5-2023

Does a Single Night of Mindfulness Meditation Improve Sleep and Stress in Female College Students?

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An Honors Thesis submitted in partial fulfillment of the requirements for Honors Studies in Psychology

By

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Spring 2023

Psychology

Fulbright College of Arts and Sciences

The University of Arkansas

Acknowledgments

I would like to acknowledge Dr. Ivan Vargas and thank him for all his help. His guidance is what allowed me to create the research plan necessary to execute this project. His help with conducting research and writing this paper was vital in making this project the best that it can be. I want to thank all the research assistants in the Sleep and Stress lab for volunteering their time and energy to help assist me in completing this project. Without their contributions, this project would not have been possible. Finally, I would like to thank my friends and family for all of their support through these 4 incredible years.

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Abstract

Several recent studies have shown that mindfulness-based practices have been effective in treating sleep problems. However, these studies have primarily looked at multi-component interventions that take place over several weeks or months. No studies have evaluated the efficacy of short-term mindfulness-based practices on sleep the same night. This study aims to do just that. The sample consisted of 10 students attending the University of Arkansas. All participants slept in a sleep laboratory on two consecutive weekday nights. During one night, they completed a mindfulness-based exercise. The other night, they completed a similar control task (counterbalanced). Polysomnography-based sleep data were collected on both nights to assess sleep quality (i.e., sleep efficiency and sleep onset latency). Saliva samples were collected 30 and 0 minutes before bedtime and 0, 15, and 30 minutes post-awakening to assess endocrine stress responses. There was no statistically significant difference in the mean sleep efficiency or mean sleep onset latency between the control night and mindfulness night. There were no significant mean differences in cortisol before bedtime. There were, however, significant group differences in cortisol post-awakening (i.e., lower cortisol at awakening and greater cortisol awakening response following the mindfulness condition). While the results from the current study do not support that an acute mindfulness exercise will have meaningful improvements in sleep the next night, there may be a relation between mindfulness meditation and cortisol stress levels the subsequent day.

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Sleep Disturbance in College Students

There is no question that sleep is a vital part of an organism's daily life. On average, humans spend approximately 7-8 hours a night asleep (Pilcher et al.,1999). Like most other biological processes and functions, sleep is not without its problems. Sleep disturbance in humans can range from acute sleeplessness or problems with the quality of one's sleep to more severe or chronic sleep disorders, such as insomnia or obstructive sleep apnea (Pavlova & Latreille, 2019). Sleep disturbance among college students is also a major concern. Somewhere between 20-30% of college students experience some form of sleep disturbance (Gaultney, 2010; Jain & Verma, 2016). For example, the prevalence of insomnia among university students is between 9-38% (Jiang et al., 2015), with one study suggesting that nearly 10% of students meet the criteria for chronic insomnia (Taylor et al., 2013). While there are many factors that can lead to the development of these disorders, such as nighttime alcohol usage and excessive noise, it seems that stress may be the biggest contributor (Jain & Verma, 2016; Lund et al., 2010). Studies have shown that increased levels of stress, regardless of source (i.e., academic, social, and vocational), decreases the quality of sleep that a college student experiences (Dusselier et al., 2010; Lee et al., 2013; Valerio et al., 2016). This decrease in sleep quality can affect the daily functioning of college students (Cummings et al., 2001; Gaultney, 2010; Pagel et al., 2007). More persistent sleep disturbances can lead to other physical and psychological health problems as well as impact academic performance (Jain & Verma, 2016; Ohayon et al., 1999).

Persistent sleep disturbance has been known to affect the physical and mental well-being of college students. Poor sleep quality due to sleep disturbances is correlated with increased physical health complaints (Jensen, 2003; Pilcher et al., 1997). One physical health complaint that is becoming more prevalent in college students is increasing weight gain (measured through body mass index or BMI). One study found that sleep disturbances played a significant predictor for overweight/obesity (BMI $\geq$ 25), regardless of age or sex (Vargas et al., 2014). The same study also found that as students age, sleep problems can increase, leading to further weight gain (Vargas et al., 2014). Obesity has also been found to increase the prevalence of cardiovascular disease, type II diabetes, some cancer, and other chronic diseases (Baranowski et al., 2003; Must et al., 1999). Besides physical health problems, some studies have shown that poor sleep quality is associated with greater depressive systems as well as lower subjective well-being (Lund et al., 2010; Peach et al., 2016). Persistent sleep disturbance and/or insufficient sleep can also affect academic performance. Studies have shown that inadequate sleep was associated with a lower grade point average (GPA) (Chen & Chen, 2019). Studies have also shown that students who exhibited one or more sleep disorders were significantly at risk for declining academic performance compared to their healthy counterparts (Gaultney, 2016; Hershner, 2020). One study has also shown that poorer sleep quality, which can be due to persistent sleep disturbances, was associated with lower academic performance in college students (Gilbert & Weaver, 2010).

