

# Sleep Quality as a Mediator Between Technology-Related Sleep Quality, Depression, and Anxiety

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## Abstract

This study examines (a) relations among technology use during sleep time, sleep quality, and depression/anxiety and (b) time awake due to technology use. Two hundred thirty-six college students completed self-report questionnaires and week-long sleep diaries. Results revealed that 47 percent of students reported night-time waking to answer text messages and 40 percent to answer phone calls. Regression analyses indicated that higher levels of technology use after the onset of sleep predicted poorer sleep quality, and poorer sleep quality predicted symptoms of depression/anxiety. Finally, sleep quality is a mediator between technology use after the onset of sleep and depression/anxiety. College students who have difficulty setting boundaries around technology use may be at increased risk for psychological health concerns.

## Introduction

COLLEGE STUDENTS ARE recognized by many as a group particularly vulnerable to sleep difficulties<sup>1</sup> that can cause significant impairments such as difficulty maintaining attention, poor performance on tasks, and mood dysregulation.<sup>2,3</sup> Reasons for sleep problems include increased academic demands, procrastination, disruptive living conditions, and not wanting to miss important social developments.<sup>4</sup> Most often, these social developments are communicated through the use of technology (i.e., texts and phone calls).<sup>5</sup> Although technology use among adolescents appears to have reached a plateau,<sup>6</sup> technology use continues to be identified as an important variable that impacts sleep quality and quantity.<sup>7</sup>

With the portability of cell phones, teens rely heavily on their phones and may not be forming appropriate boundaries around usage. For instance, the National Sleep Foundation Sleep in America 2011 Task Force found that 50 percent of teenagers use their cell phones and the Internet 1 hour before sleep. Moreover, excessive use of computers and mobile devices in the bedroom delays bedtimes and rise times.<sup>8,9</sup> Adolescents with four or more technological devices in their room had significantly less sleep on school nights and weekends than those with three or fewer devices.<sup>10</sup> As early as 2003, Van Den Bulck found that up to 1/3 of adolescents woke up from a text at least one time per month, with this trend increasing with age.<sup>11</sup> There is also evidence that heavy Facebook<sup>®</sup> use leads to a postponement in bedtime and rise times.<sup>12</sup> Equally alarming is that 20 percent of teenagers are awakened by their cell phones after they fall asleep.<sup>13</sup>

## *Sleep quantity and quality in college students*

Although most professionals recommend that college students get 9¼ hours of sleep per night,<sup>14</sup> on average students spend between 7 and 8 hours sleeping per night.<sup>1,15,16</sup> Of more concern, Lund et al.<sup>15</sup> found that 25 percent of students reported <6.5 hours of sleep per night, and only 29 percent of students reported receiving eight or more total hours of sleep per night. Sleep habits in college students are also very erratic, with weekday and weeknight schedules constantly shifting to meet the demands of college life.<sup>15</sup> Further, students who use mobile devices and social networking sites to maintain former relationships and foster new relationships in college may be at increased risk for sleep problems due to behavioral mechanisms, such as disruptions in sleep hygiene behaviors,<sup>8</sup> and biological mechanisms. Bright lights and active forms of technology increase physiological arousal and suppress melatonin production, therefore delaying sleep onset.<sup>13,17</sup>

In addition to sleep deprivation, college students are also at risk for poorer sleep quality. As many as 89 percent of students experienced sleep problems ranging from occasional to chronic.<sup>18</sup> In 2011, the American College Health Association National College Health Assessment (ACHA-NCHA) reported that 25 percent of college students reported sleep problems that were difficult to handle. This finding is paralleled by results from a random sample of 859 college students, where 77 percent of participants reported occasional sleep problems, and 12 percent reported chronically poor sleep quality.<sup>19</sup> Similarly, Buboltz et al. reported that up to 30 percent of college-aged women experienced insomnia,<sup>1</sup>

which is consistent with the National Sleep Foundation's report that ~40 percent of American adults experience chronic symptoms of insomnia.<sup>14</sup>

### *Sleep, depression, and anxiety: emerging associations with technology use*

It is well documented that poor sleep quality is related to higher levels of depression.<sup>20,21</sup> According to the ACHA-NCHA,<sup>22</sup> 12 percent of students reported experiencing depression during their college years. Even more college students (19 percent) have been diagnosed with anxiety disorders during their college years.<sup>23</sup> Individuals who are depressed and anxious often experience decreased sleep quantity due to symptoms of insomnia (i.e., an inability to fall asleep and stay asleep), as well as earlier wake times.<sup>24</sup> Depression also makes it difficult for individuals to rise in the morning, and they experience poorer overall sleep quality.<sup>25,26</sup> Conversely, difficulty initiating and maintaining sleep and poor overall sleep quality have been shown to increase depressive symptoms in college-aged students and adolescents,<sup>26</sup> but has been inconsistently linked to anxiety. Overall, the literature suggests that the association between sleep, depression, and anxiety is complex, whereas the relation between sleep and depression may be bidirectional in nature, and the association between sleep and anxiety may be unidirectional.

