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Research Article

Sleep Quality, Sleep Efficiency, and Perceived Stress after Synchronous Virtual Mindfulness Meditation Sessions for Higher Education Students

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Abstract

This study examined the effects of virtual mindfulness meditation programming on sleep efficiency using wearable tracking devices, as well as effects on sleep quality and perceived stress in higher education students. A one-group, pretest-posttest design with convenience sampling and rolling recruitment over a six-month period resulted in twenty-five participants who completed the study and were included in data analysis. Paired t-tests were used to determine statistical significance for sleep efficiency measured using the Fitbit Inspire 2, Pittsburgh Sleep Quality Index (PSQI) global score, and Perceived Stress Scale (PSS) total scores. Significance was observed in positive outcomes for sleep quality (p = 0.010) and perceived stress (p = 0.032). Sleep efficiency resulted in no significant change (p = 0.063). The

synchronous virtual program had a positive effect on the sleep quality and perceived stress; however, the use of wearables should be integrated with caution. Higher education students and professionals at higher education institutions may consider non-pharmacological approaches to treating stress and sleep.

Keywords
Mindfulness meditation; sleep efficiency; sleep quality; perceived stress

1. Introduction

Sleep is an essential occupation that optimally contributes to emotional, physical, and mental health, which are crucial in rigorous academic settings [1, 2]. Sleep is often times a fundamental occupation that students will reduce in order to achieve academic success [3]. It is recommended that young adults between 18-25 years old should have at least 7-9 hours of sleep to promote optimal health [4, 5]. However, it was found that more than 60% of higher education students experienced poor sleep quality [6, 7]. The incidence of the lack of sleep and poor sleep quality among higher education students is increasing, resulting in students being twice as vulnerable to experiencing sleep deprivation as compared to the general population [1, 8, 9]. Orzech et al [10] surveyed students' perceptions of sleep and explored factors that affect college students' sleep, and reported a link between poor sleep quality, mental health, and academic performance. Students who reported increased anxiety and depression also scored poorly in self-reported sleep quality, as measured by the Pittsburgh Sleep Quality Index (PSQI) global score. Mindfulness meditation is an approach used to address mental health issues such as anxiety, stress, and depression among higher education students. A systematic review found that mindfulness-based intervention (MBI) significantly benefits students, especially in addressing mental health issues. MBIs are effective regardless of the length of interventions in higher education settings [11]. The effect of eight sessions of synchronous telehealth mindfulness meditation on sleep quality and perceived stress in higher-education students resulted in significant findings in both outcomes. However, it was noted that the study was limited by only utilising self-reported assessments and would benefit from an objective measurement, such as actigraphy, to record sleep time and quality [12, 13]. Similarly, Chiodelli et al [11], concluded an overall lack of physiological outcome measures in previous studies on MBIs.

To track sleep through objective-based devices such as actigraphy, wearable devices such as the Fitbit and the Garmin Vivofit2 have good reliability and accuracy in sleep detection, and the Fitbit Charge HR has shown to be a valid measure when compared to polysomnography recordings, a gold standard technique to measure sleep [12, 14]. Moreno-Pino et al [15] reported acceptable sensitivity but poor specificity with obstructive sleep apnea patients to use the Fitbit for sleep tracking. Fitbit devices overestimated total sleep time and underestimated wake after sleep onset and sleep onset latency and may have insufficient accuracy in clinical settings to assess sleep. In addition to integrating physiological measures in studies on MBIs, and as the transition from in-person to virtual interventions continues to shift, online-based sleep interventions with higher education students should continue to be examined, as many interventions occur online in

academic settings [11]. As such, this study is a follow-up examination of a modified IRB of a previously conducted study done by Benham et al. [16], updated to examine the effectiveness of a mindfulness meditation program on sleep efficiency utilising actigraphy, in addition to the outcomes of sleep quality and perceived stress. The research questions include: After eight sessions of virtual mindfulness meditation practice, is there a change in sleep efficiency as tracked by the Fitbit Inspire 2™ and sleep quality as measured by the PSQI for higher education students? Additionally, after the completion of the sessions, is there a change in perceived stress as measured by the Perceived Stress Scale (PSS) for higher education students?

2. Materials and Methods

2.1 Participants

Participants were recruited through non-probability convenience sampling over six months at a small private university. The inclusion criteria for the study were full-time or part-time students, age of 18 years or older, owning a smartphone, access to a computer with an internet connection, and English-speaking. University of the Sciences Institutional Review Board (IRB) approved the study (ID # *1519081-4)*, and the study was prospectively registered on Clinicaltrails.gov (**NCT05253092**). Informed Consent was obtained from all subjects before enrollment and engaging is study procedures.

