Meditation and Stress Mitigation: can a one-time meditation session mitigate subsequent stress, as measured by heart rate, electrodermal activity, and blood pressure?

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Abstract

Objectives: This study explores the effect of one-time guided meditation on physiological measures of stress after a stress induction. The goal is to determine if meditating even once can mitigate stress in the short term. *Design/Methods*: There were 18 subjects (10 male and 8 female). The subjects were split equally into two groups, a meditation group and control group. The Trier Social Stress Test was administered to both groups; however, the meditation group performed guided meditation prior to the test. Three parameters were observed: heart rate, skin conductance, and blood pressure. Baseline measurements for all parameters were taken at the beginning of the session. For the meditation group, heart rate was recorded directly after meditation as well. For both groups, skin conductance was recorded during administration of the stress test, and heart rate and blood pressure were measured after the test. *Results*: Results did not show a statistically significant effect on the physiological factors tested. *Conclusions*: The study suggests that one-time meditation does not have significant, short-term stress mitigating effects.

Introduction

Stress is defined as a stimulus that disrupts physiological or psychological homeostasis following exposure to internal or external forces (Hsiao-Pei et al., 2011; Kryou & Tsigos, 2009). When an individual experiences a stressful stimulus, there are physiological responses to re-establish homeostasis. Increased stress arouses the sympathetic branch of the autonomic nervous system (ANS) (Saitoh, 1992 & Muller, 2014). If the ANS is highly aroused, sweating increases because the sympathetic nervous system innervates sweat glands (Chawla 2013). Varying degrees of skin moisture affects electrodermal activity. One measure of such activity is skin conductance, or the galvanic skin response, which has been found to be highly suitable for monitoring ANS activity (Jacobs et. al, 1994). Furthermore, previous studies have concluded that skin conductance increases in response to stress (Jacobs et. al, 1994). Thus, skin conductance can be used as a measure of stress.

When stressed, the body releases the stress hormones adrenaline and cortisol which prepare the body for "flight or fight" response (American Heart Association, 2013). Somatically, these hormones accelerate heart rate, a component of cardiac output, and respiration and temporarily redirect blood flow to the brain, heart, and muscles (Kryou & Tsigos, 2009). The redirection of blood flow is due to the constriction of blood vessels. It is the increase in heart rate and constriction of blood flow that increase blood pressure (American Heart Association, 2013). Many studies have used heart rate and blood pressure as measures of stress. These responses are short-lived to ensure the individual's survival. However, chronically these stress responses can have potentially harmful consequences. For example, exposure to chronic stress is a good predictor of cardiovascular disease (Schubert et al., 2009). Therefore, it is important to find ways to recover from stressful situations, and meditation is one strategy that can aid in this.

The word 'meditation' will give distinct definitions among different groups of people. There are various techniques that can be used for meditating such as sitting quietly, focusing on breath, mental imagery, or repeating a phrase to oneself. No matter what one person may choose to do to practice their own meditation, it has shown to have many benefits in a persons overall mental health, including lowering stress levels (Tang et al., 2007). For long-term studies, Integrative Body-Mind Training which, a type of meditative practice, is defined "to control thoughts, and the achievement of a state of restful alertness that allows a high degree of awareness and balance of the body, mind, and environment" and has been shown to improve self-regulation (Tang et al, 2007). For our research purposes, we will be using guided meditation exercise to define our meditative technique. In laboratory settings, meditation has been proven to reduce depression, anxiety, and panic symptoms of stress and also helps mitigate stressful events (Kabat-Zinn, et. Al., 1992).

The State-Trait Anxiety Inventory is a qualitative measure of stress rather than physiological. It contains 40 items and is used in clinical settings to diagnose anxiety (Spielberger, 1989). Via self-report, it assesses "state anxiety" which is seen as the subjects current, temporary anxiety level and "trait anxiety" which is the relatively stable, more general temperament of a subject (Julian, 2011). Scores range from 20-80, with a score above 39-40

indicating anxiety-prone individuals above the normal level (Knight, 1983).

One way to induce stress in experiment participants is by administering the Trier Social Stress Test (TSST). The Trier Social Stress Test is a protocol that induces a stress response in laboratory settings while providing a “naturalistic context” and incorporating “aspects of social and psychological stress” (Birkett, 2011). The three components of the test involve taking baseline physiological stress responses, instructing them that they have one minute to prepare a speech on why they would be a good candidate for their dream job, and a five minute period where they perform the speech in front of three judges who are actually the researchers performing the experiment. The physiological stress responses can be measured during and after the test (Birkett, 2011). The two key components for this test being stress inducing are considered the social evaluation aspect and uncontrollability (Gruenewald, et. Al., 2004).