Technology use, sleep, and symptoms of anxiety and depression are emerging as important correlates, particularly in the addiction literature (e.g., Andreassen et al.<sup>12</sup>; White et al.<sup>27</sup>). Jenaro et al.<sup>28</sup> reported that pathological Internet and cell phone use in college students was associated with high anxiety. High cell phone use was associated with insomnia, with women faring worse than men.<sup>28</sup> Similarly, Thomee et al.<sup>29</sup> reported that a high mobile phone use was associated with symptoms of depression. Overuse of technology was also associated with sleep disturbances for women, and high accessibility has been associated with sleep disturbances and symptoms of depression in both men and women.<sup>29</sup> Further, after controlling for anxiety and depression, the use of computers and mobile technologies in the bedroom has been related to poor sleep habits, but not insomnia.<sup>9</sup> Some researchers believe that depression and anxiety should be controlled for in studies of media use and sleep, given the confounding nature with symptoms of insomnia and poor sleep habits in general.<sup>9</sup> Notwithstanding these methodological concerns, however, poor sleep, depression, and anxiety are inter-related factors that impair students' functioning, causing issues such as missing morning classes and lower grade point average.<sup>2,21,30,31</sup> Therefore, examining the impact of exogenous factors, such as technology use, on college students' experience of depression, anxiety, and sleep remains judicious.

### *The current study*

Although there are clear links between delayed sleep resulting from technology use and depression/anxiety, this study aims to examine technology use after sleep onset and its associations with sleep quality, depression, and anxiety. We will use multiple methods (i.e., self-report sleep diaries and survey data) to identify sleep patterns in a college student population. The goals of this pilot study are to (a) explore the frequency and duration of technology use during sleep due to texting and phone use, and to (b) test the hypothesis that sleep

quality is a mediator between technology use and psychological functioning (i.e., depression/anxiety) (Fig. 1).

## Methods

### *Design and participants*

Data were collected from 236 junior and senior college students at a midsize northeastern university between 2008 and 2010. The majority of the sample was comprised of women, with a mean age of 22.13, who identified their race as primarily White. A breakdown of demographic information is presented in Table 1. Participants were recruited from the principal investigator's courses. Students first completed a weeklong sleep diary as a part of a class assignment to assess sleep habits. Participants then completed a 20-minute questionnaire packet assessing primary study variables. Participation was voluntary, and all participants earned extra credit toward an exam. An alternative assignment was offered. This study strictly followed all protocols approved by the University's Institutional Review Board.

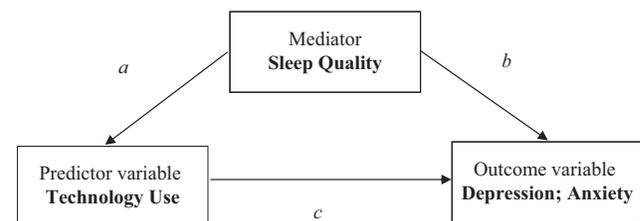
### *Measures*

In addition to a demographic questionnaire, the following questionnaires were used to assess primary study variables.

**Sleep quality.** The Pittsburgh Sleep Quality Index (PSQI)<sup>32</sup> is a 19-item self-report measure that assesses quality of sleep and sleep disturbances during the past month. While the total score on the PSQI ranges from 0 to 21, scores greater than five are suggestive of significant sleep disturbances. In healthy controls, this measure has good internal consistency ( $\alpha=0.83$ ). The seven-component score of the PSQI in this sample was acceptable ( $\alpha=0.72$ ).

**Sleep diary.** A 7-day, self-report sleep diary was used to assess students' sleep habits over the course of a week. Students were instructed to complete the sleep diary in the morning about the night prior. The sleep diary asked for information such as bedtime, time taken to fall asleep, wake time, the number of times they answered their cellular phones due to calls or texts after they fell asleep, and the amount of time they were awake after each technological occurrence.

