EFFECTS OF SLEEP QUALITY ON STRESS REACTIVITY

Senior Honors Thesis

Submitted to the Faculty of

Oklahoma State University

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May 2022

Oklahoma State University

Stillwater, Oklahoma

Abstract

Purpose: Previous research has shown that sleep quality may be related to higher stress reactivity. This pilot study evaluated relationships between baseline sleep quality and changes in positive and negative affect, blood pressure, and heart rate in response to an experimental stress task.

Methods: Participants were 34 women aged 19.47 ± 1.81 enrolled in a larger dissertation study. Sleep quality was measured through the Pittsburgh Sleep Quality Index (PSQI), with poor sleep quality being labeled as a global score higher than 5. Stress-reactivity was measured through the Positive and Negative Affect Schedule Short Form (PANAS), along with biometric measures of systolic and diastolic blood pressure and heart rate. Stress was induced through Cyberball and a modification of the Trier Social Stress Test. Relationships between study variables were analyzed with a two-way ANOVA test.

Results: Results showed a significant main effect of Sleep Quality on change in negative affect, $F(1, 30)= 4.85$, $p= .036$, $\eta_p^2=.139$, such that those with poor sleep at baseline experienced a significant increase in negative emotions from baseline to post-stressor (M= .71, SE=.38), while those with good sleep experienced a significant decrease in negative emotions (M= -.40, SE= .32).

Conclusions: This pilot study suggests that poor sleep quality may be related to a significant increase in negative emotions from baseline to post-stressor. Results indicate that those with poor sleep experienced a significant increase in negative emotions from baseline to post-stressor, while those with good sleep experienced a significant decrease in negative emotions.

Introduction

Overview

According to the Philips Global Sleep Survey in 2019, 67% of adults worldwide experience poor sleep quality, and 60% of adults who want to improve their sleep quality fail to seek professional help (Philips, 2019). Chronic sleep loss is linked to significant negative health outcomes having long-lasting effects on several bodily systems, including the cardiovascular, endocrine, immune, and nervous systems. Specifically, poor sleep quality can lead to neurocognitive issues, such as errors in judgment or slower processing speed, obesity, hypertension, diabetes, cardiovascular disease, anxiety, and depression (Altevogt & Colten, 2006). A growing area of research is biological stress reactivity as a critical mechanism in the relationship between poor sleep and poor health. Therefore, the overarching goal of this pilot study is to further investigate this relationship by focusing on healthy, undergraduate women.

Sleep Quality

The recommended amount of sleep varies across age groups, with the total amount of hours gradually decreasing with age (CDC, 2017). Sleep quality can be studied across age groups through sleep cycles, which repeat every 90 to 110 minutes. These cycles mainly consist of Rapid Eye Movement sleep (REM) and non-REM sleep, which are divided into four phases. Phase 1 is considered very light sleep, with people being easily woken. In Phase 2, the brain slows down but short bursts of activity remain. The next two phases (Stages 3 and 4) are considered deep sleep phases. After non-REM sleep, the body cycles into REM sleep, which was previously thought to be the most important for learning and memory. However, current research shows that non-REM sleep plays a more important role in these tasks. In addition, it suggests non-REM sleep as the more restorative and restful phase. These phases typically repeat in a cycle until one awakes in the morning, while some people are partially awake when the cycle ends (IQWiG, 2016 & Johns Hopkins Medicine, 2022). On average, adults need at least 7 hours of sleep a night. However, a 2014 study on the Behavioral Risk Factor Surveillance System in the United States found that 35.2% of all adults experienced short sleep (<7 hours a night), along with 34.8% of women, 32.2% of adults aged 18-24 years old, and 33.0% of adults with a BMI ≥ 30 kg/m^2 (CDC, 2014).

Poor Sleep Quality and Health Outcomes

According to the CDC, poor sleep can threaten health in many ways, including increasing the risk for chronic diseases such as type 2 diabetes, heart disease, obesity, and depression (CDC, 2018). A study investigating sleep quality and health-related quality of life in young adults revealed a significant association between sleep quality and both physical and mental health (Clement-Carbonell, Potilla-Tamarit, Rubio-Aparicio, & Madrid-Valero, 2021). Specifically, among the various components of sleep quality (which include sleep quality, latency, duration, efficiency, disturbance, use of sleep medication, and daytime dysfunction), subjective sleep quality and sleep disturbances were significantly associated with lower self-reported mental health. Subjective sleep quality, sleep disturbances, and use of sleep medication were also significantly associated with poorer physical health (Clement-Carbonell et al., 2021). Poor sleep is also a leading cause of motor vehicle accidents and injuries (de Mello, Narciso, Tufik, Paiva, Spence, BaHammam & Pandi-Perumal, 2013). In fact, workers with poor sleep are 1.62 times more likely to be injured on the job than workers without sleep problems (Uehli, Mehta, Miedinger, Hug, Schindler, Holsboer-Trachsler & Künzli, 2014).

