

The Effects of App-Delivered Cognitive Behavioral Therapy for Insomnia (CBT-I) on Sleep  
Quality, Dysfunctional Beliefs, and Sleep Hygiene

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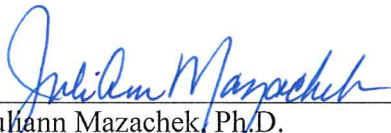
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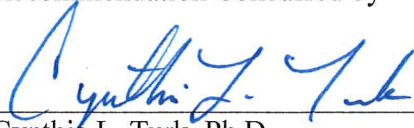
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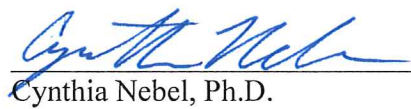
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## Abstract

Sleep quality is correlated with physical and mental health and is an important target for overall well-being. CBT-I is an evidence-based strategy to improve sleep quality; however, shortage of qualified providers, logistical issues such as cost, travel, and time, privacy concerns, and a desire to resolve symptoms on one's own limit access to CBT-I. Compared to traditional face-to-face or web-based delivery of CBT-I, app-delivered CBT-I may be an efficacious alternative capitalizing on the portability, privacy, and accessibility of mobile phones. The present study examined the effectiveness of the CBT-I Coach for educating participants about the importance of healthy sleep practices and dysfunctional beliefs about sleep, and targeted sleep quality among college students. Results indicated use of the CBT-I Coach resulted in significant improvements in sleep quality ( $t(21)=4.38, p<.001, d=0.93$ ), dysfunctional beliefs about sleep ( $t(21)=3.12, p=.001, d=0.66$ ), sleep hygiene behaviors ( $t(21)=3.26, p=.001, d=0.70$ ), and sleep efficiency ( $t(21)=4.93, p<.001, d=1.05$ ). This study provides new evidence that the use of the CBT-I Coach has the potential to be an effective intervention in improving sleep quality in college students.

*Keywords:* sleep, technology, mobile apps, cognitive behavioral therapy for insomnia

The Effects of App-Delivered Cognitive Behavioral Therapy for Insomnia (CBT-I) on Sleep  
Quality, Dysfunctional Beliefs, and Sleep Hygiene

Sleep quality has been well researched and supported as a predictor of physical and mental health (Ohayon et al., 2017). In 2016, The National Sleep Foundation assembled a panel of sleep experts to review and discuss literature to provide an evidence-based set of recommendations regarding indicators of good sleep quality. Across the 277 studies included in the review, shorter sleep onset latencies (time taken to fall asleep), fewer awakenings, and higher sleep efficiency (ratio of time asleep to time in bed) were indicators of good sleep quality across the lifespan (Ohayon et al., 2017). In contrast, poor sleep quality has been linked to impairment in emotion regulation and increases in negative emotions (O’Leary, Small, Panaite, Bylsma, & Rottenberg, 2017). Poor sleep quality is often a sign of chronic sleep difficulties like insomnia (O’Leary et al., 2017).

The essential feature of insomnia is a predominant dissatisfaction with sleep quantity or quality and difficulty initiating or maintaining sleep (American Psychiatric Association, 2013). Insomnia is the most prevalent of all sleep disorders and population estimates indicate about one-third of adults report experiencing symptoms of insomnia (American Psychiatric Association, 2013). Insomnia is often comorbid with, and often predicts the development of, additional psychological and medical conditions, such as chronic pain, diabetes, and various cardiovascular and respiratory disorders (Dikeos & Georgantopoulos, 2011). According to the American Psychiatric Association (2013), 40-50% of individuals that meet diagnostic criteria for insomnia also present with a comorbid mental disorder. There is evidence that sleep disturbances and comorbid psychological and medical diagnoses have a cyclical influence such that sleep problems lead to greater decline in general and psychological health which in turn worsens sleep

problems (Kaplan & Harvey, 2014). It is therefore important to understand the sleep regulation processes and the interventions to mitigate the consequences of insomnia and its effect on overall general and psychological health.

Sleep regulation can be understood as a two-process model in that sleep and wakefulness are dependent on a homeostatic and circadian process (Borbely, 1982). The homeostatic process involves sleep pressure that increases with time spent awake. When there is sleep pressure (e.g. when a person has been deprived of sleep), there will be an increased tendency to sleep and when there is less sleep pressure (e.g. after a person has had substantial sleep), there is a decreased tendency to sleep (Borbely, 1982; Kaplan & Harvey, 2014). The circadian system works as an internal clock that regulates sleep-wake patterns in conjunction with cues from the environment and is responsible for changes in melatonin, temperature, and alertness throughout the day (Kaplan & Harvey, 2014; Sunnhed & Jansson-Fröjmark, 2015). The two processes work together such that when sleep pressure is high and circadian arousal is low, sleep is likely to occur (Borbely, 1982; Kaplan & Harvey, 2014). When the two processes are out of sync, sleep difficulties develop and are maintained through the imbalance of systems.