**Depression.** Depressive symptoms were measured using the Beck Depression Inventory-II (BDI-II). The BDI-II is comprised of 21 items scored on a 4-point Likert scale of 0–3.<sup>33</sup> Scores on the BDI-II range from 0 to 63 and indicate varying levels of depression: 0–13 minimal, 14–19 mild, 20–28 moderate, and 29–63 severe. The BDI-II has high internal



**FIG. 1.** Sleep quality as a mediator between technology use and depression.

TABLE 1. DEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS (N=236)

Variable	% of sample	Mean	SD	Range
Age		22.13	4.24	19–50
Gender				
Female	80% (n=185)			
Male	20% (n=47)			
	Did not report sex (n=4)			
Race/ethnicity	79.7% White, 8.9% Black/African American, 3.8% Hispanic/Latino, 2.5% Other, 2.1% Asian, 1.7% Multiracial, 0.8% American Indian/Alaska Native, 0.4% Native Hawaiian or Pacific Islander			
Living arrangement	55% off campus, 19% living with family/parents, 16% dormitory, 5% Greek housing, 5% other living arrangement			
Class standing	60.2% senior, 37.7% junior, 1.7% nonmatriculating, 0.4% sophomore			
Sleeping status room	79% sleep alone, 19% 1 person in room, 2% 2 people in 37% slept $\leq 6.5$ hours			
Night-time tech use	46.7% answered texts, 40.2% answered phone			
Wake up (past month)	29.2% once or twice, 28.8% less than once, 27.5% three or more, 14.4% none			

consistency with  $\alpha=0.92$ . Internal consistency for the current sample was  $\alpha=0.87$ .

**Anxiety.** Anxiety was assessed using the Adult Manifest Anxiety Scale (AMAS)-College.<sup>34</sup> This 36-item measure assesses worry/oversensitivity, social concerns/stress, physiological anxiety, and test anxiety in college students. The AMAS has good internal consistency ( $\alpha=0.85$ ). Internal consistency for the current sample was  $\alpha=0.86$ .

## Results

### *Descriptive information: technology use and sleep*

On average, students in our sample experienced significant problems with sleep quality. Twenty-nine percent of students reported that over the past month, they woke up once or twice throughout the night, with an average of 7.03 hours of sleep per night. Thirty-seven percent of students reported that they received  $< 6.5$  hours or less of sleep per night. Students identified that they needed 8.26 hours of sleep to feel rested, thus indicating a discrepancy between the sleep they

are receiving and the sleep they need to feel rested (see Tables 1 and 2).

Forty-seven percent of students reported that they answered text messages after sleep onset, and 40.2 percent answered phone calls after sleep onset over the course of the previous week. For students who reported using technology during sleep, sleep was disrupted for  $\sim 26.99$  minutes throughout the week due to text messaging, and  $\sim 18.89$  minutes due to phone use for a total disruption of 45.88 minutes per week. For the full sample, participants reported that their sleep was disrupted for  $\sim 14.77$  minutes throughout the week due to text messaging, and  $\sim 10.28$  minutes due to phone use for a total disruption of 25.11 minutes per week (see Tables 1 and 2).

### *Preliminary analyses*

The preliminary analyses included tests for normality and multicollinearity. The group differences between women and men on study variables were tested by analysis of variances. Means, standard deviations, skewness, and kurtosis are presented in Table 2. Histograms were used to examine the

TABLE 2. MEAN, STANDARD DEVIATION, RANGE, KURTOSIS, AND SKEWNESS OF VARIABLES

Variable	Mean	SD	Range	Kurtosis	Skewness
PSQI	8.84	2.65	3–17	–0.288	0.315
Depression	10.10	7.06	1–35	1.38	1.19
Anxiety	15.36	6.66	0–28	–0.908	–0.009
Hours of sleep	7.03	1.24	0–11	5.93	–0.824
Hours for rested	8.26	1.34	0–13	6.39	–0.981
Time awake-phone (full sample)	10.28	28.67	0–300	48.48	5.87
Time awake-texts (full sample)	14.77	31.99	0–260	22.04	4.13
Total time awake: phone and texts (full sample)	25.11	46.57	0–360	14.73	3.25
Total # texts and phone (full sample)	2.42	3.48	0–24	7.76	2.32
Time awake-phone (tech users)	18.89	36.84	0–300	28.01	4.45
Time awake-texts (tech users)	26.99	39.32	0–260	12.82	3.18
Total time awake: phone and texts (tech users)	45.88	54.95	2–360	9.21	2.53
Total # texts and phone (tech users)	4.31	3.77	0–24	5.95	1.95

PSQI, Pittsburgh Sleep Quality Index.