In addition, studies have shown a relationship between sleep deprivation and impairments in human functioning and mood. A 1996 meta-analysis summarizes 19 studies on the effects of sleep loss (Pilcher & Huffcutt, 1996). The results indicated that sleep deprivation led to a decrease in performance, along with a negative effect on cognitive performance. In addition, sleep-deprived subjects reported worse moods than those who were not sleep-deprived (Pilcher et al., 1996).

In addition to the negative effects of long-term sleep deprivation, researchers have also studied the effects of one night of limited sleep. In a study of 338 individuals who had no prior issues with sleep deprivation, 66.86% (226 participants) slept six or more hours the night before the assessment, and 33.14% (112 participants) slept less than six hours the night before (Barnett, 2008). During the session, both groups completed surveys on mood and stress. They also completed cognitive testing and their cardiovascular and electrophysiological (via EEG) functioning were measured. Those in the sleep-deprived group reported higher depression, anxiety, and stress scores, as well as poorer overall well-being than those in the “good sleep” group. On cognitive testing, the poorer sleep group made more errors on simple cognitive tasks than the good sleep group. On physiological measures, the poorer sleep group had a significantly higher resting heart rate and a higher alpha and beta power on EEG testing at rest, which suggests that individuals who get poor sleep may experience higher physiological arousal during waking hours - even when resting - than individuals who get a good amount of sleep (Barnett, 2008). Although this study investigates only sleep duration- rather than sleep quality - it provides important evidence that sleep plays a role in brain functioning, which may include cognition and emotion regulation. The study also suggests how even transient sleep loss (i.e., one night of limited sleep duration) exerts adverse impacts on next-day functioning. The documented negative effects on cognitive performance and emotion regulation have implications for many populations, especially college students, for which cognitive performance is essential for academic achievement. The present thesis goes beyond sleep duration to investigate how sleep quality can affect how the body responds to an experimental stressor in a pilot sample of undergraduate students.

Stress Reactivity

One major mechanism between sleep and its negative health outcomes is stress. Several studies have investigated the relationship between poor sleep and chronic stress. In fact, a study among college students in Indonesia showed that sleep quality has a strong relationship with general stress levels, with students who experience poor sleep quality being 4.7 times more likely to report being stressed than those who experience good sleep (Herawati & Gayatri, 2019). A 2015 study examined the effects of sleep quality on cortisol reactivity to acute psychosocial stress (Bassett, Lupis, Gianferante, Rohleder & Wolf, 2015). Responses to the Trier Social Stress Test showed a gender-specific change in cortisol levels such that men experienced a significant increase in cortisol while women with poor quality sleep showed a decrease in cortisol. This suggests that the Hypothalamic-Pituitary-Adrenal (HPA) axis may play a role in the relationship between poor sleep and social stress. The HPA axis is a physiological system that enables humans to initiate a response to events that impact homeostasis. It does so by activating neural networks and initiating an immune and endocrine response (Sapolsky, Romero, & Munck, 2000). With the ability to create slow and rapid responses, a rapid response would manifest itself as increased heart rate and blood pressure (Allen, Kennedy, Cryan, Dinan, & Clarke, 2014). These biological responses to stress show a possible indication of the importance of sleep on poor health outcomes. The gender-specific findings of the study may be caused by differences in emotion regulation between men and women. The authors suggest that men may be more likely to suppress emotions, and this coping strategy has been linked to greater cortisol responses

(Bassett et al., 2015). To further understand this relationship, the current study focuses on the effects of poor quality sleep on stress reactivity to an experimental social stressor in women undergraduates only.