The circadian system can be impacted by different variables such as light, sound, temperature, alcohol and other substances, and behavioral factors (Mukherjee et al., 2015). Behaviors that support a normal circadian rhythm are labeled “behavioral sleep hygiene” and are classified into five main categories: sleep scheduling, restricted substance use (including caffeine), behaviors that promote relaxation near bedtime, utilizing the bedroom only for sleep, and maintaining a comfortable environment conducive to sleep. There is no evidence that poor sleep hygiene causes sleep disorders. Rather, poor sleep hygiene is best described as contributing to or exacerbating existing sleep disturbances (Stepanski & Wyatt, 2003).

Interventions for sleep difficulties are varied in approach and may include any combination of medical interventions (e.g. hypnotics, benzodiazepines, antihistamines, antidepressants, melatonin), complementary therapeutic practices (e.g. supplements, acupuncture, meditation, aromatherapy), and psychological interventions (Mitchell & Weinshenker, 2010; Proctor & Bianchi, 2012). Psychological interventions involve targeting both behavioral and cognitive components of sleep disturbance. Behavioral components involve *sleep restriction, stimulus control, and sleep scheduling*. *Sleep restriction* utilizes sleep efficiency (ratio of time in bed to time asleep) to aid in strengthening the relationship between bed and time asleep. In other words, total time in bed should be reduced in that time in bed should be closely equivalent with the amount of time an individual estimates he/she spends sleeping (Kaplan & Harvey, 2014). The goal of *stimulus control* is to reestablish or strengthen the relationship between sleep and the conditions under which sleep typically occurs. Stimulus control involves recommendations such as only going to bed when sleepy, getting out of bed if sleep onset is delayed more than 20 minutes, keeping the bedroom for sleep, and discouraging napping (Kaplan & Harvey, 2014). *Sleep scheduling* refers to keeping regular routines to maintain the balance between the homeostatic and circadian processes. In sleep scheduling, it is important to have a wind-down routine that promotes relaxation before bed, a wake-up routine that promotes circadian arousal, and regularity in sleep and wake times (Kaplan & Harvey, 2014).

The cognitive components of sleep disturbance are *worry, attention and monitoring, harboring unhelpful beliefs about sleep*, and using *safety behaviors*. *Worry* is an important target for intervention in that it disrupts the circadian and homeostatic balance through activation of the sympathetic nervous system which hinders healthy sleep onset (Kaplan & Harvey, 2014).

Individuals with sleep disturbances who worry often cope in an unhelpful way such as attempting to suppress worries and ruminating on “why” questions (e.g. “Why am I having such a difficult time sleeping?”). Individuals with insomnia will often have difficulties with *attention and monitoring* such that they may become more anxious about their sleep, may overestimate time spent awake at night, and may have increased hypervigilance towards their own sleep state. The anxiety, overestimations, and hypervigilance lead to monitoring the fatigue during the day, listening closely for sounds and disruptions at night, monitoring for physical appearance changes (e.g. dark circles under eyes), and an increased focus on the clock (Kaplan & Harvey, 2014).

Additionally, *unhelpful beliefs about sleep* can promote problematic sleep behaviors (e.g. watching TV to aid sleep onset), lead to changes in daytime routine (e.g. cancelling activities because of poor sleep), and feelings of hopelessness (Eidelman, Talbot, Ivers, Belanger, Morin, & Harvey, 2016). In order to address these feelings, people often engage in safety behaviors. *Safety behaviors* are actions taken to avoid a feared outcome (e.g. using a sound machine to sleep with the belief that without it, sleep is not possible). Safety behaviors are problematic in that they prevent new learning from occurring and may increase the chance that the feared outcome will happen if there is a disruption in the safety behavior. Unhelpful beliefs and attitudes about sleep have been found to play an integral part in the maintenance of sleep difficulties as these thoughts are believed to promote pre-sleep arousal and result in frequent and longer nighttime awakenings (Kaplan & Harvey, 2014).