As persistent sleep disturbance can evolve into chronic sleep disorders, as well as lead to other physical and psychological health problems, it is critical to identify and study potential strategies to alleviate these disturbances. In the case of insomnia, the first-line treatment is a behavioral intervention known as Cognitive Behavioral Therapy for Insomnia (CBT-I) (Castronovo et al., 2018). CBT-I is a multi-component intervention that focuses on using behavioral strategies (i.e., sleep restriction therapy and stimulus control therapy) to rectify patient difficulties with sleep initiation and maintenance problems (i.e., being able to fall asleep and stay asleep). The problem with CBT-I is that a standard dose of therapy includes 6-8 weekly or biweekly sessions with a therapist. While this approach may be suitable for a student with chronic insomnia, it's likely excessive for someone with less chronic sleep disturbance. Alternative strategies to help college students with their sleep problems are therefore needed.

Mindfulness and Sleep

Many different types of sleep interventions exist, from behavioral interventions to medications, however, one strategy that has become more popular in recent years is mindfulness-based stress reduction and meditation (Macleod et al., 2018). There have been several recent studies supporting the use of mindfulness-based therapies for sleep problems, including insomnia (Birnie et al, 2010; Huberty et. al, 2019; Ong et al., 2008). This research, however, has been limited to multi-component therapies that are delivered over the course of weeks or months (i.e., such as combined mindfulness meditation and CBT-I; (Ong et al., 2008). No studies have evaluated whether brief mindfulness-based practices or exercises can acutely improve sleep (e.g., that same night). This was the focus of the present study.

Mindfulness has its roots in Eastern traditions, stemming from Buddhism, and is most notably associated with practices and ideas revolving around self-reflection and mindfulness meditation (Shapiro et al., 2006). Jon Kabat-Zinn has brought the application of mindfulness to clinical and psychotherapeutic practices in modern times (Allen et al., 2006). This application of mindfulness to clinical and psychotherapeutic practices has led to the development of multiple therapeutic techniques, for example, mindfulness-based stress reduction (MBSR).

Mindfulness-based stress reduction (MBSR) is an 8-week empirically-supported treatment that uses mindfulness-based meditation practices to relieve discomfort associated with several different physical and psychological conditions (including insomnia) (Goldin et al, 2014; Grossman et al., 2004). Looking specifically at sleep problems, using MBSR in conjunction with other treatment methods, such as Cognitive Behavioral Therapy for Insomnia (CBT-I), has proven to be very effective. A study done by Ong et al. (2008) found that CBT-I with mindfulness meditation significantly reduced pre-sleep arousal, sleep effort, and dysfunctional sleep-related cognitions. While MBSR is very effective in its ability to reduce sleep disturbances and insomnia, the intervention, like CBT-I, does require a great deal of time and effort. This is one of the primary barriers to increasing the overall use and acceptability of this treatment (especially among college-aged samples) since not everyone can or wants to dedicate significant time to group mediation practices (Gryffin et al., 2014).

Alternatively, the introduction of mobile apps like “Calm” that employ MBSR practices have become widely popular and are potentially effective at reducing the disturbances done to stress and mood while also increasing one’s levels of mindfulness and self-compassion as well as reducing disturbances in sleep (Birnie et al, 2010). By not being constrained to meditation sessions at a set time and place like in traditional MBSR, the use of these mobile applications has allowed users to complete MBSR exercises anywhere and anytime throughout the day, including at bedtime. While the empirical evidence for these apps is still in its infancy, some preliminary research suggests that they may be helpful in improving sleep. Participants that have used app-based interventions for sleep, such as Calm, have found a significant decrease in sleep disturbances (Huberty et. al, 2019).