2.2 Measures

Demographic characteristic information was collected via a questionnaire form.

2.2.1 Sleep Quality

Sleep quality was measured with the PSQI, which is a self-reported, standardized measurement designed to assess perceived sleep quality. It uses 19 self-rated questions divided into seven components of sleep quality and is reported as a composite as the global score. The global score ranges from 0-21; a score > 5 is interpreted as “poor” sleep quality [17].

2.2.2 Perceived Stress

Perceived stress was assessed using the PSS, a self-reported measure designed to evaluate stress in both young and older adults within the past month. The PSS consists of ten self-report questions, answered using a 5-point Likert scale. The total score of the PSS can range from 0 to 40, and higher scores indicate higher stress [18].

2.2.3 Sleep Efficiency

The Fitbit Inspire 2™ was used to collect sleep efficiency (SE) data objectively; SE was calculated by dividing the total sleep time (TST) by the total time in bed (TIB) [13, 19]. Pretest data were collected and calculated as the average of five weeknights (Sunday-Thursday) of the week~~,~~ to account for the more consistent weekday routines of younger adults. A study was conducted to monitor overall sleep activity and evaluate Fitbit Inspire 2™ performance and effectiveness through comparison with polysomnography (PSG). The results showed significant differences in the total

sleep time (TS), deep sleep, and rapid eye motion (REM) between Fitbit Inspire 2™ and PSG. TST, deep sleep, and REM were overestimated in Fitbit Inspire 2. However, Fitbit Inspire 2™ has a high sensitivity (93.9%) and low specificity (13.1%), with an accuracy of 76%. Based on the results, Fitbit Inspire 2™ is possible to use as an objective sleep to monitor sleep in daily life [20].

2.3 Procedure

The design was a one-group pretest to posttest (i.e., repeated measures) study. Participants were recruited via email through various student organizations, posting of flyers around the campus, and through the university's various social media accounts. Participants who met the inclusion criteria and signed the consent form then completed the pretest measures in person, which consisted of the demographic questionnaire, the PSQI, and the PSS. Participants also received the Fitbit Inspire 2™ devices and education on device utilization. After the pretest, five consecutive weeknights (Sunday to Thursday) of baseline data were collected on sleep efficiency through Fitbit tracking for each participant. Once baseline data was collected, the mindfulness meditation intervention sessions began, and the eight mindfulness meditation sessions were completed within three to four weeks. Each participant was required to attend at least three sessions per week to complete eight sessions within the allotted time frame. All participants completed the study within the timeframe, no participants completed more than three sessions per week. In instances of unforeseen scheduling conflicts, if participants completed less than three sessions per week, the time frame was extended into an additional week to make up the sessions to a total of eight attendance sessions to complete the study. The variation in schedule was influenced by participants' busy academic and personal schedules. Each telehealth mindfulness meditation session was conducted over Zoom (Zoom Video Communications, Inc., https://zoom.us) and lasted for 30 minutes, allowing five minutes for an introduction to the session, 15 minutes of mindfulness meditation, and 10 minutes of discussion. The number of participants in each session varied from one person in a session to multiple people (more than one person). Guided mindfulness meditation was used, and the same two scripts were alternated between each session. The mindfulness meditation scripts were standard scripts that were available online and modified for the session [21-23].

The meditation session was conducted by same two researchers who were trained in the instruction of guided mindfulness meditation sessions before conducting actual intervention sessions. The two researchers were trained by a certified yoga instructor and a faculty trained in mindfulness education. The researchers' training focused on delivering methods such as speed and tone. During the meditation portion of the session, participants were asked to mute their microphones and given the option to turn off their cameras. During the discussion session, participants were provided with resources such as meditation apps, sleep hygiene, and education on how to incorporate meditation into their daily practice. At the completion of the eight mindfulness meditation sessions, posttests were conducted in person (PSQI and PSS). Participants were instructed to wear the Fitbit for the duration of the study. The posttest sleep efficiency data were collected and calculated as the average of the last five weeknights of collected data of the intervention phase.

3. Results

3.1 Analysis

A priori power analysis estimated the sample size required for our study based on predetermined Type I error and Type II error rates of a significance level set at 0.05 and power at 80%. Based on the previous examination of mindfulness meditation and a reported effect size of 0.6 [24], the power analysis revealed that enrolling 24 participants would be necessary to detect significance (G*Power 3.1). To account for an estimated 20% attrition rate and potential issues with lost data through actigraphy, which could be as high as 19-28% of data lost, the researchers aimed to recruit 30 participants [25, 26].