Cognitive Behavioral Therapy for Insomnia (CBT-I) is a psychological treatment comprised of sleep hygiene strategies including stimulus control, relaxation, and cognitive restructuring of dysfunctional beliefs about sleep. CBT-I posits that maladaptive beliefs about sleep are critical targets in treatment to promote corrective learning and long-term benefits

(Kaplan & Harvey, 2014). A randomized control trial conducted by Eidelman et al. (2016) found that individuals who participated in CBT had a significant decrease in dysfunctional beliefs about sleep and had reduced insomnia symptoms and impairment at both post-treatment and follow-ups when compared to behavioral therapy and cognitive therapy alone. A meta-analysis conducted by Geiger-Brown et al. (2015) found that, in the presence of comorbid diagnoses, CBT-I improved subjective sleep quality post-treatment and overall there was a significant reduction in sleep onset latency, an improvement in total sleep time, and a 9% increase in sleep efficiency. Treatment effects were stable at follow-ups.

However, there are several factors that limit access to traditional CBT-I including shortage of qualified providers, logistical issues such as cost, travel, and time, privacy concerns, and a desire to resolve symptoms on one's own (Manber, Simpson, & Bootzin, 2015; Miner, Kuhn, Hoffman, Owen, Ruzek, & Taylor, 2016). These limitations have led to a call for ways to increase access to treatment while still retaining effectiveness (Manber et al., 2015). Researchers have emphasized the need to disseminate CBT-I in ways other than the traditional face-to-face individual therapy sessions (Blom et al., 2015).

Compared with traditional face-to-face delivery of psychological care, technology offers possible solutions to expand access to mental health services (Miner et al., 2016). Technology can enable access to empirically supported psychoeducational information and self-management tools with little to no professional involvement in the treatment of sleep difficulties (Miner et al., 2016). Furthermore, there is evidence that technology-based interventions for insomnia are efficacious when compared to traditional care and control groups. Blom et al. (2015) compared group therapy for insomnia to internet-delivered CBT-I and found that both treatments significantly decreased insomnia severity with large effect sizes. Kaldo et al. (2015) compared



therapist-guided internet-delivered CBT-I and an active internet-delivered control treatment and found that the CBT-I condition reduced sleep difficulties and improved sleep at the close of the study and at follow-up.

While internet-delivered treatments have demonstrated efficacy, there are still factors that limit access to treatment that internet-delivered treatments do not fully address. Internet-delivered treatments involve contact with a licensed provider and have comparable structure and treatment length to traditional face-to-face CBT-I (Blom et al., 2015; Manber et al., 2015; Miner et al., 2016). Interventions involving smart phones, including mobile apps, are readily accessible as smartphone usage has steadily increased with over three-quarters (77%) of American adults currently owning smartphones, an increase from 64% in 2015 (Pew Research, 2017). Of the age cohorts surveyed, young adults between the ages of 18-29 accounted for the largest share of smartphone ownership, reporting that 94% own a smartphone (Pew Research, 2018).

App-delivered CBT could potentially exceed the advantages of internet-delivered treatment because mobile phones are portable, private, and usually with the person at all times (Horsch et al., 2017). Furthermore, app-delivered interventions have the potential to be less structured, less time intensive, and have reduced to no professional contact while still maintaining effectiveness. There is evidence that app-delivered interventions are both feasible and efficacious. In a pilot study conducted by Babson, Ramo, Baldini, Vandrey, and Bonn-Miller (2015) the CBT-I Coach app was used as an intervention for Veterans with cannabis use disorders and sleep difficulties. The study included four participants, two of which used the CBT-I Coach app and two with a placebo control application which tracked mood. The intervention period was two weeks long, after which, participants who used the CBT-I Coach app reported both a decrease in cannabis use and improvements in sleep (Babson et al., 2015). Of

the two participants in the control group, one dropped out of the study and the other reported minimal app use and increased cannabis use.

One of the first randomized controlled trials investigating app-delivered CBT-I was conducted by Horsch and colleagues in 2017. CBT-I was delivered using the Sleepcare mobile app over a six-week period. A total of 151 individuals participated in the study and were randomly assigned to the app-condition or the waitlist condition. The Sleepcare app contained a sleep diary, a relaxation exercise, a sleep restriction component, a psychoeducational component that outlined sleep tips and facts, and sent reminders for participants to engage in the prescribed weekly exercises. The app was a standalone intervention which did not include contact with a licensed professional. At the close of the study, researchers found that participants in the treatment condition showed a significant decrease in insomnia severity and notable improvements in sleep efficiency when compared to the waitlist condition (Horsch et al., 2017). The improvements in symptom severity and sleep quality were found to be maintained at the 3-month follow-up.