Current study

The current study was part of a larger dissertation study investigating the effects of social exclusion and social stress on biological stress reactivity and executive functioning. Although the larger study was not designed specifically to answer the present pilot study's questions, the available data allows for preliminary examination of how baseline poor sleep quality affects stress reactivity to an experimental social stress task in undergraduate women. The current study had the following hypotheses:

1. Individuals who experience poor-quality sleep will exhibit a larger change in stress reactivity measures, such that:
    a. Poor sleep quality will be related to a significant increase in negative emotions from baseline to post-stressor.
    b. Poor sleep quality will be related to a significant decrease in positive emotions from baseline to post-stressor.
    c. Poor sleep quality will be related to a significant increase in both systolic and diastolic blood pressure (SBP and DBP) from baseline to post-stressor.
    d. Poor sleep quality will be related to a significant increase in heart rate from baseline to post-stressor.

2. No *a priori* hypotheses were made regarding the effects of stress condition (i.e., Cyberball Inclusion vs. Exclusion) on stress reactivity. Stress condition was included in the analyses to account for the randomized experiment in the larger dissertation study.

Method

For this pilot study, 34 participants were recruited from the psychology department subject pool as part of a larger dissertation study. To be eligible, participants had to identify as women; be between the ages of 18 and 25; free of oral health conditions, such as gingivitis; and be free of chronic medical conditions, including severe psychiatric disease, inflammatory disorders, and cardiometabolic disorders. In addition, participants had to avoid taking any anti-inflammatory medications 24 hours before the study; must not be currently using a prescription of psychotropic medications; must not be a current smoker or vaper; and must not be pregnant at the time of the study. Informed consent was provided prior to the start of the study. This study protocol was approved by the university's institutional review board and adheres to APA ethical guidelines.

Measures

Screening information was collected from the participants via an online questionnaire, along with demographic information such as age, race/ethnicity, BMI, and sexual orientation.

Sleep (Predictor)

Sleep was measured through the Pittsburgh Sleep Quality Index (PSQI). The PSQI, developed in 1989, is a self-rated questionnaire that measures sleep quality and disturbance for the past 1 month (Buysse, Reynolds III, Monk, Berman & Kupfer, 1989). It measures 7 components of sleep through 19 self-answered questions, and 5 optional questions answered by someone that shares a room or bed with the individual. Since this was an individual study, the 5 optional questions were disregarded. Each component is answered on a scale of 0 (no difficulty) to 3 (high difficulty), and added for a maximum possible score of 21 total. Individuals with a score higher than 5 are considered to have clinically significant sleep disturbances (Buysse et al., 1989). This value was used in the present study to compute the dichotomous variable of Sleep Quality (-1=good sleep quality, 1=bad sleep quality). The PSQI is included in Appendix A.

Sleep Quality Assessment

A common measure assessment used to study sleep quality is the Pittsburgh Sleep Quality Index (PSQI). This instrument studies sleep through 7 components: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction. These components are presented in a questionnaire format with self-rated questions that yield a global score allowing researchers to qualify participants' sleeping experiences as "good" or "bad" sleep. This assessment provides an index for researchers to further understand sleep disturbances and sleep quality (Buysse et al., 1989).

Blood Pressure and Heart Rate (Outcome)

To study the stress response, the participants' heart rate (HR; beats per minute), systolic (SBP), and diastolic (DBP) blood pressure (mmHg) were recorded throughout the study. A blood pressure cuff was attached to the participant's non-dominant arm, and kept on throughout the entire study. Readings were recorded at baseline and post-stressor. For each time point, two seated blood pressure readings were taken at 2-min intervals by a trained research assistant. A third reading was taken if values in the first two readings differed by 10 mmHg or more. HR, SBP, and DBP values were computed as an average of the two or three readings. The baseline readings were taken immediately after the first 10-minute break, which was intended to allow the participants to habituate to the laboratory setting, and the post-stressor readings were recorded immediately after the Speech Task. Change scores for HR, SBP, and DBP were computed by subtracting the post-stressor score from the baseline score, where a negative change score suggests a decrease in indicators from baseline to post-stressor, and a positive change score suggests an increase in indicators from baseline to post-stressor.

Positive and Negative Affect (Outcome)

Positive Affect (PA) and Negative Affect (NA) were studied to further understand the participants' changes in emotions throughout the study. To do this, the Positive and Negative Affect Schedule Short Form (PANAS-SF) was completed by the participants at baseline and post-stressor. These time points were consistent with those in which blood pressure and HR were recorded, described above.