The Current Study

While there is an abundance of literature that looks at the long-term treatment effects of MBSR on mild to severe sleep issues (Grossman et al., 2004), one facet of this literature that has not been fully explored is the acute effects of using mindfulness meditation on mild to moderate sleep issues. In this study, we examined the effect of acute, single-night use of mindfulness meditation (i.e., video-guided body scan exercise). The primary outcome of interest was sleep, specifically sleep onset latency and sleep efficiency. Sleep onset latency (SOL) is the time it takes (in minutes) to fall asleep and represents one of the most common forms of insomnia (i.e., initial insomnia). Sleep efficiency (SE) is the proportion of time spent asleep while in bed. SE is commonly used to quantify sleep quality, as it measures how consolidated one's sleep is. Considering that most prior research relied on subjective reports of sleep as derived from sleep diaries or other self-report questionnaires (e.g., Insomnia Severity Index, Pittsburgh Sleep Quality Index), the present study assessed sleep objectively, in the lab, using polysomnography or PSG (the gold standard in sleep measurement). While self-report data is significant in that it provides data on how a person feels about their sleep, it does not assess whether there are any objective changes to sleep.

In addition, the present study also explored one potential pathway by which an acute mindfulness meditation exercise may improve sleep outcomes – stress. While there are many ways to operationalize stress, the present study again focused on an objective measure of stress – salivary cortisol. Cortisol is a stress hormone produced by the hypothalamic-pituitary-adrenal (HPA) axis. The HPA-axis is a major neuroendocrine system that consists of a feedback loop between the hypothalamus, pituitary gland, and adrenal gland (Tsigos & Chrousos, 2002). The HPA axis plays a major role in controlling stress and regulating bodily processes such as digestion and the immune system (Smith & Vale, 2022; Tsigos & Chrousos, 2002). While there are many outside influences that can affect one's HPA axis, it is also greatly affected by sleep (Nicolaides et al., 2020). One method that scientists use to measure the relationship between the HPA axis and sleep is cortisol. Some studies have shown that deep sleep has an inhibitory effect on the HPA axis system, leading to declining levels of cortisol in plasma (Follenius et al., 1992; Nicolaides et al., 2020; Weitzman et al., 1983). Other studies have shown that a dysregulated HPA axis system has been shown to be involved in increased levels of cortisol, leading to sleeplessness and arousal, causing the disruption of sleep (Nicolaides et al., 2020; Späth-Schwalbe et al., 1991). In the case of this study, we will be using salivary cortisol to measure sleep disruptions caused by the HPA axis system and sleep efficiency.

Taken together, the study aims to evaluate, in a preliminary way, the effectiveness of an acute mindfulness-based meditation as a quick, one-time solution in improving sleep quality and quantity, and whether the mindful meditation exercise is also related to decreased physiological stress levels (as assessed by cortisol functioning). A reason for testing this was to acquire a more in-depth look at how the link between acute- mindfulness treatment prior to sleep might vary when compared to no treatment prior to sleep. In doing so, we can begin to understand if acute versions of the MBSR treatment effectively treat mild sleep issues, as well as develop potential reasonings as to why. Due to the lack of research on the topic, we treated these analyses as exploratory. In the current study, we used a within-subjects design to address two specific goals. The primary goal of this study is to assess whether acute mindfulness meditation exercises right before bedtime can improve sleep outcomes during the subsequent night. The secondary aim is to assess whether the mindfulness meditation exercise also affects stress/cortisol levels. If so, this could suggest that any improvements in sleep may be related to reductions or regulation in HPA-axis stress. We specifically hypothesized that following a night of mindfulness meditation, compared to a night where they watched a neutral video, participants will experience short sleep onset latency times, greater sleep efficiency, and lower cortisol levels at bedtime.

Methods

Participants and Recruitment

Participants included 11 women attending the University of Arkansas. One participant did not complete both parts of the study and was therefore excluded from the present sample. This means the final sample consisted of 10 college Freshmen (mean age = 18.5 years, *SD* = 0.73). Most participants identified as White (60%), though at least one participant identified as biracial/multiracial or bi-ethnic/multiethnic (10%), Hispanic/LatinX (10%), American Indian/Native American/Alaskan Native (10%), and undisclosed (10%). Participants were recruited during the Spring and Fall 2022 semesters from the general psychology participant pool and received course credit for their participation. Participants signed up for the study through the Department's SONA system.