The limitations of previous research on technology-delivered interventions call for new research to examine the efficacy of app-delivered CBT-I. Babson et al. (2015) found that participants had positive attitudes toward the app and that participants did endorse sleep improvements, additional evaluation of app-delivered intervention is needed to address sampling, generalizability of findings, and to evaluate the feasibility and efficacy with participants whose main difficulty is sleep disturbance. Similarly, the research completed by Horsch et al. (2017) found significant improvements in sleep components in the participants in the treatment condition when compared to the waitlist condition but they observed no change in dysfunctional beliefs about sleep, a major component in the maintenance of sleep disturbance according to the

theoretical basis of CBT-I (Kaplan & Harvey, 2014), due to the Sleepcare app having no clear cognitive component or stimulus control exercise (Horsch et al., 2017). Although internet-based interventions for insomnia have been shown to reduce insomnia symptoms (Blom et al., 2015; Kaldo et al., 2015) and evidence suggests that smartphone apps can improve insomnia, PTSD, depression, and anxiety symptoms (Donker, Petrie, Proudfoot, Clarke, Birch, & Christensen, 2013; Horsch et al., 2017; Miner et al., 2016), there is a need for further investigation into the effect of mobile app-delivered CBT-I in a non-clinical population.

The relationship between quality of sleep and quality of academic achievement, emotional well-being, and health has been well demonstrated in importance, and college age is a critical period for shaping sleep attitudes and behaviors to make lasting impressions into adulthood (Kloss, Nash, Walsh, Culnan, & Horsey, 2016). College students are an ideal cohort to educate and intervene with in the area of sleep because they are an at-risk population to sleep disorders and other negative effects of poor sleep (Kloss et al., 2016). The *2011 Sleep in America Poll* by the National Sleep Foundation reported that young adults, ages 19-29 years, frequently reported sleep disturbances and were identified as one of the populations most at risk for developing sleep disorders. Furthermore, 67% of the young adults polled claimed they were not getting enough sleep to function properly and most reported at least some impact on mood, school performance, family or home responsibilities, work, social life, and/or intimate relationships. One in two young adults polled reported that they had driven drowsy at least once a month which was significantly higher than all other age groups (Gradisar, Wolfson, Harvey, Hale, Rosenberg, & Czeisler, 2013).

Additionally, college students may be more vulnerable to poor sleep hygiene because they prioritize school activities and social relationships and events at the detriment of sleep.

College students in particular also tend to have less living space so their bedrooms serve more purposes than sleep. Furthermore, it is common for college students to live in community style dormitories or have roommates in apartments or houses where they have less control over their environment (Gellis, Park, Stotsky, & Taylor, 2014). Raising awareness about sleep hygiene, educating about sleep myths, understanding the effects of substance use on sleep, and teaching empirically based strategies to shape healthy sleep has the potential to decrease the adverse effects of poor sleep among this age group (Kloss et al., 2016).

### **Current Study**

The aim of the current study is to test the effectiveness of an app-based CBT-I approach, the CBT-I Coach, with a focus on educating participants about the importance of healthy sleep practices, dysfunctional beliefs about sleep, and targeting sleep quality. Traditional face-to-face CBT-I is usually comprised of 6 to 8 sessions (Kaplan & Harvey, 2014). In the current study, the intervention has a duration of 3 weeks without traditional face-to-face contact. The three-week treatment window includes a psychoeducation course on both cognitive and behavioral targets of change. It is hypothesized that at the completion of the study, individuals will endorse fewer dysfunctional beliefs about sleep, engage in more sleep hygiene practices, and report better sleep quality when compared to pre-test scores.

- Hypothesis 1: Education about dysfunctional beliefs about sleep and sleep hygiene and using the CBT-I Coach app will result in sleep quality improvement from pre-treatment to post-treatment as reported on the Pittsburgh Sleep Quality Index.
- Hypothesis 2: Education about dysfunctional beliefs about sleep and sleep hygiene and using the CBT-I Coach app will result in decreased dysfunctional beliefs about sleep as

measured on the Dysfunctional Beliefs about Sleep Scale from pre-treatment to post-treatment.

- Hypothesis 3: Education about dysfunctional beliefs about sleep and sleep hygiene and using the CBT-I Coach app will result in increased healthy sleep behaviors as measured on the Sleep Hygiene Practice Scale from pre-treatment to post-treatment.
- Hypothesis 4: Education about dysfunctional beliefs about sleep and sleep hygiene and using the CBT-I Coach app will result in increased sleep efficiency from pre-treatment to post-treatment as measured through the daily sleep diary entries.