The PANAS-SF consists of 10 adjectives for emotional states, 5 positive and 5 negative. The assessment instructed participants to rate each feeling on a scale of 1 (Very Slightly or Not at all) to 5 (Extremely) (Mackinnon, Jorm, Christensen, Korten, Jacomb & Rodgers, 1999). Change scores were computed for both PA and NA by subtracting the post-stressor score from the baseline score. Similar to blood pressure and HR above, a negative score suggests a decrease in PA or NA, while a positive score indicates an increase in PA or NA from baseline to post-stressor.

Cyberball Task (Stressor)

To simulate stress, the Cyberball paradigm was used as the first stressor task. In this task, participants were randomized to be either included or excluded in a virtual ball-tossing game (Williams, Cheung & Choi, 2000). To create deception, the research assistant informed the participants that students at a collaborating laboratory would be playing the game with them virtually. However, in reality, participants were playing with the computer, and all throws were predetermined based on their randomized condition. Participants in each respective condition experienced the same amount of throws, and both conditions were pre-programmed to have a 0.5

- 4.0 second wait between throws. In the exclusion condition, participants were initially included in the game, but the other two players eventually completely stopped tossing the ball to them. With a total of 60 throws, 2 of the first 10 were to the participant and the participant was completely excluded from the next 50 throws. In the control condition, each "player" received 20 throws. In other words, the participant was included throughout the entirety of the game. Both conditions took around 5 minutes to complete. Debriefing took place at the end of the study, in which participants were informed that the two other players were not real, and the tosses were preprogrammed.

Speech Anticipation Task (Stressor)

For the second stressor, participants were told that the study required a speech task. They were instructed that they may or may not be in the group that requires them to give the speech, which would be recorded and evaluated virtually by 3 research assistants and the principal investigator. After 5 minutes of "speech anticipation," participants were given instructions on what to include in their speech, and 5 minutes to prepare the speech. However, after the 5-minute timer went off, all participants were told that they were in the group that did *not* have to give the speech. This task is a modified version of the Trier Social Stress Test (TSST), which requires participants to give a presentation and complete a mental algebraic test in front of a panel of reviewers who do not provide feedback throughout the task (Allen, Kennedy, Dockray, Cryan, Dinan & Clarke, 2017). While the task in this study does not require them to complete the speech and arithmetic tasks, the anticipation and preparation phases have been shown to cause a stress response (Dietrich, Andreatta, Jiang, & Stemple, 2020).

Procedure

Recruitment and Screening

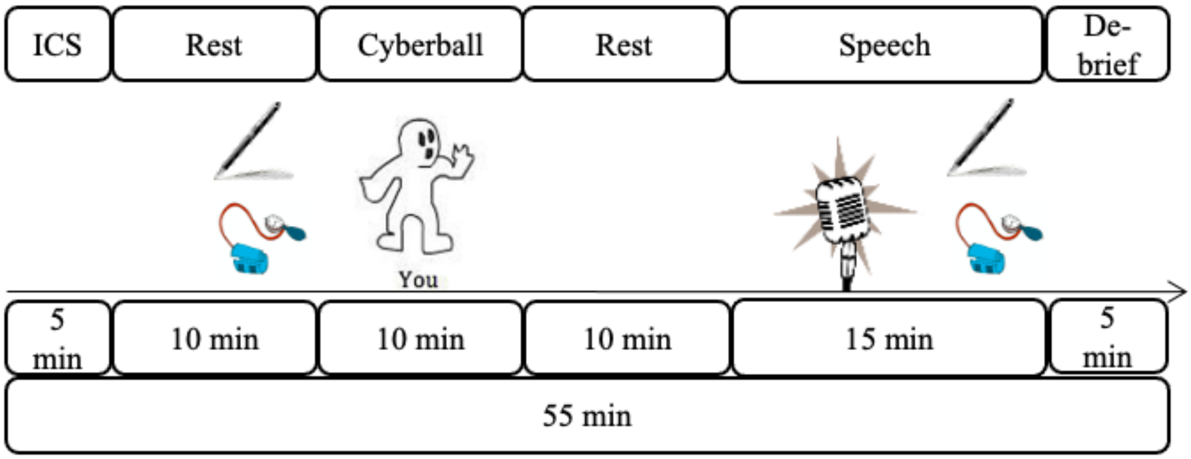
Participants were recruited from the psychology department pool (SONA) at Oklahoma State University for a larger dissertation study, *Social Processes and Biological Stress Reactivity: Implications for Executive Functioning* by Madison E. Stout. Participants completed an online screening through Qualtrics, which allowed the researchers to determine their eligibility for participation in the in-lab session. The Qualtrics survey collected demographic and contact information, as well as inclusion and exclusion criteria. If eligible, the participants were contacted by the researcher via email to set up the in-lab session.