The TSST has proven effective in the activation of the hypothalamic-pituitary-adrenal axis (Ruiz, et. Al., 2010). When the TSST was administered to a group, participants reported having significantly higher scores than controls on the State Trait Anxiety Inventory which is a subjective, psychometric measure of strain, challenge, and stress (von Dawans, et. Al, 2011). The TSST has been found to induce physiological stress symptoms as well as psychometric. Researchers found that the stress responses of elevated heart rate, blood pressure, and hormone stress markers such as cortisol induced by the TSST were comparable to physical stressors such as a saline injection (Kirshbaum et. Al., 2004).

If an experimental group meditates before stress is induced by the Trier Social Stress Test, their physiological stress responses of heart rate, electrodermal activity, and mean arterial blood pressure will be lower than a control group that does not meditate before stress is induced.

By using the BIOPAC MP36 system, heart rate, galvanic skin response, and blood pressure will be measured prior to the meditation in the experimental group (Kremer, 2010). The galvanic skin response was calculated using electrodermal activity (EDA). The control group will not undergo meditation and therefore will have heart rate, galvanic skin response, and blood pressure measured immediately prior to the stress test. These will be used as baseline stress levels for the experimental and control groups. After both the experimental and control groups are exposed to the stress test, heart rate, galvanic skin response, blood pressure will be measured again. These post-test measurements will be compared to the baseline stress levels to determine the total increase in heart rate, galvanic skin response, and blood pressure. These values can then be compared between the experimental and control groups to determine if meditation causes a reduction in the physiological stress response.

Because meditation has been shown to reduce stress in experimental participants, it could be a sound prediction that participants who undergo meditation before being exposed to a stressful stimulus such as the Trier Social Stress Test will show a lower physiological stress response in the form of heart rate, electrodermal activity, and blood pressure than the experimental group that does not undergo meditation.

Materials

The materials used in this study were BIOPAC Student Lab System: BSL 4.0 Software and MP36 Hardware, BIOPAC Electrode Lead Set, BIOPAC EDA setup: Nonin Pulse Oximeter/CO2 Detector Model 9843 with Adult Articulated Finger Clip to measure heart rate, EDA Transducer (SS3LA) and Isotonic Recording Electrode Gel (GEL101) to measure skin conductance, BIOPAC Pressure Cuff (SS19L with gauge dial) and BIOPAC Stethoscope (SS30L) to measure blood pressure, a guided ten minute meditation recording, the Trier Social Stress Test to create anxiety, and the State Trait Anxiety Inventory to determine current stress levels in the subjects (Kremer, 2010).

Methods

Study and Design

The purpose of this study was to measure the effects that one-time meditation has on stress, as measured by heart rate, electrodermal activity (EDA), and blood pressure. This study was conducted on 18 subjects (8 females and 10 males) between the ages of 20 and 23. All subjects were members of the medical physiology course for which this study was done. Two participants were run at a time: one in the meditation condition and one in the control condition. First, baseline recordings were taken for each measure and the State-Trait Anxiety Inventory was completed. Those in the meditation condition underwent the meditation induction in a smaller, separate room (Room 2). This induction consisted of the 10 minute guided meditation on www.calm.com which the participants listened to in the dark with earbuds. During this time, the control participant underwent a modified version of the Trier Social Stress Test (TSST) in Room 1 (a larger room where the measurements were done). The TSST is a 3-part stress induction. First, the participant is told they have 30 seconds to prepare to speak for 3 minutes about their future (career, dreams, summer, etc). The participant gives this 3 minute speech and are then asked to count down from 1022 by 13's for two minutes. If they make a mistake, they are asked to start over. EDA was measured during the TSST, and blood pressure and heart rate were measured directly afterward. The completion of this task coincided with the completion of the meditation induction. After the control participant is finished with the study, the meditating participant finishes guided meditation. The meditating participant's heart rate is promptly measured, and they then begin the TSST. Their EDA is also measured throughout the TSST, and their heart rate and blood pressure is taken at the end. Table 1 visually displays how the procedure was outlined.

