, the *non-reactivity* post sub-score was squared to improve normality. Blood pressure was also analyzed with repeated measures ANOVAs, individually assessing both systolic and diastolic blood pressure averages for left and right arms; time (baseline and post) was the repeated measures predictor on individual participants and treatment was the between-group factor. Right systolic and diastolic blood pressure data were squared to achieve normality. T-tests were used to compare Fitbit data (resting heart rate average and difference, sleep, steps, activity minutes, and heart rate difference during meditations) between control and treatment groups. All values are reported as mean ± SD. Differences were considered significant if $p < 0.05$.

3. RESULTS

3.1 Participants

There was no difference between average age of participants in the control and treatment groups ($X^2 = 0.35$, df = 1, p = 0.55; Table 1). The majority of participants identified as female and white (Table 1). There was no significant association between treatment and demographics, including class (Fisher's p = 0.33), sex (odds ratio = 2.61, Fisher's p = 0.57), gender (Fisher's p = 1), race/ethnicity (Fisher's p = 0.64), living situation (Fisher's p = 0.71), or support network (Fisher's p = 0.47).

Regarding COVID-19 experience, a majority of participants had not personally tested positive for COVID-19, but a majority did know a family member, friend, or another person who had tested positive for COVID-19 (Table 2). There was no association between treatment and COVID-19 experience, including testing positive (odds ratio = 2.13, Fisher's p = 0.61), quarantining (odds ratio = 1.31, Fisher's p= 1), a family member or close friend testing positive (odds ratio = 3.31, Fisher's p = 0.57), another acquaintance testing positive (odds ratio = 3.31, Fisher's p = 0.57), and knowing someone who experienced serious complications, or died, as a result of COVID (odds ratio = 0.47, Fisher's p = 0.61).

3.2 Questionnaires

PSS scores were significantly reduced by time, though there was no effect of the treatment or interaction between time and treatment (Tables 3, 5). Overall FFMQ scores, as well as the *describing* and *acting with awareness* sub-scores, were significantly higher at post-treatment than pre-treatment across both groups (Tables 4, 5). The other sub-scores (*observing*, *non-judging*, *non-reactivity*) were not significantly changed with time (Tables 4, 5). The *observing* sub-score was significantly different between groups, with the control group having higher overall scores than the treatment group. No other scores (overall FFMQ, *describing*, *acting with awareness, non-judging,* and *non-reacting* scores) were impacted by treatment. No scores had a significant interaction between time and treatment (Tables 4, 5).

3.3 Feasibility and Acceptability

Participants were asked to complete ten meditations during the two-week study and of the fifteen participants, 67% completed at least ten meditations, with an average of 8 meditations in the control group and 10.7 meditations in the treatment group. Only two participants logged less than 8 meditations (one and two meditations, specifically).

A majority of participants either *strongly agreed* or *agreed* that they were satisfied with the outcome of the mindfulness practice used in the study (87.5% in the control group and 71.5% in the treatment group), and all participants described the time commitment required in the study as the *right amount* (Table 6). One participant even noted that they did more meditation than requested. A majority (87.5%) of participants in the control group either *strongly agreed* or *agreed* that they plan to continue practicing the mindfulness techniques used in this study, while only 42.9% of participants in the treatment group *strongly agreed* or *agreed* with this statement (Table 6).

Within the treatment group, all participants either *disagreed* or *strongly disagreed* that the music used in the study is what they normally listen to, but 57% *strongly agreed* or *agreed* that the music used in the study was relaxing. A smaller percentage (43%)

strongly agreed or *agreed* that the music helped them focus on the mindfulness practice (Table 6). Some obstacles to completing the meditation practice were noted and included: boredom, congestion, timing/schedule, focus, and finding the music distracting. One participant also reported that the two weeks of the study were unusually stressful, which may have impacted their results.

3.4 Physiology

Neither time nor treatment significantly impacted left systolic, left diastolic, right systolic, or right diastolic blood pressure. Additionally, the interaction between time and treatment was not significant for all blood pressure measures (Tables 5, 7).

There were no significant differences in Fitbit data between treatment groups, including resting heart rate averages and differences (t_{12} = 1.36, p = 0.19 and t_{11} = 0.82, p = 0.43, respectively), sleep (t_{12} = -0.03, p = 0.98), steps (t_{12} = 0.59, p = 0.56), activity minutes (t_{12} = 0.32, p = 0.76), change in heart rate during meditation (t_9 = 0.71, p = 0.50), or number of meditation sessions (t_{12} = -0.36, p = 0.73) (Table 8).