Study Overview

The study used a within-subjects, crossover design. Specifically, participants were asked to sleep in the lab for two consecutive weekday nights. Participants were asked to arrive at the lab, located in the Department of Psychological Science at the University of Arkansas at approximately 2100. During both nights, participants completed a sleep study with polysomnography (PSG) and provided saliva samples during the night and subsequent morning. Lights Out (aka bedtime) was 2330 and Lights On (aka waketime) was 0730. During one of the nights, they were asked to watch a brief (30-minute) mindfulness meditation video (Mindfulness 360 - Center for Mindfulness, 2016) immediately before bed. During the other night, they were asked to watch a brief (30-minute) neutral video (Orlowski, 2017) before going to bed. The order of the nights was counterbalanced across participants. Participants completed written informed consent during the first night in the lab. All study procedures were reviewed and approved by the Institutional Review Board at the University of Arkansas.

Data Collection Procedures

Sleep

Sleep was assessed using PSG. PSG is a diagnostic tool that is used to record physiological data relevant to sleep (Chesson et al., 1997). PSG utilizes numerous different devices, such as the electroencephalogram, electromyogram, electrocardiogram, pulse oximetry, and airflow/respiratory rate to measure sleep and analyze what stage of sleep one enters at a certain time throughout the night and how long one stays in those stages (Rundo & Downey, 2019). PSG is considered to be the gold standard when it comes to diagnosing sleep-related breathing disorders (Rundo & Downey, 2019). All PSG scoring was conducted according to American Academy of Sleep Medicine (AASM) standards. The recording montage consists of 14 electrophysiological signals. The basic montage includes 2 EOGs referenced to a single mastoid [LOC & ROC], 6 EEGs referenced to linked mastoids [F3, F4, C3, C4, O1, O2,], 1 bipolar mentalis, an EKG, 2 bipolar tibial EMGs (to screen for PLMD), and an oximeter measure of blood oxygen saturation. All signals were recorded using Clevemed’s Sapphire PSG system and transmitted the data wirelessly to the Crystal PSG acquisition software in the control room next door. The PSG was monitored online and simultaneously recorded to a PC located in the control room. As mentioned above, sleep quality was assessed in two ways: sleep onset latency (SOL) and sleep efficiency (SE). SOL was measured as the amount of time (in minutes) from Lights Out to the first 30-second epoch of sleep (any stage). SE was measured as the percent of time in bed (i.e., time from Lights Out to Lights On) spent sleeping (i.e., sleep duration/time in bed x 100).

Cortisol

Saliva was used as the method for obtaining cortisol. This will be accomplished by collecting 5 samples of salivary cortisol each day. Participants provided two saliva samples at night: one 30 minutes before going to Lights Out and one 0 minutes before Lights Out. In the morning, the participants provided 3 additional saliva samples: one at 0 minutes after Lights On, one at 15 minutes after Lights On, and one at 30 minutes after Lights On. The three morning samples were used to measure the Cortisol Awakening Response (CAR). Samples were stored at -20°C until assayed. Samples were assayed in duplicate using commercial enzyme immunoassay kits (Salimetrics). To avoid inter-assay variability, all samples from the same participant were assayed together.

Statistical Analysis

One-way analysis of variance (ANOVA) via SPSS GLM was used to test the effect of condition (mindfulness vs. control video) on sleep (i.e., SOL and SE) and stress (i.e., nighttime cortisol). Alternatively, we used linear mixed-effects models via SPSS MIXED to examine the impact of the condition on morning cortisol trajectories from baseline (i.e. CAR). Specifically, we examined the effect on baseline cortisol (intercept) and CAR (slope). We used mixed modeling as opposed to repeated-measures analysis of variance (ANOVA) in order to model the correct covariate structure of the interrelated repeated-measures data (Hruschka et al., 2005; Gueorguieva and Krystal, 2004). We modeled linear slopes as opposed to basic examinations of the area under the curve (AUC) because it allows for better characterization of patterns of activation and thus can be more sensitive to subtle differences in cortisol activation, particularly in small samples (Lopez-Duran et al., 2014). For the mixed models, time and condition effects (and their interaction) were entered as fixed effects. All models included intercept and linear slopes as random effects to account for clustering within participants (i.e., each participant had multiple cortisol samples). An unstructured covariance structure and restricted maximum likelihood effects model were used to allow for the best fit to the data since it is a more conservative approach when dealing with small samples. Cortisol values were log-transformed to correct for skewness.

Results

A total of 10 participants completed both nights of data collection and were included in the subsequent analyses. The PSG data for one additional participant was lost due to a technical error and therefore their data were excluded from the sleep analyses.