Time Block	Experimental: Subject A	Control: Subject B
1 (3-5 min)	HR, EDA, & BP Location: Room 1	Stress Questionnaire Location: Room 1
2 (3-5 min)	Stress Questionnaire Location: Room 1	HR, EDA, & BP Location: Room 1
3 (10 min)	Meditation Post-Meditation HR Location: Room 2	TSST HR, EDA & BP Location: Room 1
4 (6 min)	TSST Location: Room 1	
5	HR, EDA, & BP Location: Room 1	

Table 1. This figure gives an overall schematic of the procedural outline.

Measures

Heart rate was measured with a pulse oximeter. EDA was interpreted using three aspects of the recording: the mean, maximum, and area. All were derived using the BIOPAC software in which the measurements were taken. Blood pressure was measured using the traditional cuff-and-stethoscope method.

Positive Controls

To prove that the tests we performed elicited physiological responses, positive control tests were used. The positive control tests were heart rate, electrodermal activity, and mean arterial blood pressure after or during one minute of jumping jacks. The results are depicted in Figure 2, Figure 3, and Figure 4, respectively.

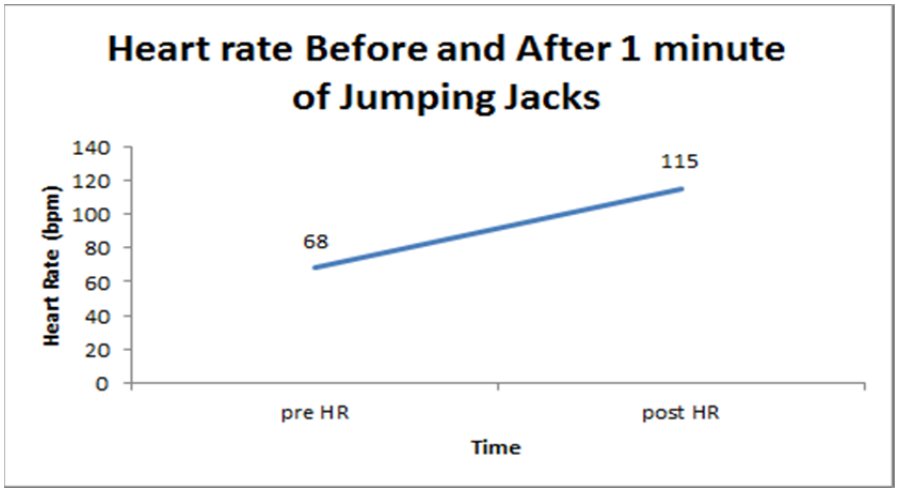

Figure 1. Heart Rate

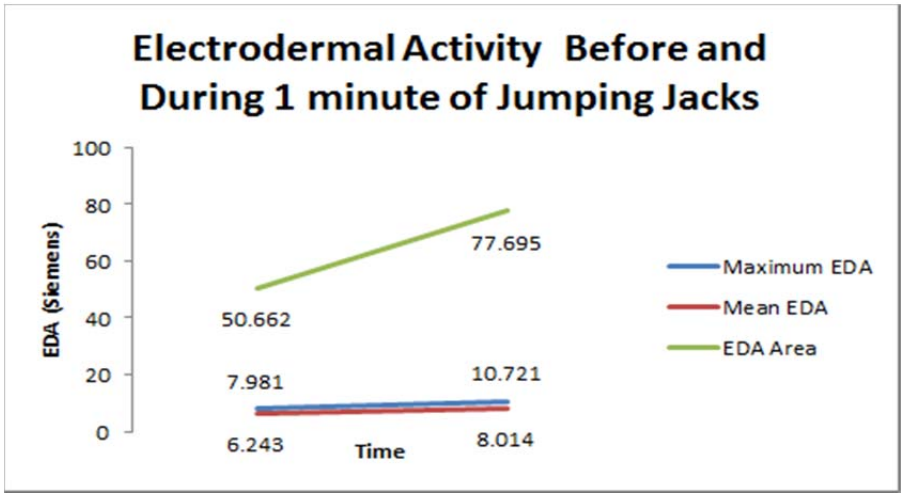