4. DISCUSSION

We hypothesized that college students who completed a two-week breathing meditation with music would see a greater improvement in their perceived stress and physiological stress markers than those who meditated without calming music. Our results indicate that college students who completed breathing meditation for two weeks reported a significant reduction in stress and a significant increase in overall mindfulness at post-treatment compared to baseline, independent of whether music was included. Furthermore, there were no significant differences in blood pressure or Fitbit measures of physiology, including resting heart rate, sleep, and activity minutes, either with time or between treatment groups. Thus, neither aspect of the hypothesis was supported – music did not impact perceived stress or physiological stress in this study. A majority of participants completed the number of meditations requested for the study, and most were satisfied with the outcome of the mindfulness practice used in the study. These findings suggest that a brief 5-minute breathing meditation practice may help college students improve mindfulness and reduce stress, with or without the inclusion of music.

The reduction in stress reported by students in our study is similar to previous studies that demonstrated reduced PSS scores after yoga and meditation (Prasad et al. 2016). However, the lack of significant findings for sleep differences after meditation in our study differs from previous studies, which found that mindfulness practice improved the sleep quality of chronic pain patients as measured by the Pittsburgh Sleep Quality Index (Doorley et al. 2021). While the data did not reveal any significant differences in heart rate due to time or treatment group, Trivedi et al. (2020) found that an active meditation practice improved heart rate variability, and in other studies, left uninostril breathing was associated with parasympathetic activation, yielding lowered heart rate and blood pressure (Pal et al. 2014; Saoji et al. 2019). Our blood pressure results fall within a normal range for a healthy adult (120/80), with similar values to other studies (Pal et al. 2014), however there were no significant differences due to time or treatment in our study. Additionally, our findings do not align with some of the literature relating to music and stress, which suggests that slow tempo music can reduce heart rate via an entrainment effect and produce anxiolytic effects, particularly for daily stress (Yehuda 2011), and that music improved sleep quality (as assessed by the Pittsburg Sleep Quality Index) when compared to an audiobook and no intervention (Harmat et al. 2008).

In this study, the *observing* sub-score of the FFMQ differed between treatment groups, which is interesting because one study found that analysis excluding this sub-score best fit the data prior to mindfulness-based cognitive therapy (MBCT) (Gu et al. 2016). The researchers discuss how prior to MBCT intervention, participants may report higher-than-appropriate *observing* sub-scores, and that MBCT intervention gives participants a new understanding of what it means to mindfully observe. This may cause the pre- and post-intervention *observing* sub-scores to be incomparable (Gu et al. 2016). Ultimately, it's unclear why a difference was observed here, and further research could assess the reliability of the *observing* sub-score after a variety of interventions. Also in our study, the *describing* and *acting with awareness* sub-scores changed with time, along with overall FFMQ scores. *Describing* is the ability to label internal experiences and *acting with awareness* is one's ability to act deliberately in a given moment, rather than "on auto-pilot" with their attention elsewhere. The *non-judging* and *non-reactivity* sub-scores, however, were not significantly different between times in the current study, and represent one's capacity to not evaluate thoughts or feelings and to allow thoughts and feelings to pass without getting caught up by them, respectively (Baer et al. 2008).

Contrary to our hypothesis, there was no significant impact of the music treatment on survey results – either PSS or FFMQ-15. Additionally, only 57% of participants who practiced breathing meditation with music *strongly agreed* or *agreed* that the music used in the study was relaxing and only 43% *strongly agreed* or *agreed* that the music helped them focus on the mindfulness practice, suggesting that music did not provide a perceived additional benefit as originally hypothesized. Examining the use of music with meditation could be a subject of future research to assess whether other types of music would be successful, and assess the role of music, or even broadly sound environment, in both stress management and mindfulness. Overall, the improvement in stress and mindfulness reported in our study aligns with previous literature, while the lack of significant change in physiology differs from some previous studies.