## Methods

### Participants

Participants were recruited from a mid-sized Midwestern University during the academic year. Eligible participants were smartphone owners, over the age of 18, and not currently in treatment for sleep difficulties. Participating psychology faculty members made announcements about the opportunity to participate in the study to students enrolled in undergraduate psychology courses. Participants were awarded course credit points set at the professors' discretion. All participants who completed the study were entered into a gift card drawing.

### Materials

**Demographic Questionnaire.** Participants completed a demographic questionnaire assessing age, gender, and class standing.

**Sleep Diary.** All participants completed a daily sleep diary (Appendix A) throughout the four-week study. The use of sleep diaries, especially in electronic form, are intended to capture experiences close to the time of occurrence, thereby limiting memory lapses and bias, producing more accurate and reliable information than self-report sleep questionnaires alone. Participants

completed an online sleep diary that was emailed to them for the first week to establish a baseline. Participants also completed three additional weeks of sleep diaries within the app used for intervention. The baseline sleep diary utilized the same questions as the in-app sleep diary and addressed bedtime, sleep onset latency, number of awakenings, wake time, and quality of sleep. Participants did not use the in-app sleep diary for the baseline week in order to capture a pre-treatment week with no intervention of the app. During the pretreatment week, participants were sent a link to an online sleep diary each morning to submit the daily sleep diary data from the previous night. Participants utilized the in-app sleep diary for the final three weeks of the study and were sent a link to input their previous week's sleep diary data on the last day of each week.

**Pittsburgh Sleep Quality Index (PSQI).** The PSQI (Appendix B) was utilized in the current study as a pre- and post-measure of sleep quality. The PSQI is a 19 item self-rated questionnaire that assesses sleep quality and disturbances over a 1-month time interval (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The items on the PSQI generate seven component scores in the areas of 1) subjective sleep quality; 2) sleep latency; 3) sleep duration; 4) habitual sleep efficiency; 5) sleep disturbances; 6) use of sleeping medication, and 7) daytime dysfunction. The sum of scores for these components yield one global score. The global score has a range of 0-21 with higher scores indicating worse sleep quality (Buysse et al., 1989). A score of 5 or above is indicative of poor sleep quality. In comparable studies conducted with a college population, average pre-test scores on the PSQI were between 6.29 and 6.98 (Kloss et al., 2016; Peach, Gaultney, & Gray, 2016). The PSQI is found to be a reliable measure with evidence of strong correlations of the 7 components to the global construct ( $\alpha=.83$ ) and performance consistency with a reliability coefficient of .85 (Buysse et al., 1989).

**Dysfunctional Beliefs and Attitudes about Sleep Scale (DBAS-16).** The DBAS-16 (Appendix C) was employed in the current study as a pre- and post-measure of sleep-related cognitions targeted by CBT-I. The DBAS-16 is a 16 item self-report measure designed to evaluate sleep related cognitions in four domains, 1) perceived consequences of insomnia; 2) worry/helplessness about insomnia; 3) sleep expectations; and 4) medication (Morin, Vallieres, & Ivers, 2007). Participants rate their beliefs about the item on a 10-point Likert scale with from 0 (strongly disagree) to 10 (strongly agree). The items on the DBAS-16 are summed and averaged for a total score. A higher score indicates a stronger endorsement of dysfunctional beliefs. In comparable studies focused on cognitive components of sleep disturbance, average pre-test scores on the DBAS-16 were between 4.21 and 5.2 (Eidelman, et al., 2016; Horsch et al., 2017). The DBAS-16 is found to be a reliable measure as evidenced by acceptable internal consistency ( $\alpha=0.79$ , research sample;  $\alpha=0.77$ , clinical sample) and test-retest reliability ( $r=.83$ ). The DBAS-16 demonstrated significant convergent validity ( $r=.18-.45$ ) when compared to other self-report measures of insomnia severity and acceptable discriminant validity ( $r=-.12-.20$ ) when compared to demographic characteristics of age, gender, and education level.

**Sleep Hygiene Practice Scale (SHPS).** The SHPS (Appendix D) was applied in the current study as a pre- and post-measure of the behavioral target of change in CBT-I, sleep hygiene. The SHPS is a 30 item self-report scale designed to assess sleep hygiene behaviors that may have a negative impact on the circadian system (Yang, Lin, Hsu, & Cheng, 2010). These sleep habits are classified into four domains, 1) arousal-related behavior; 2) sleep scheduling and timing; 3) eating/drinking behaviors; and 4) sleep environment (Yang et al., 2010). Participants rate how often they engaged in the behavior listed in the item using a 6-point Likert scale from 1 (never) to 6 (always). The items in each domain are summed to generate four subscale scores for

each participant (Yang et al., 2010). In comparable studies, average pre-test scores on the SHPS were between 70.18 and 91.78 (Peach, Gaultney, & Gray, 2016; Yang et al., 2010). The SHPS demonstrates sound internal consistency among items in each domain respectively (arousal-related behavior -  $\alpha = .58$  and  $.70$ ; sleep scheduling and timing -  $\alpha = .74$  and  $.82$ ; eating/drinking behavior -  $\alpha = .74$  and  $.82$ ; and sleep environment -  $\alpha = .65$  and  $.67$ ; Yang et al., 2010).