Figure 2. Electrodermal Activity

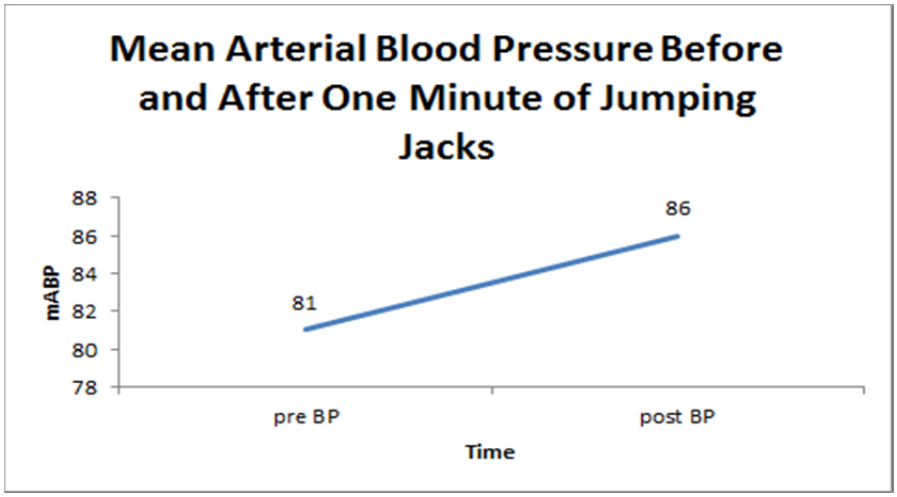

Figure 3. Mean Arterial Blood Pressure

Results

None of our measures reached significance in between-groups comparisons. However, numerous trends did appear. Although the differences in means of measures did not differ significantly between groups, there are differences, and they are in the direction that we expected.

Parameter	Group	Overall Change	Standard Deviation	Matches Hypothesis?	T-value	P-value	Statistically Significant?
HR	Control	-1.80	10.84	No	0.955	0.352	No
	Experimental	2.60	9.74				
EDA - max	Control	4.57	3.88	Yes	-1.637	0.119	No
	Experimental	1.48	4.55				
EDA - mean	Control	2.34	2.05	Yes	-1.756	0.096	No
	Experimental	0.28	3.09				
EDA - area	Control	540.3	504.5	Yes	-0.545	0.592	No
	Experimental	422.97	495.7				
mABP	Control	5.40	3.86	Yes	-1.700	0.106	No
	Experimental	-0.10	9.47				

Table 2. Overall summary of data analysis. The change in heart rate ($t = 0.955$, $p = 0.352$), electrodermal activity (EDA) maximum ($t = -1.637$, $p = 0.119$), EDA mean ($t = -1.756$, $p = 0.096$), EDA area ($t = -0.545$, $p = 0.592$), and change in mean arterial blood pressure ($t = -1.700$, $p = 0.106$) were not significant (p-value < 0.05).