In-Lab Session

Upon the participant's arrival, the research assistant (RA) reviewed the consent form with the participant. This informed them that their participation in the study was completely voluntary, and they were free to withdraw from the study at any time. After review, participants were asked to sign the consent form if they agreed to continue with their participation. In addition, they were asked to use the restroom before the session began, to silence or turn off their phones, and avoid eating or drinking during the session to decrease the interference of external stimuli. Demographic information previously obtained during the screener was then reviewed with the participant to later be entered into REDCap by the researcher. Once this was completed, the participant's height and weight were measured, followed by a 10-minute rest period to allow for habituation to the lab before starting the experiment. During this rest period, the RA used REDCap to enter the demographic information and randomize the participant into one of the two Cyberball conditions: the exclusion group or the inclusion group. After the habituation period, blood pressure, and HR were collected, and participants completed the PANAS baseline measure. Participants then completed the Cyberball task while unaware of the conditions, followed by the Speech Anticipation task. At the end of the speech. Blood pressure, HR, and PANAS scores were recorded again. The study timeline is detailed in Figure 1. In addition to these measures, a saliva sample was collected during the same time points for a larger dissertation study, but not included in the present study. Once all tasks were completed, study debriefing took place. Debriefing informed the participant of the nature of the study, including how no participant had to give a speech, and that the Cyberball game was preprogrammed and there was no collaborating laboratory. The participant was then able to ask any questions if needed, and was asked to provide feedback on what they thought the study was about. Participants were then compensated with course credit or a gift card and the session ended.

Figure 1

Participant Protocol



Note. The larger dissertation study included additional tasks and data collection time points. They are not included in this figure for simplicity of describing the present analyses (See *In-Lab Session* Section)

Results

Participants Demographics

Participants were all women, had an average age of 19.47 ± 1.81 years old, and an average BMI of 24.70 ± 5.61. They were 50% white and 79.4% heterosexual (see Table 1). Group cells were relatively evenly distributed (Good Sleep-Inclusion=12, Good Sleep-Exclusion=8, Bad Sleep-Inclusion=6, Bad Sleep-Exclusion=8), (p=.487). Demographic factors were also evenly distributed between the groups (ps≥.308).

Table 1

Demographic information

Study Variables	**(*N*= 34)**
Demographic Factors	
Age	19.47 [1.81]
BMI	24.70 [5.62]
Race/Ethnicity	
American Indian/ Alaska Native	1 (2.9%)
Asian	3 (8.8%)
Black/ African American	4 (11.8%)
Hispanic/ Latinx	4 (11.8%)
White	17 (50%)
Multiracial	5 (14.7%)
Sexual Orientation	
Straight	27 (79.4%)
Gay, Lesbian, Homosexual	1 (2.9%)

Bisexual	3 (8.8%)
Asexual	2 (5.9%)
Choose not to respond	1 (2.9%)

ANOVA Results

Changes in Affect

Negative Affect. A 2 (Cyberball Condition) x 2 (Sleep Quality) ANOVA revealed a significant main effect of Sleep Quality on change in negative affect, $F(1, 30)=4.85$, $p=.036$, $\eta_p^2=.139$, such that those with poor sleep experienced a significant increase in negative emotions from baseline to post-stressor (M= .71, SE=.38), while those with good sleep experienced a significant decrease in negative emotions (M= -.40, SE= .32). Further, results showed no main effect of Cyberball on change in negative emotions, $F(1, 30)=.140$, $p=.711$, $\eta_p^2=.005$. There was a non-significant interaction of Cyberball and Sleep Quality on change in negative emotions, $F(1, 30)=.292$, $p=.593$, $\eta_p^2=.010$.