Data analysis was performed using the IBM SPSS package (SPSS Version 26.0; IBM Corp., Armonk, NY). Descriptive statistics were used to report participants' demographics. The within-group analyses met the assumptions of normality; therefore, the paired t-test was used with significance set at 5% for all outcome measures.

3.2 Outcomes

A total of 30 students enrolled and participated in the study. All participants completed the eight sessions, and of these, five were excluded from the final data analysis due to missing or incomplete data. The mean age of students (n = 25) were 21.0 ± 1.6 years old, being mostly female (76.0%), and representing races of Asian (n = 14, 56.0%), White (32.0%), Black (8.0%), and Native Hawaiian or Other Pacific Islander (4.0%). Students mostly lived in off-campus housing (66.7%) and were undergraduate (48.0%) and graduate-level students (52.0%). All participants were full time students, and either part-time employed (86.7%) or not currently employed (13.3%) (see Table 1).

Table 1 Demographics (n = 25).

Characteristic	n (%)
Gender	
Female	19 (76.0%)
Male	6 (24.0%)
Race	
Asian	14 (56.0%)
Black or African American	2 (8.0%)
Native Hawaiian or Other Pacific Islander	1 (4.0%)
White	8 (32.0%)
Academic Year	
Undergraduate	12 (48.0%)
Graduate	13 (52.0%)
Enrolment Status	
Full Time	15 (100.0%)
Part Time	0 (0.0%)
Housing Location	
On-Campus	5 (33.3%)

Off-Campus	10 (66.7%)
Student Athlete	
Yes	0 (0.00%)
No	15 (100.00%)
Honors Program	
Yes	2 (13.3%)
No	13 (86.7%)
Employment Status	
Full Time	0 (0.00%)
Part Time	13 (86.7%)
Not Employed	2 (13.3%)

The PSQI pretest and posttest results revealed decreases in the global mean score, as paired t-test indicated significance, t (24) = 2.84, p = 0.010 (see Table 2), indicating improvements in sleep quality. However, the sleep efficiency changes were not significant from pretest to posttest as collected through Fitbit sleep tracking t (24) = 1.85, p = 0.063. To address the secondary research question, the PSS pretest and posttest scores were analyzed, with a statistically significant decrease in perceived stress, t (24) = 2.28, p = 0.032. Figure 1 illustrates the results of the three outcome measures.

Table 2 Pretest-Posttest Comparison of Outcome Measures (n = 25).

Measures	Pretest *M* ± SD	Posttest *M* ± SD	Difference *M* ± SD	*t* (24)	*p*
PSQI Global Score	8.36 ± 3.17	6.72 ± 1.62	-1.64 ± 2.91*	2.84	0.010**
Sleep Efficiency	0.882 ± 0.027	0.871 ± 0.014	-0.011 ± 0.027	1.85	0.063
PSS	19.88 ± 7.36	16.48 ± 5.21	-3.20 ± 7.01*	2.28	0.032**

Note: PSQI= Pittsburgh Sleep Quality Index, PSS= Perceived Stress Scale. *decreases in PSQI and PSS scores indicate improvements in outcomes; **$p \leq 0.05$.