Sleep Quality

While there were small differences in mean sleep onset latency between the control and the mindfulness conditions (i.e., 10.6-minute reduction in SOL during the mindfulness night), these differences were not statistically significant (see also Table 1), $F(1, 16) = 0.59$, $p >$

0.20. Similarly, no significant differences were observed in sleep efficiency by condition, $F(1, 16) = 2.10$, $p = 0.054$. See Table 1 for means and standard deviations.

Stress

No mean differences in nocturnal cortisol were observed prior to (-30 minutes to bedtime) or immediately after (0 minutes to bedtime) watching the videos, N1 sample, $F(1,17) = 0.09$, $p > 0.20$, N2 sample, $F(1,18) = 0.11$, $p > 0.20$ (see Figure 1). When comparing differences via one-way ANOVAs, mean differences at awakening and 15 minutes post-awakening suggest that participants had higher cortisol following the control condition compared to the mindfulness condition, though, these differences were not significant, 0 minutes post-awakening, $F(1,18) = 3.41$, $p = 0.08$, 15 minutes post-awakening, $F(1,17) = 2.46$, $p = 0.14$. In contrast, no mean differences in cortisol were observed 30 minutes post-awakening, $F(1,18) = 0.05$, $p > 0.20$ (see also Figure 1). These findings were further corroborated by the linear mixed effect models that supported there were significant differences in cortisol at awakening and in CAR (i.e., linear slopes from awakening). Specifically, when compared to the control condition, the mindfulness condition was related to lower cortisol at awakening, time, $b = 0.19$, $t(37) = 3.56$, $p = 0.001$, and a blunted (flatter) linear slope from baseline, time x condition, $b = -0.09$, $t(37) = -2.12$, $p = 0.04$ (see also Figure 2). Following the mindfulness condition, participants had lower cortisol at baseline but had a steeper increase in cortisol after awakening.

Discussion

Sleep Quality

While the results showed that there were differences in the mean SOL between the two conditions, these differences were not significant. While there was no significance in the data, the SOL being slightly less for the mindfulness condition is in line with previous research on the effects of mindfulness on SOL (Gong et al., 2016). Similarly to SOL, there were no significant differences in the mean SE between the two conditions. The data showed that the control condition had a higher SE than the mindfulness condition, which contradicts trends found in previous research (Gong et al., 2016). However, considering the small sample size and large between-subject variability, these trends should be interpreted with caution.

Cortisol

Salimetrics was used to measure evening cortisol levels and the cortisol awakening response (CAR). CAR describes the increase in cortisol levels for the first 30-45 minutes after awakening (Stalder et al., 2016). CAR is especially important because it ties our reactivity to awakening with aspects of our circadian rhythm (Stalder et al., 2016). With that being said, low levels of cortisol post-awakening indicate worse sleep throughout the night as cortisol levels are usually at their lowest around midnight and peak early in the morning (Fries et al., 2009; Stalder et al., 2016). The results of this study show that there was no significant difference in the mean nocturnal cortisol between both conditions for both nocturnal samples (-30 & -0). Using linear mixed effects models, the study showed that there was a significant difference in cortisol at awakening and in CAR for the mindfulness group. The mindfulness group started with lower average cortisol at baseline compared to the control group. However, they had a steeper increase in cortisol over time compared to the control group. These results are in line with findings from previous research that show that mindfulness-based practices (e.g. MBSR) have an effect in lowering morning cortisol, though this research primarily looks at the long-term use of mindfulness-based practices (Brand et al., 2012). Further research should look into the outside influences that can affect this relationship, such as the irregularity in sleep schedules for college students as well as outside stressors (e.g., financial, social, and educational).

Strengths and Weaknesses

This study has two primary strengths. The first is that this study is one of the first studies to look at the acute effects of mindfulness meditation on objective sleep and stress levels. Previous research studies have looked at the long-term effects of mindfulness on sleep through weekly interventions as well as incorporating mindfulness in already established sleep interventions such as CBT-I (Goldin et al, 2014; Grossman et al., 2004; Ong et al., 2008). While these have proven to be effective in reducing sleep disorders, the question remains, can this be done even quicker? Thus, the primary goal of this study was to observe if a single-night mindfulness intervention was strong enough to show differences in a participant's sleep. The second strength is that this study takes an objective look at sleep in-lab observation and data collection. The PSG and salivary cortisol that was collected and analyzed in the lab allow for more precise and accurate representations of sleep quality, onset, and efficiency when compared to subjective data.