**CBT-I Coach Application.** CBT-I was administered using the CBT-I Coach mobile application. The content of the CBT-I Coach is adapted from critical components from *Cognitive Behavioral Therapy for Insomnia in Veterans* (Manber et al., 2014). The app was developed by the US Department of Veterans Affairs (VA) in collaboration with the Stanford University Medical Center and the Department of Defense's National Center for Telehealth & Technology (US Department of VA, 2013).

The CBT-I Coach includes four main categories including 'My Sleep,' 'Tools,' 'Learn,' and 'Reminders.' The 'My Sleep' displays data collected through the sleep diary function of the app including graphs that depict a personalized sleep summary, containing time in bed and hours asleep by date, sleep efficiency, sleep onset latency, number and duration of awakenings, and wake times. The 'Tools' section provides psychoeducation on CBT-I strategies that include healthy sleep behavior guides demonstrating how to incorporate new sleep habits into a nighttime routine that leads to quality sleep. It includes key cognitive components including scheduling worry time for gaining control over rumination that interrupts sleep and changing perspectives by endorsement of a more rational statement in the face of sleep difficulties. Guided imagery, breathing exercises, and progressive muscle relaxation are also found in the 'Tools' component of the CBT-I Coach.



The ‘Learn’ component of the application includes psychoeducation on CBT-I, the importance of healthy sleep, the stages of sleep, what regulates sleep, and additional sleep disorders. The ‘Learn’ component also includes a glossary of terms in reference to CBT-I and information on stimulus control (worrying in bed, watching the clock bedroom activities), napping guidelines, and sleep hygiene practice (winding down, eating, caffeine use, exercise, alcohol use, nicotine use). Each section under the ‘Learn’ component has a psychoeducation function (e.g. under “eating” the app gives information about how eating a large meal before bed disturbs sleep and gives suggestions on when and how much to eat before bed). Finally, the ‘Reminders’ component aids the individual in setting reminders for critical components of CBT-I discussed above. The CBT-I Coach can be downloaded for free from Google and iTunes stores.

Participants completed daily sleep diaries for three weeks using the CBT-I Coach. Participants utilized the reminders function of the application most notably to complete the daily sleep diary but also for wind down, worry, bed and wake times, and time to restrict caffeine intake. The app does not have a structured program for use, so the participants determined how they wished to use the app outside of the daily sleep diaries and reminders.

**Mobile Application Rating Scale (MARS).** The MARS (Appendix E) was utilized in the current study to evaluate and assess the CBT-I Coach after participants used the app for the duration of the study. The MARS is a 23-item tool used to assess the quality of mobile health apps (Stoyanov, Hides, Kavanagh, Zelenko, Tjondronegoro, & Mani, 2015). There are four objective quality scales: 1) engagement; 2) functionality; 3) aesthetics; and 4) information quality, and one subjective quality scale which includes 4 items (recommendation for others; future use; worth the price; and overall rating of the app). All of the items are rated on a 5-point scale from “1-Inadequate” to “5-Excellent.” The MARS is scored by calculating the mean of the

four objective quality subscales and an overall mean app quality total. Testing on the MARS total score indicated a high level of internal consistency ( $\alpha=.90$ ). The MARS subscales were also found to be internally consistent ( $\alpha=.80-.89$ ). The MARS demonstrated an excellent level of interrater reliability ( $ICC=.79$ ). Each participant was asked to complete the four objective quality subscales and the subjective quality subscale.