4.1 Limitations

While a mixed-methods approach was used in this study, some of the data collected were dependent on participant self-reporting. Two participants did not report the minimum number of meditation sessions; however, they may have completed the meditations and not accurately recorded them in the Fitbit app. Because these participants may have completed the study, they were included in analysis where their data were complete, such as in the PSS analysis. A different participant verbally confirmed after the conclusion of the study the number of meditation sessions they performed, and this was not accurately recorded in the Fitbit app. This suggests that the participants who did not report every meditation may have still performed them. Similarly, participant reports through psychometric scales may lead to a phenomenon called “shifting baseline” or “response shift,” resulting in underreporting of mindfulness by individuals who have practiced mindfulness due to a shift in their internal reference (Sauer et al. 2013). Regular mindfulness practitioners may also have a different understanding of the items in a mindfulness inventory than non-practitioners, leading to a difference in scores due to differences in semantic interpretation (Grossman 2008).

Other limitations were the small sample size and the use of an active control rather than a negative control. It can be difficult to interpret the results of smaller studies, but a small pilot study often allows results to be obtained in a relatively short time and can prompt a larger follow-up study (Hackshaw 2008). An advantage of an active control was that it allowed for analysis of music’s effect on breathing meditation and the potential interaction between music and meditation.

4.2 Future Directions

Future studies should address the limitations of this study – increase sample size, include a negative control alongside an active control, and increase the length of the study to determine if any significant results occur with time – to allow more robust conclusions. Future studies could also investigate whether practicing mindfulness improves student academic achievement over a semester and the impact this may have on student retention. In addition, future studies could assess how music preference among participants may impact acceptability of the meditation practice.

4.3 Significance

The present research identified a significant improvement in both mindfulness and perceived stress after just two weeks of independent breathing meditation, with or without music. This suggests that short, regular breathing meditations can effectively support college students as they navigate the stress of higher education. In addition to the improved FFMQ and PSS scores, a majority of participants reported that they are satisfied with the outcome of the mindfulness practice (Table 6).

Another notable outcome of the study was participant adherence to the requested meditation sessions. Most participants completed all requested meditations, and some completed more than requested. Additionally, all participants (100%) agreed that the time commitment in this study was the "right amount." This suggests that short, regular, and cost-effective mindfulness practices are likely readily accessible to college students. This addresses two of the reasons college students cite for not pursuing mental healthcare – cost and time commitment (Miranda et al. 2015; Eisenberg et al. 2007). By promoting an accessible mental healthcare option that requires minimal time commitment, college students can prioritize their well-being and reduce stress.

4.4 Conclusions

The present study suggests that short, 5-minute breathing meditations may be an effective, accessible technique to help college students manage day-to-day stress in higher education. The data showed improvements in both perceived stress and mindfulness after breathing meditation and suggest no difference between the presence and absence of calming music during meditation. All participants reported that the study involved an appropriate time commitment, and the majority were satisfied with the outcome of the study. However, no significant physiological differences were observed as a result of the intervention. Future studies could verify these findings with a larger sample size, enabling the inclusion of a negative control group. This study continues the discussion around mental health care that is accessible to college students and offers a potential technique to begin meeting that need.

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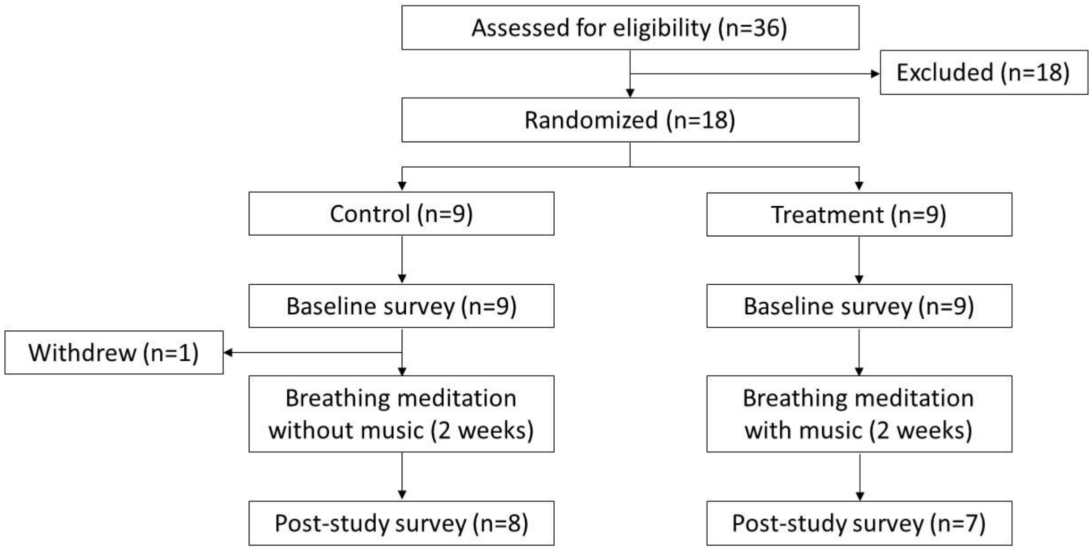
APPENDIX A

Figure 1. Study design with sample sizes included. Two participants in the treatment group failed to complete all components of the study, including the post-study survey.