Positive Affect. A 2 (Cyberball Condition) x 2 (Sleep Quality) ANOVA revealed no significant main effects of Sleep Quality on change in positive affect, $F(1, 30)=.001$, $p=.979$, $\eta_p^2= .000$, or of Cyberball on change in positive emotions, $F(1, 30)=1.492$, $p=.231$, $\eta_p^2=.047$. However, there was a trending significant interaction of Cyberball and Sleep Quality on change in positive emotions, $F(1, 30)=3.113$, $p=.088$, $\eta_p^2=.094$. Upon further exploration of this interaction, it was revealed that Cyberball had a trending significant simple main effect among those who endorsed bad sleep. Specifically, individuals with poor sleep in the exclusion condition (M= -1.63, SE= .77) experienced a decrease in positive emotions, while those with poor sleep in the inclusion condition did not (M= .67, SE= .89), $F(1, 30)=3.82$, $p=.060$, $\eta_p^2=.113$.

Among those who endorsed good sleep, the Cyberball condition did not have an effect (ps≥.215). The trending significant interaction is depicted in Figure 2.

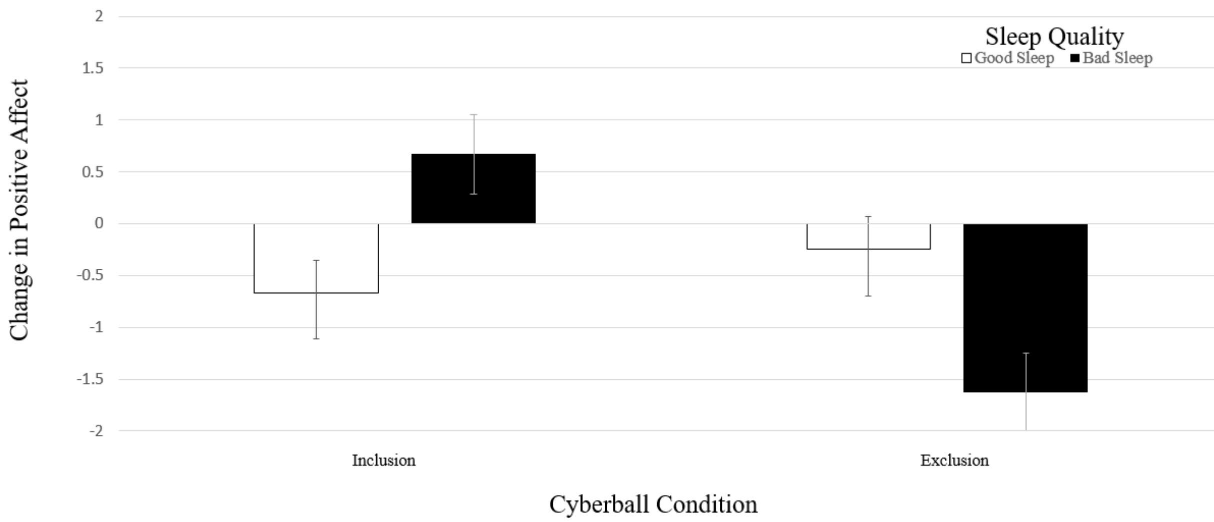


Figure 2. Change in positive affect for Cyberball Condition (Inclusion vs. Exclusion) and Sleep Quality (Good vs. Bad). *Note.* Negative numbers indicate a decrease in positive affect.

Cardiovascular Results

There were no significant changes in cardiovascular measures from baseline to post-stressor. Null results are detailed below for each measure.

Systolic Blood Pressure. A 2 (Cyberball Condition) x 2 (Sleep Quality) ANOVA revealed a non-significant main effect of Sleep Quality on change in systolic blood pressure, F(1, 30)= .048, p= .828, η_p^2= .002, and of Cyberball on change in systolic blood pressure, F(1, 30)= .106, p= .747, η_p^2=.004. There was also a non-significant interaction of Cyberball and Sleep Quality on change in systolic blood pressure, F(1, 30)= .634, p= .432, η_p^2=.021.

Diastolic Blood Pressure. A 2 (Cyberball Condition) x 2 (Sleep Quality) ANOVA revealed a non-significant main effect of Sleep Quality on change in diastolic blood pressure,

$F(1, 30) = .137$, $p = .714$, $\eta_p^2 = .005$, and of Cyberball on change in diastolic blood pressure, $F(1, 30) = .041$, $p = .840$, $\eta_p^2 = .001$. There was also a non-significant interaction of Cyberball and Sleep Quality on change in diastolic blood pressure, $F(1, 30) = .160$, $p = .692$, $\eta_p^2 = .005$.