### **Procedure**

After consenting to participate in the study (Appendix F), participants were included in the study based on the following eligibility criteria: participant is over 18, not currently receiving treatment for insomnia, and has a smartphone capable of downloading and running mobile applications. Participants created a unique ID and provided their cell phone number to receive follow-up survey links. Individuals who consented to participate and who met the inclusion criteria completed baseline measures that included: (a) a demographic questionnaire; (b) PSQI; (c) DBAS; and (d) SHPS. All measures were made available through *Survey Monkey*. The following day after the completion of the baseline measures, participants were sent a link to complete a sleep diary for the previous night. This was done every day for seven days to collect the pre-treatment sleep diaries. On those days, texts were sent at 10:00am through *Texting Base* and included a link to *Survey Monkey*. During the pre-treatment week of the study, participants were also texted dates and times of a 90 minute in-person meeting. Participants waited between 1 day and 10 days, depending on their availability with the times and dates offered, between the pre-treatment week and their attendance of a scheduled in-person meeting where no intervention was implemented, or sleep diary information was collected. Participants were only eligible to attend the meeting to begin the intervention weeks on the day of their last pre-treatment sleep diary entry or later.

Participants attended a 90 minute in-person meeting which included psychoeducation regarding the two-phase sleep model, the National Sleep Foundation's recommendations for good sleep quality, cognitive distortions in sleep related thoughts, and sleep hygiene practices. The in-person meeting also included a walkthrough of the CBT-I Coach app where participants were oriented to the overall organization of the app, and specific components including the in-app sleep diary, tools, and reminders. Participants were instructed to set a consistent bedtime and a waketime, to not go to bed unless they were sleepy (even if it was the scheduled bedtime), to get out of bed when they couldn't sleep, to evaluate and make changes to their sleep environment to promote sleep, and to wind down before bed.

The CBT-I coach components in the 'Tools' section were suggested to help troubleshoot the barriers to adhering to the sleep behavior components. Participants were introduced to activities that promote wakefulness to use prior to bedtime when sleepiness is a problem, activities for wakefulness after sleep onset that promote relaxation, and morning activities to promote getting out of bed on time. They were shown app-components that aid in setting up a sleep environment which included recommended adaptations for shared living spaces. Participants were also educated on behavioral components that interrupt sleep including caffeine intake, nicotine intake, cold medication, consumption of a heavy meal, and exercise 2-3 hours prior to bedtime. Participants were reminded of this 2-3 hour window as they set a daily reminder in the app to stop caffeine. Participants set daily reminders for sleep diary entry, wind down time, stop caffeine time, and worry time while in the meeting. Participants were provided with handouts reviewing the psychoeducational components (Appendix G) and were given a calendar (Appendix H) detailing the daily tasks to be completed for the remainder of the study (daily sleep diary; weekly sleep diary entries; post-treatment measures).

Following the in-person meeting, participants completed daily sleep diaries in the CBT-I Coach app for three weeks. Participants were sent a text message on the last day of each week prompting them to submit the sleep diary data for the previous week through *Survey Monkey*. These weekly entries also included an inquiry into the use of the app during that week. At the end of week 4, participants were texted a link to the post-treatment measures which included: (a) PSQI; (b) DBAS; (c) SHPS; and (d) MARS. Following the post-treatment measures, participants were given a debriefing form (Appendix I) outlining the purpose of the study and contact information for follow-up or additional questions and resources.

## **Results**

### **Preliminary Analyses**

A total of 41 eligible participants consented to participate in the study. During the study period, 19 participants withdrew from the study due to not consenting to text messaging, missing more than two out of seven sleep diaries per week for the duration of the study, absence at the in-person meeting, and/or incomplete or missing post-treatment surveys. Therefore, 22 out of 41 participants completed the study and were included in the analyses.

Data was cleaned by two investigators to achieve interrater agreement among final scores. This process involved downloading data sheets from *Survey Monkey* and hand-scoring the PSQI, DBAS, and SHPS for each participant who provided both pre- and post-test data. Sleep diary information was organized for each day the participant provided data by converting time into a decimal consistent with a 24-hour system (e.g. 11:30 PM was converted to 23.5). Length of time as reported in sleep onset latency and length of awakenings were converted into a decimal by dividing the minutes reported by 60 (e.g. 25 minutes was converted to 0.42). When participants reported ranges, such as '10-15 minutes', the midpoint was used. Tests for outliers

and normality of distributions showed all variables were in the acceptable range. Participants who had missing data and still met completion criteria (e.g. 5 out of 7 sleep diaries completed per week), were still included in final analyses but their data for that day was omitted.

Variables of interest were overall PSQI pre- and post-treatment scores, overall DBAS pre- and post-treatment scores, SHPS pre- and post-treatment scores, and average sleep efficiency scores from pre-treatment week 1 and post-treatment week 4. Due to multiple comparisons, the significance level for the four overall scores were adjusted using the Bonferroni correction. Subscale components for each measure are also reported for exploratory purposes and as such, their significance levels have not been adjusted.