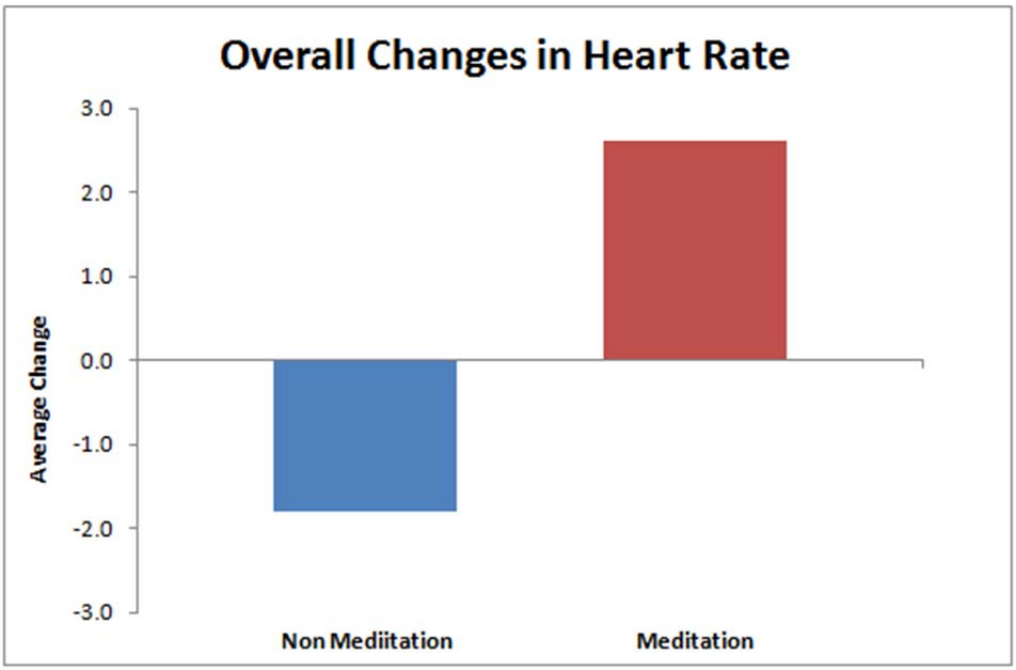

Figure 4. Average change in heart rate (HR) of both groups from baseline measurements to post-TSST measurements. The control group, surprisingly, showed a large decrease in HR while the meditation group showed an increase.

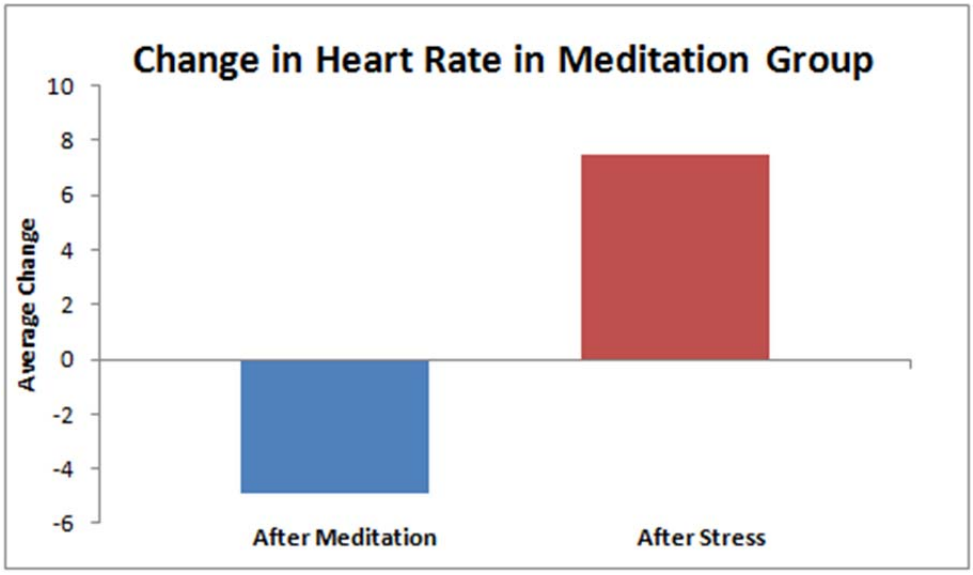

Figure 5. Average change in heart rate (HR) for meditation group after meditation and after TSST. The meditation group showed a non-significant decrease in HR ($t = 1.423$, $p = 0.188$) after meditating and a non-significant increase in HR ($t = -1.883$, $p = 0.0924$) after TSST. TSST appears to have almost perfectly undone this effect, showing an increase in HR of nearly the same value.