Heart Rate. A 2 (Cyberball Condition) x 2 (Sleep Quality) ANOVA revealed a non-significant main effect of Sleep Quality on change in heart rate, $F(1, 30) = .602$, $p = .444$, $\eta_p^2 = .020$, and of Cyberball on change in heart rate, $F(1, 30) = 1.174$, $p = .287$, $\eta_p^2 = .038$. There was also a non-significant interaction of Cyberball and Sleep Quality on change in heart rate, $F(1, 30) = 1.305$, $p = .262$, $\eta_p^2 = .042$.

Discussion

This pilot study shows that poor sleep quality is related to a significant increase in negative emotions from baseline to post-stressor among undergraduate women. Specifically, results suggest that those who got poor sleep may have struggled to regulate their emotions after the stressor, and thus experienced a significant increase in negative emotions. In addition, a trending significant interaction between Cyberball condition and Sleep Quality on change in positive affect was detected. Specifically, among the individuals who got good quality sleep, both those who were included and excluded had a decrease in positive emotions. However, among those who got poor quality sleep, the people who were included in the Cyberball game had an increase in positive emotions, while those who were excluded from the game experienced a substantial decrease in positive emotions. Findings among the poor sleep quality group for both positive affect and negative affect may indicate that individuals who do not get good quality sleep experience increased emotional lability. Essentially, this pattern means that getting bad quality sleep may make an individual significantly more sensitive to socially stressful experiences.

These findings are consistent with previous studies that suggest that poor sleep quality is related to increased mood and mental health symptoms (Barnett, 2008; Clement-Carbonell et al., 2021). In one study, participants were asked to complete rumination, positive and negative affect, and sleep quality questionnaires, and the results showed an independent association between poor sleep quality and both rumination and negative mood (Thomsen, Mehlsen, Christensen & Zachariae, 2003). In addition, a study measuring self-reported sleep, positive and negative affect, and subjective happiness showed a strong association between poor sleep and negative affect (Shen, van Schie, Ditchburn, Brook & Bei, 2018). The present results add to the literature by demonstrating a change in both positive and negative affect after a stressful experimental speech task.

The conclusions of the present study - that individuals who get poorer sleep may be more sensitive to stressful stimuli - can be explained by the role of the amygdala in the effects of sleep and emotions. Specifically, the amygdala is known as the emotional center of the brain and plays a role in sleep mechanisms. Sleep deprivation causes the amygdala to have intensified responses to negative stimuli, decreases mood, and causes emotional instability (Saghir, Syeda, Muhammad & Abdalla, 2018). This finding can also be explained through recent studies in which sleep has been described as a natural analgesic, correlating sleep problems with higher pain reactivity in the somatosensory cortex and showing an association between decreased sleep quality and increased experienced pain (Krause, Prather, Wager, Lindquist & Walker, 2019).

Implications

Results of the present study will add to the literature by providing a deeper understanding of the relationship between poor sleep quality and emotional reactivity to stress. This work is important because research shows that sleep-related problems affect 70% of American adults

(CDC, 2009; Philips, 2019). As sleep quality is believed to correlate with reaction times, learning abilities, mood, alertness, hand-eye coordination, and short-term memory (SleepHealth, 2022), research on this topic is crucial for the prevention of health-related problems and provides a better approach for treatment.

These findings also have implications for treatment. Perhaps improving sleep quality would improve emotion regulation in adults. In fact, providing sleep hygiene education is associated with sleep improvements, and may be considered a first-step treatment due to its low cost and wide availability (Chung, Lee, Yeung, Chan, Chung & Lin, 2018). In addition, Cognitive Behavioral Therapy (CBT) has proved to be an effective treatment for insomnia, favored over pharmacotherapy as a long-term treatment (van der Zweerde, Bisdounis, Kyle, Lancee, & van Straten, 2019). Providing these effective interventions could improve sleep and, in turn, reduce stress reactivity.

Limitations

Limitations of this pilot study include a very low sample size, which may influence the reliability of the results presented in this research. In addition, failure to successfully create deception during the Speech task may have impacted the participants' reaction to the stressor, causing a higher or lower change in BP, heart rate, and/or positive and negative affect than in participants who fully believed the study required them to present a speech. Lastly, the modifications presented in this study to the Trier Social Stress Test, which did not require the participants to give a speech, could limit stress reactivity.