This study has one primary weakness. This weakness is that the study uses a convenience sample. The sample size consisted of only women, all of which were undergraduate students, all of which participated by signing up for the study. The sample size was extremely small, being 10, making this sample not representative of the population. Due to this, it is difficult to state if any of the results can apply to the general population.

Future Directions

One direction that should be taken is conducting this study with a broader, more diverse sample group. This sample group should be larger and include college students of all genders, as well as include college students of all types (undergraduate or graduate). Doing so would allow the results of the study to be more applicable to the general population, making the findings more significant.

Another direction that should be taken with this study is to include subjective data from baseline and post-awakening surveys. This data should then be compared to the objective data from PSG and salivary cortisol. Doing so would allow researchers to see if the subjective experiences of the participants match up with the objective data that they produce.

Conclusion

Sleep is a vital part of a college student's life. Better sleeping habits can lead to a reduction in stress and a healthier lifestyle. While previous studies have found that mindfulness-based practices (e.g., MBSR) are effective in reducing sleep disturbances, these studies have looked at long-term practices. This study has shown that acute mindfulness-based practices may not be immediately effective in treating sleep disturbances, though these practices can influence morning cortisol levels (perhaps suggesting more robust HPA-axis functioning). The results of this study and previous studies indicate that time, persistence, and dedication to practicing mindfulness are necessary to reduce sleep disturbances. Future research should examine if there are more accessible ways for college students to engage with mindfulness and help with common sleep disturbances that they face.

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Appendix A- Tables and Figures

Condition	Mean SOL (minutes)	SD SOL (minutes)	Mean SE (%)	SD SE (%)
Control Night	43.3	37.3	81.2	8.7
Mindfulness Night	32.7	18.9	68.7	14.5

Table 1 – Mean and Standard Deviation of Sleep Onset Latency (SOL) and Sleep Efficiency (SE) for Participant's Control Night and Mindfulness Night

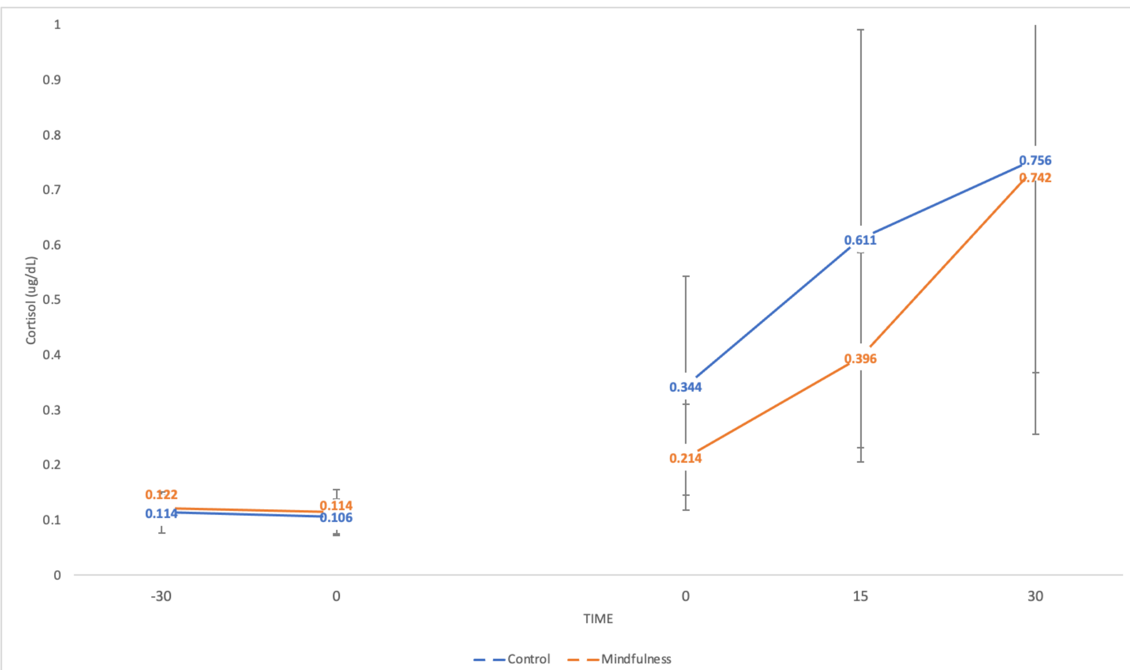

Figure 1 – Means and standard deviations for cortisol by condition. Night sample 1 was taken 30 minutes before lights out. Night sample 2 was taken at lights out. Morning sample 1 is taken at awakening. Morning sample 2 is taken 15 minutes after awakening. Morning sample 3 is taken 30 minutes after awakening.