APPENDIX B

Table 1: Demographics of the participants in the control and treatment groups. Multi-racial is inclusive of Hispanic, Latino, or Spanish origin and white and Asian and Native Hawaiian or Other Pacific Islander. Support Group allowed for the selection of one group: family, friends, roommates, teammates, or other (please specify).

	Control (n=8)	**Treatment (n=7)**
Age In Years, M (SD)	20.75 (3.32)	19.57 (1.71)
Class Standing		
Freshman	37.5%	14.3%
Sophomore	12.5%	57.1%
Junior	12.5%	14.3%
Senior	37.5%	14.3%
Sex		
Male	12.5%	28.6%
Female	87.5%	71.4%
Gender Identity		
Male	25%	28.6%
Female	62.5%	71.4%
Nonbinary	12.5%	0%
Race And Ethnicity		
Black or African American	25%	14.3%
White	50%	85.7%
Multi-racial	25%	0%
Living Situation		
With Family	12.5%	14.3%
With Roommates	62.5%	71.4%
Alone	25%	0%
Other	0%	14.3%
Support Group		
Family	25%	0%
Friends	75%	85.7%
Other	0%	14.3%

Table 2: COVID-19 experience of participants in the control and treatment groups

	Control (n=8)	Treatment (n=7)
Have You Ever Tested Positive For COVID-19?		
Yes	25%	42.9%
No	75%	57.1%
Have You Ever Been Quarantined Because Of Exposure Or Possible Exposure To COVID-19?		
Yes	50%	57.1%
No	50%	42.9%
Has A Family Member Or Close Friend Been Diagnosed With COVID-19?		
Yes	62.5%	85.7%
No	37.5%	14.3%
Do You Know Anyone Other Than A Family Member Or Close Friend That Has Been Diagnosed With COVID-19?		
Yes	62.5%	85.7%
No	37.5%	14.3%
Do You Know Anyone Who Has Had Serious Complications With, Or Died From COVID-19?		
Yes	75%	57.1%
No	25%	42.9%

Table 3: Perceived Stress Scale (PSS) survey results. Values are reported as Mean (Standard Deviation)

	Control (n=8)	Treatment (n=7)
Total		
Baseline	18.5 (7.84)	20.28 (5.96)
Post	15.1 (7.02)	13.3 (7.83)

Table 4: Five Facet Mindfulness Questionnaire (FFMQ-15). The *observing* sub-score relates to an individual's ability to mindfully notice their surroundings, *describing* is the ability to label internal experiences, *acting with awareness* is acting deliberately in a given moment, *non-judging* is acknowledging internal experiences without assigning a value judgement to them, and *non-reactivity* is the ability to remain unaffected by unpleasant or unwanted stimuli. Values are reported as Mean (Standard Deviation).

	Control (n=6)	**Treatment (n=7)**
Total		
Baseline	53.2 (12.42)	48.3 (6.95)
Post	55.2 (8.86)	55.7 (5.59)
Observing		
Baseline	11.8 (2.32)	8.6 (3.15)
Post	11.8 (2.32)	9.3 (2.56)
Describing		
Baseline	10.7 (2.87)	9.9 (2.48)
Post	11.2 (1.94)	11.7 (1.89)
Acting with Awareness		
Baseline	9.7 (3.20)	8.9 (2.41)
Post	10.0 (2.68)	10.6 (2.23)
Non-Judging		
Baseline	11.3 (3.61)	11.4 (2.51)
Post	11.7 (2.66)	13.1 (1.57)
Non-Reactivity		
Baseline	9.7 (3.88)	9.6 (2.07)
Post	10.5 (2.26)	11.0 (1.00)

Table 5: Results of Repeated Measures Analyses. The numerator degrees of freedom was 1 for all factors (time, treatment, time x treatment). The denominator degrees of freedom was XX for PSS data. The denominator degrees of freedom was 11 for all FFMQ data. The denominator degrees of freedom was 13 for all blood pressure data. Significant factors and associated F and p values are shown in bold.