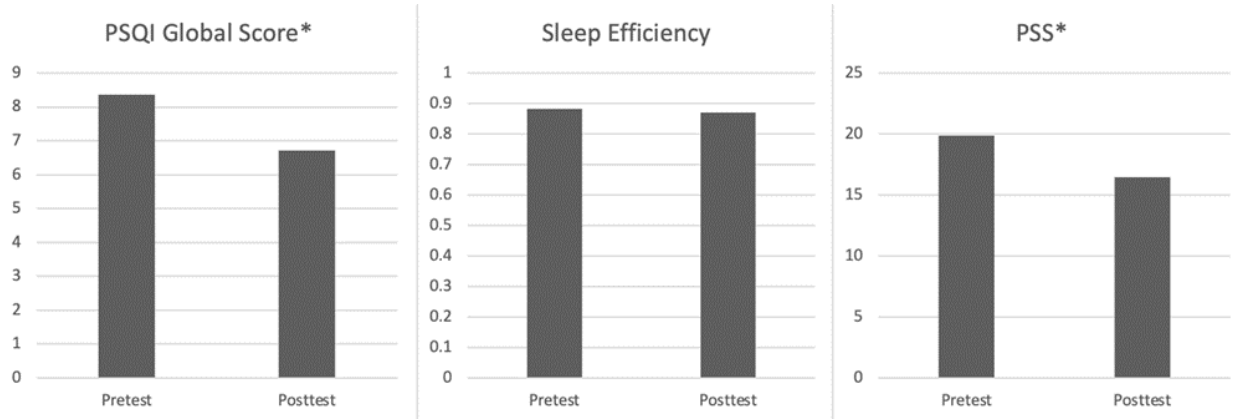

Figure 1 Visual Representations of Mean Score Comparisons of Outcome Measures (n = 25). *Note:* PSQI = Pittsburgh Sleep Quality Index, PSS = Perceived Stress Scale. *decreases in PSQI and PSS scores indicate improvements in outcomes.

4. Discussion

This study aimed to examine the effects of mindfulness meditation on sleep quality, sleep efficiency, and perceived stress levels among higher education students. The results showed significant changes in PSQI global scores and PSS scores after synchronous virtual mindfulness meditation, indicating improvement in sleep quality and perceived stress. The findings from the current study align with previous studies that reported that synchronous virtual mindfulness meditation sessions may improve sleep quality and perceived stress among students [18]. Other studies with higher education students also indicated that mindfulness meditation improves overall sleep quality and reduces stress levels [27, 28].

The current study did not show significant improvement in sleep efficiency. The timeline of the study might have influenced the results as well as rolling recruitment, with some participants finishing the study while the final exam academic workload was high. Measures of SE may lack consistency, as SE is influenced by psychosocial issues, especially self-reported evaluation of SE with working women. Overcommitment to work, poor social support, and depressive symptoms may be negatively associated with self-reported SE [29]. Another possibility for the discrepancy between subjective and objective sleep outcomes for this study could be that participants had difficulty accurately recalling the time to fall asleep and the total amount of sleep on PSQI. A study by Hughes et al [30] found a discrepancy between subjective and objective sleep assessments results. Participants overestimated SE or reported worse SE on a subjective measure. Similar findings were also seen in females with posttraumatic stress disorder, where participants reported elevated sleep problems in subjective assessments [31].

5. Limitations

There were several limitations to the study; using non-probability convenience sampling did not accurately represent the population of higher education students as the participants were primarily female and of Asian descent. The results of this study reveal promising outcomes in sleep quality and perceived stress but no significant change in SE using wearable tracker actigraphy. The finding of this study may be due to participants over-estimating their total sleep time on the subjective measure, as reported by previous studies. Lastly, the absence of a control group is a limitation of this study. The plan was to run the study as a pilot study to explore the effectiveness of mindfulness meditation on sleep and stress using subjective and objective measures. Therefore, the one-group pretest to posttest design was chosen to explore the benefit of using the Fitbit Inspire 2^{TM} for future planning, such as submission for future grants and a research protocol with a control group.

Future studies should focus on accurately assessing sleep in higher education students, as there are limited reports in this area. Furthermore, it would be beneficial to increase the study's timeline to allow two weeks of baseline data collection and allow participants to complete eight sessions over an extended time. Lastly, a control group will allow the results to be reliably attributed to the intervention. These changes may amplify the mindfulness meditation program's effectiveness and depict more accurate sleep data.

6. Conclusions

Although the study focuses on higher education students, everyone may be affected by poor sleep quality and stress. Lack of sleep and consistent high-stress levels can potentially create a cycle of poor physical, emotional, and mental health. These factors affect an individual's participation and performance in daily activities. Examining integrative and complementary medicine-based interventions, such as mindfulness meditation, allow for new ways to address sleep problems and stress management. According to the results, a telehealth mindfulness meditation program has the potential to positively impact the sleep quality and perceived stress of higher education students. Completing the program virtually ultimately aids in the feasibility and flexibility of the mindfulness meditation program, which allows for a broader population to benefit from its positive effects.

The study adds to the current literature by demonstrating that virtual mindfulness meditation sessions reduce stress and improve sleep quality. The study also shows the need for further studies in the area of objective measurement for sleep.

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Author Contributions

The authors confirm contribution to the paper as follows: Nabila Enam study implementation and data collection; Sara Benham and Nancy Green data analysis and interpretation; Nabila Enam, Sara Benham, and Nancy Green manuscripts preparation. All authors reviewed and approved the final version on the manuscript.

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Competing Interests

The authors have declared that no competing interests exist.

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