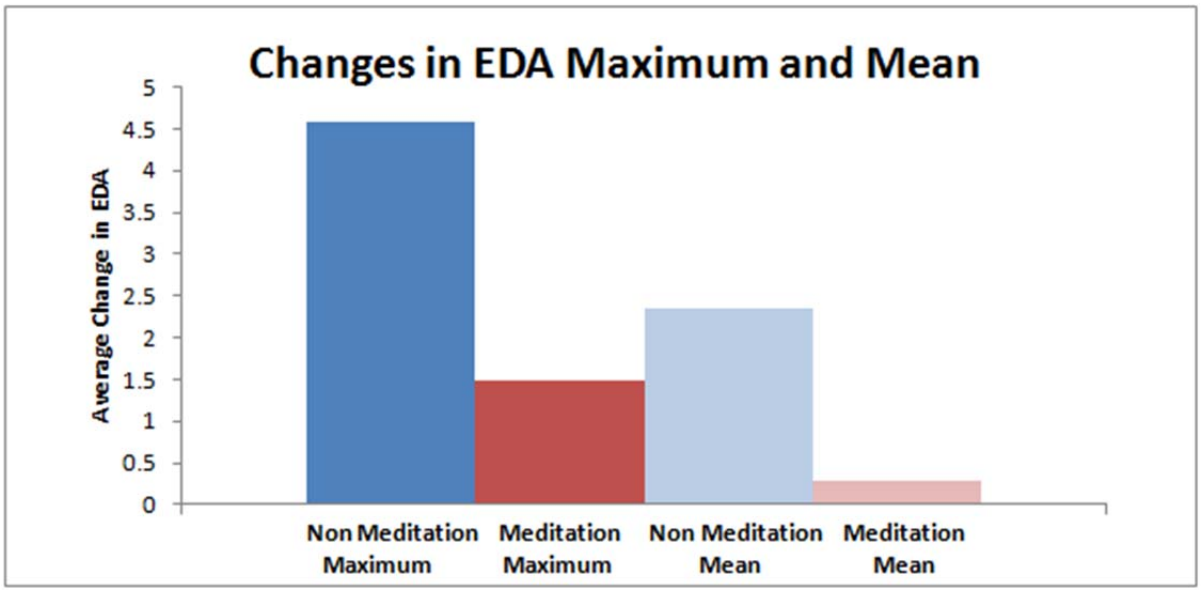

Figure 6. Average changes in electrodermal activity (EDA) maximum and mean. The meditation group showed a smaller increase than the control group in both EDA maximum and mean, though this difference was not significant.

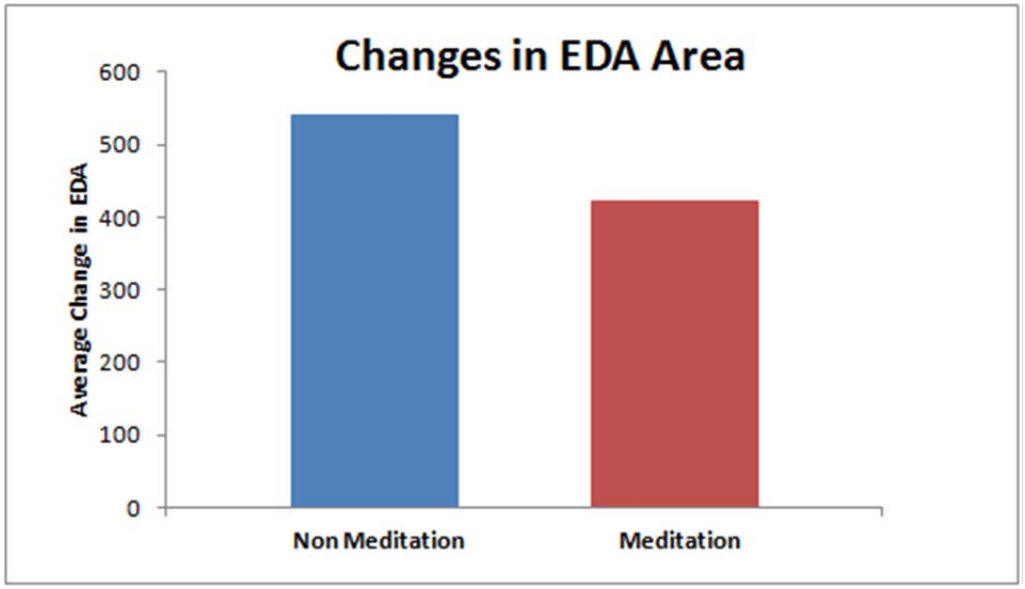

Figure 7. Average changes in EDA area. The EDA area increased in both the control group and the meditation group, although it increased less in the meditation group. This difference is also not significant.