TABLE 3. INTERCORRELATIONS OF PRIMARY STUDY VARIABLES ( $N=236$ )

	1	2	3	4	5	6	7
1. Age	—	-0.02	0.07	-0.07	-0.04	-0.11	0.15*
2. Gender		—	0.07	0.14*	0.29**	0.001	0.09
3. PSQI			—	0.55**	0.42**	0.19**	0.11
4. Depression				—	0.61**	0.11	0.14*
5. Anxiety					—	0.08	0.11
6. Total awake phone and text						—	0.67**
7. Total # texts and phone							—

\* $p \leq 0.05$ .\*\* $p \leq 0.01$ .

distribution of scores for each variable. Next, issues of multicollinearity were assessed. A correlation matrix was computed to examine the correlations among the study variables in Table 3.

#### Preliminary regression and mediational analyses

To establish mediation, three ordinary least-squares regressions were conducted to examine the relation between (a) technology use during sleep time (texting and phone) and sleep quality, (b) sleep quality and depression, and (c) sleep quality and anxiety. First, after controlling for age and gender, time awake (minutes) due to technology use was significantly associated with poor sleep quality  $\beta=0.010$ ,  $p<0.01$ . Time awake due to technology use, age, and gender explained 4.3 percent proportion of variance in sleep quality,  $F(3, 225)=3.354$ ,  $p<0.01$ . Second, after controlling for age and gender, poor sleep quality significantly predicted depression  $\beta=1.389$ ,  $p<0.001$ . Poor sleep quality, age, and gender explained 29.7 percent of variance in depression,  $F(3, 225)=31.256$ ,  $p<0.001$ . Finally, after controlling for age and gender, poor sleep quality significantly predicted anxiety among college students  $\beta=1.059$ ,  $p<0.001$ . Poor sleep quality, age, and gender explained 25.9 percent of variance in anxiety,  $F(3, 218)=25.026$ ,  $p<0.001$  (see Table 4). Overall, while the relation between technology use and sleep quality was significant, the effect size was small. There were

large effect sizes for the associations between sleep quality, depression, and anxiety.

Two mediation models were conducted to examine sleep quality as a mediator between (a) technology use and depression and (b) technology use and anxiety. Mediation analyses were conducted according to Mackinnon et al.<sup>35</sup> distribution of product method. As predicted, the hypothesis was supported, indicating that sleep quality was a mediator of the relation between technology use and depression,  $\beta=1.526$ ,  $p<0.001$ , and between technology use and anxiety,  $\beta=0.10$ ,  $p<0.001$  (Figs. 2 and 3).

#### Discussion

The purpose of this study was to better understand the impact of technology use after sleep onset on the sleep quality and experience of anxiety and depression in college students. Almost half of the students in this sample reported waking up to answer texts and phone calls. The results of this study also supported the hypotheses that sleep quality acts as a mediator between technology use after sleep onset and depression and anxiety.

#### Sleep disruption due to technology

In a given week, students who used technology after sleep onset reported an average of 46 minutes of time awake due to technology. Students reported answering text messages more

TABLE 4. ORDINARY LEAST-SQUARES REGRESSION ANALYSES ( $N=236$ )

Predictor	SE	$\beta$	t	R <sup>2</sup>	F
Model I: sleep quality				0.043	3.354**
Total awake (phone and text)	0.004	0.010	2.672		
Age	0.040	0.061	1.528		
Gender	0.431	0.514	1.192		
Model II: depression				0.297	31.256***
PSQI	0.149	1.389	9.302		
Age	0.091	-0.165	-1.822		
Gender	0.969	1.748	1.803		
Model III: anxiety				0.259	25.026***
PSQI	0.151	1.059	7.01		
Age	0.103	-0.102	-0.994		
Gender	0.969	4.510	4.655		

\*\* $p < 0.01$ .\*\*\* $p < 0.001$ .

Model I: total awake phone and text as a predictor of sleep quality; dependent variable=Pittsburg Sleep Quality Index.

Model II: sleep quality as a predictor of depression; dependent variable=Beck Depression Inventory.

Model III: sleep quality as a predictor of anxiety; dependent variable=Adult Manifest Anxiety Scale-College.