Future Directions

For better results, future research is encouraged to recruit a larger sample size. In addition, modifications to the Speech task may provide more successful results, such as setting up a fake zoom meeting with whom the participants will believe are the observers reviewing the speech. Alternatively, following the protocol of the Trier Social Stress Test and having participants give the speech may yield a more accurate stress response.

As stress was primarily measured through a self-reported questionnaire, studying biomarkers of stress such as cortisol and inflammation may lead to a more accurate understanding of stress reactivity. This may be collected through saliva samples, as well as urine or blood samples. Lastly, this research could be extended to understand how stress impacts important functioning. For example, research has shown that stress can have a significant effect on executive functioning (Shields, Bonner, & Moons, 2015; Shields, Sazma, & Yonelinas, 2016). Future studies could use cognitive testing programs such as the Automated Neuropsychological Assessment Metrics-IV (ANAM) and NIH Toolbox to investigate the effects of stress on executive functioning.

Conclusion

Sleep quality has been labeled as critical for human functioning. Research shows that poor sleep quality has been linked to elevated levels of stress (Alotaibi, Alosaimi, Alajlan & Abdulrahman, 2020). Individuals who experience poor quality sleep exhibit a larger effect on stress-reactivity measures. Upon the completion of stress-inducing tasks, such as Cyberball and Speech task, individuals who regularly experience poor quality sleep show an increase in negative emotions from baseline to post-stressor. As poor quality sleep is common amongst many adults, these implications are important to better understand the effects this phenomenon has on human functioning, as well as providing a baseline of symptoms that may be expected to appear in individuals with sleep problems. As studies propose this significant effect, future research is needed to gain greater insight and awareness of these effects.

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APPENDIX A

Study Measures

Right now, to what extent to you feel:

	Not at all				Extremely
Determined	1	2	3	4	5
Attentive	1	2	3	4	5
Alert	1	2	3	4	5
Inspired	1	2	3	4	5
Active	1	2	3	4	5
Afraid	1	2	3	4	5
Nervous	1	2	3	4	5
Upset	1	2	3	4	5
Ashamed	1	2	3	4	5
Hostile	1	2	3	4	5

PANAS

PITTSBURGH SLEEP QUALITY INDEX (PSQI)

INSTRUCTIONS: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, when have you usually gone to bed at night?
   USUAL BED TIME ____________

2. During the past month, how long (in minutes) has it usually take you to fall asleep each night?
   NUMBER OF MINUTES ____________

3. During the past month, when have you usually gotten up in the morning?
   USUAL GETTING UP TIME ____________

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spend in bed.)
   HOURS OF SLEEP PER NIGHT ____________

INSTRUCTIONS: For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
(a) ...cannot get to sleep within 30 minutes	☐	☐	☐	☐
(b) ...wake up in the middle of the night or early morning	☐	☐	☐	☐
(c) ...have to get up to use the bathroom	☐	☐	☐	☐
(d ...cannot breathe comfortably	☐	☐	☐	☐
(e) ...cough or snore loudly	☐	☐	☐	☐
(f) ...feel too cold	☐	☐	☐	☐
(g) ...feel too hot	☐	☐	☐	☐
(h) ...had bad dreams	☐	☐	☐	☐
(i) ...have pain	☐	☐	☐	☐

(j) Other reason(s), please describe

____

____

How often during the past month have you had trouble sleeping because of this?	☐	☐	☐	☐

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	Very good	Fairly good	Fairly bad	very bad
6. During the past month, how would you rate your sleep quality overall?	☐	☐	☐	☐

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
7. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?	☐	☐	☐	☐
8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?	☐	☐	☐	☐

	No problem at all	Only a very slight problem	Somewhat of a problem	A very big problem
9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	☐	☐	☐	☐

	No bed partner or roommate	Partner/ roommate in other room	Partner in same room, but not same bed	Partner in same bed
Do you have a bed partner or roommate?	☐	☐	☐	☐

If you have a roommate or bed partner, ask him/her how often in the past month you have had...

	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
(a) ...loud snoring	☐	☐	☐	☐
(b) ...long pauses between breaths while asleep	☐	☐	☐	☐
(c) ...legs twitching or jerking while you sleep	☐	☐	☐	☐
(d) ...episodes of disorientation or confusion during sleep	☐	☐	☐	☐
(e) Other restlessness while you sleep; please describe	☐	☐	☐	☐

____

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