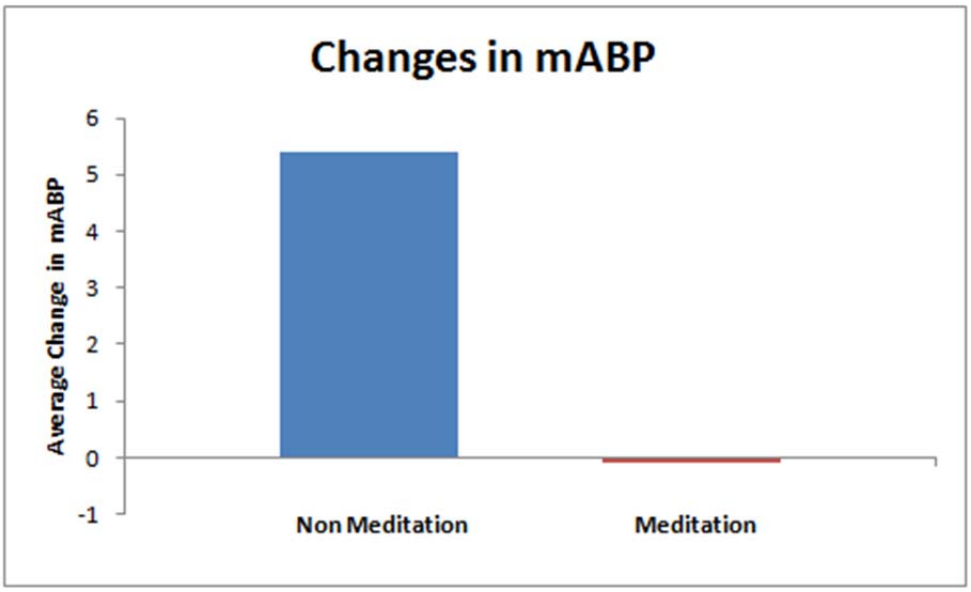

Figure 8. Average changes in mean arterial blood pressure (mABP). The control group showed an increase in mABP while the meditation group showed a slight decrease in mABP, though this difference was also not significant.

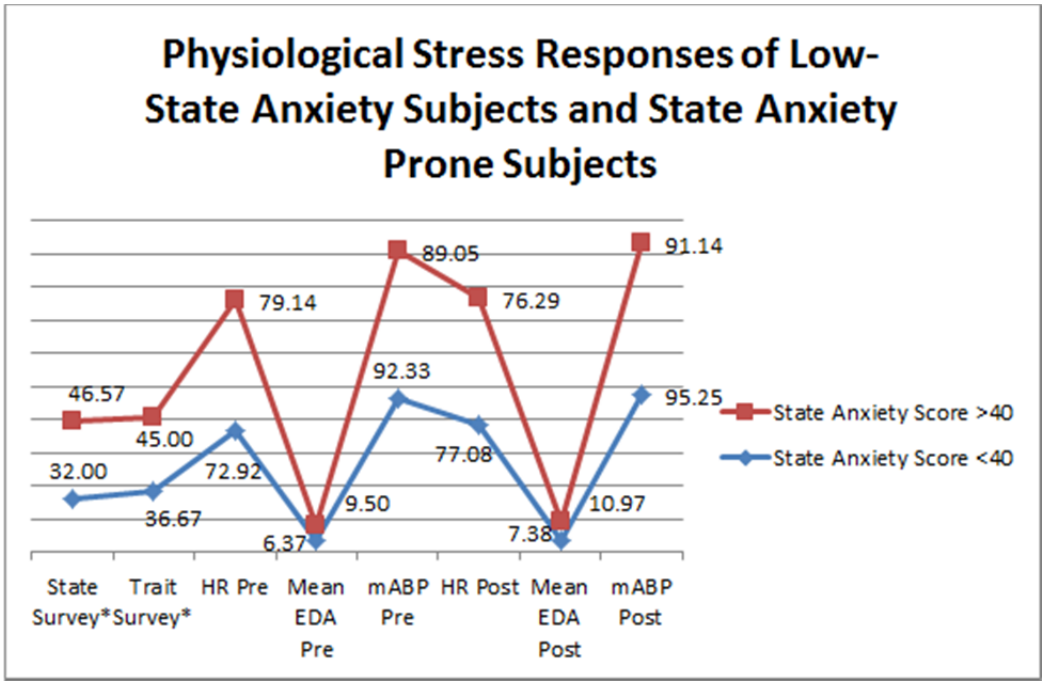

Figure 9. Data was separated into two categories based on their self-reported State Anxiety score on the State-Trait Anxiety Inventory. Eight subjects scored over 40 points and 12 subjects scored below the normative value of 40 points. The results of the State survey score, Trait survey score, heart rate (bpm), mean EDA (Siemens), and blood pressure (mmHg) were averaged and plotted in the order they were taken. The X-axis labels of Pre and Post distinguish when the data was collected respective to the Stress Test. The X-Axis labels followed by an (*) indicates a p-value<0.05.

Gender Differences		
Variable	**T values**	**P values**
State Survey	-.308	.761
Trait Survey	.252	.804
EDA max	1.976	.064
EDA mean	1.727	.101
EDA area	.411	.686
HR	.410	.686
mABP	.712	.485

Table 3. There were no statistically significant findings between genders.

Discussion

The results do not support with statistical significance the hypothesis that participants who undergo meditation before being exposed to a stressful stimulus will show a lesser physiological stress response as measured by heart rate, electrodermal activity, and blood pressure. This hypothesis was based on the assumption that these three parameters were appropriate indicators of the level of stress in a given individual.