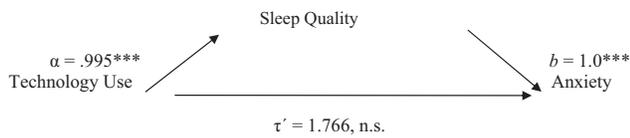


FIG. 2. Sleep quality as a mediator between technology use and anxiety.

often than phone calls after sleep onset, which is in line with texting being a primary mode of communication for most teens. At first glance 46 minutes may not appear to be a significant amount of time; however, on average, students only reported 7 hours of sleep per night. Although this sample reported that on average they needed 8.26 hours of sleep to feel well rested, a typical college student requires  $9\frac{1}{4}$  hours of sleep per night.<sup>14</sup> Two hours of sleep debt per night paired with almost an additional hour of debt per week could be particularly debilitating for a student's performance, placing them at risk for not being able to perform the multiple tasks expected of them as emerging adults.

Our findings also indicated that the time awake due to technology use, rather than the volume of texts and phone calls, predicted sleep impairment. Therefore, it is possible that there could be an emotional component or sleep hygiene issues that delay a person returning back to sleep. Additionally, in our sample, there were students who clearly identified spending a significant amount of time answering their phone and texts after sleep onset, with the highest rate being 300 minutes per week. As supported by other researchers, it is likely that high technology users will experience more overall impairment.<sup>36</sup>

#### The mediating role of sleep quality

Meditational analyses revealed that waking up to answer one's phone predicted lower sleep quality, which in turn predicted both depression and anxiety. With regard to depression, the negative influence of decreased sleep quality on mood has long been established.<sup>23,25</sup> Similarly, findings indicated a large effect size for the relation between sleep quality and depression. Since sleep is an important biological mechanism in mood regulation,<sup>36</sup> students whose sleep is disrupted due to technology use may be more likely to experience markers of depression such as concentration problems, loss of energy, and daytime sleepiness.<sup>37</sup> Individuals who are depressed may also have sleep problems and use the technology to pass the time.

The association between sleep quality and anxiety has garnered less support, although our findings indicated a large effect size between sleep quality and anxiety. The strength of this association, paired with the finding that sleep quality mediated the relation between technology use and anxiety,

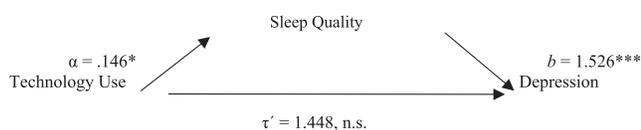


FIG. 3. Sleep quality as a mediator between technology use and depression.

implicates the potential role of technology-related sleep disturbance in anxiety. It is possible that a person who experiences chronic technology-related sleep problems may begin to experience more anxiety about their ability to perform, particularly in college where evaluation in the classroom, sports, and/or social relationships is the norm. Their experience of anxiety may be biological (e.g., due to cortisol levels), as well as psychological (e.g., anticipatory anxiety about sleep).<sup>38</sup> Conversely, students who experience technology-related sleep problems may experience and/or perceive more life stressors. They may feel anxious about missing an important development; thus, answering the phone to decrease their anxiety, which in turn perpetuates anxiety.

#### Limitations

A number of limitations with the current study design should be noted. First, the frequency and duration of time awake due to technology use during sleep time were retrospectively reported the following morning. Future studies should employ objective measures of phone use (e.g., tracking devices) and sleep disruption (e.g., actigraphy). Second, all data collected were self-report, increasing the likelihood of self-report bias. Likewise, there is also a chance that completing the sleep diary increased self-awareness and affected rates and patterns of use. Third, participants were recruited from one course biasing the variety of students who participated in the study. Fourth, although this study proposed that time awake due to technology predicted anxiety and depression, it is likely that a bidirectional association exists. Higher rates of depression are related to sleep disruptions,<sup>37</sup> and people experiencing anxiety may rely on technology as a form of connection to others.<sup>39</sup> The study design prevents us from identifying causal pathways among variables. Finally, the convenience sample, small sample size, and racial homogeneity of the sample limit generalizability to broader populations of college students.

#### Future directions

Future research should examine the specific timing of sleep disruption due to technology use. Researchers should examine if the timing of the sleep disruption (i.e., earlier or later in the sleep cycle) differentially predicts outcomes. Furthermore, since sleep onset delays play a significant role in insufficient sleep and general sleep disturbance,<sup>15</sup> future research should continue to unravel the role of sleep onset delays versus sleep disruption in college students' functioning. In an effort to promote health and wellness, individuals should be encouraged to place boundaries on technology use during sleep.

#### Author Disclosure Statement

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