	Awakening Cortisol			Linear Slope		
	Estimate	SE	t-values	Estimate	SE	t-values
CAR						
Condition	0.185	0.052	3.556***	-0.085	0.04	-2.116**

Table 2 – Log transformed cortisol variable. Time and condition were entered as fixed effects. Intercept and time were entered as a random effect. A Restricted Maximum Likelihood effects model was used to account for the small sample size. ***p<0.01, **p<0.001*

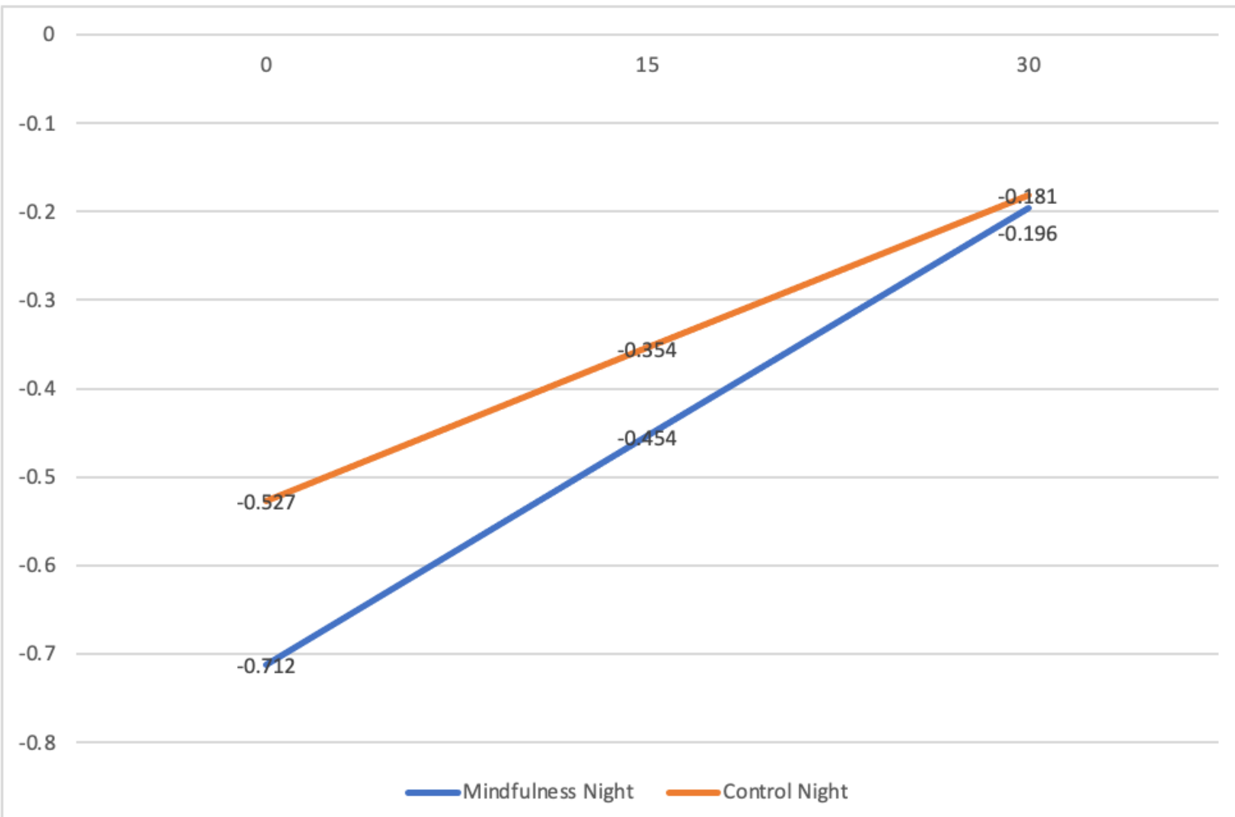

Figure 2 – Fixed effects (from Table 2) of the cortisol samples taken after awakening for control and mindfulness conditions. Morning sample 1 is taken at awakening. Morning sample 2 is taken 15 minutes after awakening. Morning sample 3 is taken 30 minutes after awakening. These values are negative because they are log-transformed.