Although the results were not statistically significant, there were trends in the direction we expected. EDA max, mean, and area increased less in the meditation group, as did mean arterial blood pressure. This suggests that one-time meditation does have some limited ability to mitigate stress in the short term. However, our results show that heart rate increased more in the meditation group, contrary to our hypothesis. In the meditation group, we observed an increase in systolic BP and slight decrease in mABP. It is possible that a compensatory mechanism drove this increase in HR. Measuring the total peripheral resistance (TPR) and the stroke volume (SV) in future studies may afford better understanding of this trend.

It is possible that EDA and mABP results followed our hypothesis but were not of statistical significance because the sample we obtained is comprised entirely of science-oriented university upperclassmen, individuals likely under more stress than the general population. Thus, not only was the sample size small, but the population from which we drew our sample might be under more stress than can be significantly attenuated by a single 10 minute meditation session, especially when thoughts of their uncertain, ominous futures are evoked. In fact, the average trait anxiety score for both groups was above 42, putting them in the range of clinically significant anxiety (Julian, 2011). In a follow-up survey to gauge caffeine consumption and smoking habits, we found that our sample consumed on average 1 cup of coffee per day, and 6-8 per week, with one person consuming 4 per day and 18 or more per week. None claimed to smoke. It is likely that regular caffeine consumption, especially preceding the study, affected our results.

The meditation during the experiment was a ten minute long guided meditation in which some of the participants had some experience meditating, while others had no experience. The meditation session might not have been effective enough to significantly alter one's response to stress. After meditating, and before the stress test was administered, the HR was taken to give a quantitative measure that the meditation did indeed elicit a physiological response. Although not significant, the HR tended to decrease suggesting a relaxed response to meditation.

Also, the quick transition from the relaxed state after meditating to an immediate stressful event may contribute to stress because of the drowsiness and nature of a relaxed state after meditating. Habitual practice and integrating meditation into one's lifestyle may prove to be more effective in mitigating stress response. Some people also noted that towards the end of the mediation session, they could hear sounds from outside the meditation room. This indicates a disturbance during the meditation practice. For future studies, decreasing extraneous noise during the experiment could increase accuracy of measurements. Also, recording the diet and lifestyle behaviors of each participant before administering measurements, specifically coffee and smoking, could help explain variations and outliers in data.

The results of the State-Trait Anxiety Inventory may be helpful in interpreting the data. The State Survey results ranged from 27-57 and the Trait survey results ranged from 23-55. The possible range is 20 – 80, with a higher score indicating greater anxiety. A cut point of 39 – 40 has been suggested to detect clinically significant symptoms of anxiety (Julian, 2011). The data was interpreted on the basis of above or below the cut point of 40 to indicate lower stress subjects data compared to subjects more prone to anxiety. Figure 10 shows that those with higher State Anxiety score responses on average had higher Trait survey results; higher heart rate before and after the stress test; higher mean EDA values before and after the stress test; and higher mABP before and after the stress test was administered. This is not unexpected as those who report typically being more stressed would likely carry a larger physiological stress response than those subjects who fell on the lower end of the anxiety range. In the future, the State-Trait Anxiety Inventory results could be used to assess the patients data on an individual basis instead of the binary scale of above or below 40. A correlation between a lower trait anxiety score, mediation experience, and decreased physiological stress response could also be explored.

Though none of the results were statistically significant, they tended to support what would be expected if meditation did in fact mitigate stress response. This is relevant because, if future studies confirmed with significance that meditation lessens the response to stress, these findings could potentially be extrapolated to incorporate meditation into treatments for anxiety disorders. Interestingly, one study already found that meditation does have anxiety-reducing effects (Goleman, et Al., 1976). Similarly, further studies may find that meditation is a potentially effective therapy for individuals dealing with anger management. It could also help treat symptoms of cardiovascular disease, which include chronic exposure to stress (Schubert et al., 2009). Essentially, this study is a good starting point to investigate whether or not meditation will actually lessen stress response or even simply lower stress in general. Future studies could

further investigate this issue by better isolating the experimental variables and more effectively removing any possible confounding factors.

Researching habitual meditation would be a great follow up to this study. Additionally, increasing the sample size and getting a more generally representative sample could increase the power and validity of the study.

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