Response Variable	Factor	F	p
PSS Total	Treatment	<0.01	0.99
	Time	**8.29**	**0.01**
	Treatment * Time	1.01	0.33
FFMQ Total	Treatment	0.23	0.64
	Time	**8.28**	**0.02**
	Treatment * Time	2.74	0.13
Observing	**Treatment**	**5.15**	**0.04**
	Time	0.16	0.70
	Treatment * Time	0.16	0.70
Describing	Treatment	0.01	0.91
	Time	**4.89**	**0.05**
	Treatment * Time	1.62	0.23
Acting with Awareness	Treatment	0.01	0.93
	Time	**9.43**	**0.01**
	Treatment * Time	3.28	0.10
Non-Judging	Treatment	0.34	0.57
	Time	2.94	0.11
	Treatment * Time	1.34	0.27
Non-Reacting	Treatment	0.03	0.86
	Time	2.44	0.15
	Treatment * Time	0.17	0.69
Left Systolic Blood Pressure	Treatment	0.34	0.57
	Time	3.06	0.10
	Treatment * Time	0.03	0.86
Left Diastolic Blood Pressure	Treatment	0.06	0.80
	Time	0.26	0.62
	Treatment * Time	0.42	0.52
Right Systolic Blood Pressure	Treatment	1.58	0.23
	Time	1.72	0.21
	Treatment * Time	0.02	0.90
Right Diastolic Blood Pressure	Treatment	1.76	0.21
	Time	0.04	0.85
	Treatment * Time	0.83	0.38

Table 6: Results of Feasibility Survey. All questions except for time commitment provided the following response options: strongly agree, agree, neither agree nor disagree, disagree, strongly disagree. The question about time commitment included the following response options: not enough, right amount, too much.

	Control (n=8)	Treatment (n=7)
I am satisfied with outcome of the mindfulness practice used in this study		
Strongly Agree	37.5%	28.6%
Agree	50%	42.9%
Neither agree nor disagree	0%	14.3%
Strongly Disagree	12.5%	14.3%
Describe the time commitment required in this study.		
Right amount	100%	100%
I plan to continue practicing the mindfulness techniques used in this study.		
Strongly Agree	12.5%	14.3%
Agree	75%	28.6%
Neither agree nor disagree	0%	14.3%
Disagree	0%	42.9%
Strongly Disagree	12.5%	0%
The music used in this study is what I normally listen to.	N/A	
Disagree		42.9%
Strongly Disagree		57.1%
I found the music used in this study to be relaxing.	N/A	
Strongly Agree		28.6%
Agree		28.6%
Neither agree nor disagree		42.8%
The music helped me focus on the mindfulness practice.	N/A	
Strongly Agree		28.6%
Agree		14.3%
Neither agree nor disagree		14.3%
Disagree		42.8%

Table 7: Blood Pressure data for control and treatment groups. Values are reported as Mean (Standard Deviation).

	Control (n=8)		**Treatment (n=7)**	
	Left Arm	Right Arm	Left Arm	Right Arm
Baseline Systolic	111.0 (7.82)	113.5 (8.99)	108.4 (8.00)	118.0 (5.42)
Post Systolic	114.6 (8.09)	115.8 (8.94)	112.9 (9.99)	120.6 (7.07)
Baseline Diastolic	70.13 (7.61)	70.5 (5.15)	72.9 (12.89)	68.0 (9.93)
Post Diastolic	70.5 (9.86)	71.9 (7.83)	69.9 (5.81)	65.71 (6.80)

Table 8: Fitbit Data for control and treatment groups. BPM stands for Beats Per Minute. Values are reported as Mean (Standard Deviation).

	Control (n=7)	**Treatment (n=7)**
Resting Heart Rate (Average, BPM)	69.76 (11.57)	62.57 (7.69)
Resting Heart Rate (Difference, BPM)	-1.33 (6.77)	-3.71 (3.50)
Sleep (Minutes)	406.34 (58.98)	407.01 (38.01)
Steps	8593.9 (2250.96)	7937.6 (1875.42)
Activity (Minutes)	270.8 (62.28)	261.3 (50.61)
Number of Meditation Sessions[1]	8.0 (4.21)	10.71 (1.38)
Heart Rate Difference during Meditation[2]	-0.20 (3.49)	-1.69 (3.45)

[1]n=8 for control group; [2]n=5 for control group and n=6 for treatment group