### **Descriptive Data**

Participants' ages ranged from 18-62 years with a mean age of 22 ( $SD=9.416$ ) years and included 13.6% freshmen, 45.5% sophomores, 27.3% juniors, and 13.6% seniors. The majority of the participants were female (77%), while 23% were male. The baseline measures and the pre-treatment sleep diaries were examined to describe the study sample. At baseline, participants demonstrated poor overall sleep quality as evidenced by an average PSQI score of 7.82 ( $SD=3.25$ ) and average sleep efficiency of 83.14% ( $SD=9.05$ ). The average sleep length reported in the pre-treatment sleep diaries was 8 hours and 13 minutes ( $SD=55$  minutes), the average number of awakenings was 1.28 ( $SD=0.94$ ), and the average sleep onset latency was 36 minutes ( $SD=33.6$  minutes). Participants reported low frequency of sleep hygiene practices as measured by the SHPS ( $M=85.27$ ,  $SD=18.88$ ) and held unrealistic expectations of sleep and thoughts about ability to cope with sleep loss as measured by the DBAS ( $M=4.83$ ,  $SD=1.68$ ).

Participants reportedly spent an average of 33 minutes in the app ( $SD=9$  minutes) during post-treatment week one, 38 minutes in the app ( $SD=18$  minutes) during post-treatment week

two, and 39 minutes in the app ( $SD=9$  minutes) during post-treatment week three. All participants reported use of the ‘My Sleep’ component where sleep diaries were filled out within the app. Of the ‘Learn’ subsection of CBT-I Coach, 41% engaged with ‘Habits & Sleep’, 36% explored ‘Sleep 101’, and 9% utilized the CBT-I glossary. The ‘Tools’ section included both cognitive and behavioral interventions and troubleshooting techniques and 55% of participants utilized ‘Quiet Your Mind’ tools and 41% used the ‘Create New Sleep Habits’ tools.

### Changes in Subjective Sleep Quality

The first hypothesis stated that education about dysfunctional beliefs about sleep and sleep hygiene and using the CBT-I Coach app will result in sleep quality improvement from pre-treatment to post-treatment as reported on the PSQI. Mean changes from pre-treatment to post-treatment were compared using paired samples  $t$ -tests. When pre- and post-test measures of sleep quality using the PSQI (pre-test:  $M=7.82$ ,  $SD=3.25$ ; post-test:  $M=5.55$ ,  $SD=2.4$ ) were compared, a significant improvement was found (PSQI  $t(21)= 4.38$ ,  $p<.001$ ,  $d=0.93$ ). Of the 7 component scores, significant mean changes were most apparent on subjective sleep quality, sleep latency, and daytime dysfunction. Changes in sleep quality overall and by subscale from pre- to post-test can be seen in Table 1 below.

Table 1  
*Comparison of Pre-Post Scores for Sleep Quality*

Variable	Pre-test		Post-test		$t$	$p$	$d$
	$M$	$SD$	$M$	$SD$			
Subjective Sleep Quality	1.36	0.58	1.05	0.49	2.31	.031	0.49
Sleep Latency	1.68	0.99	0.86	0.95	4.23	.0002	0.90
Sleep Duration	0.77	0.81	0.55	0.96	1.23	.234	0.26
Habitual Sleep Efficiency	0.86	1.13	0.64	0.73	1.00	.329	0.21
Sleep Disturbances	1.23	0.61	1.14	0.64	0.81	.427	0.17
Use of Sleeping Medication	0.50	1.01	0.55	1.01	-0.58	.576	0.12
Daytime Dysfunction	1.41	1.01	0.77	0.81	3.31	.003	0.71
Overall	7.81	3.25	5.45	2.40	4.38	.0007	0.93

*Note.* Overall score  $p$ -value was adjusted for multiple comparisons using a Bonferroni correction.

### Changes in Endorsement of Sleep Myths

The second hypothesis focused on changes from baseline to four-weeks on endorsement of maladaptive beliefs about sleep which was targeted through the psychoeducation and app intervention. Mean changes from pre-treatment to post-treatment were compared using paired samples *t*-tests. When pre- and post-test measures of beliefs about sleep (pre-test:  $M=4.82$ ,  $SD=1.68$ ; post-test:  $M=3.99$ ,  $SD=1.29$ ) were compared, a significant improvement was found (DBAS  $t(21)= 3.12$ ,  $p=.001$ ,  $d=0.66$ ). Changes in endorsement of sleep myths overall and by subscale can be seen in Table 2 below.

Table 2  
*Comparison of Pre-Post Scores for Dysfunctional Beliefs about Sleep*

Variable	Pre-test		Post-test		<i>t</i>	<i>p</i>	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Perceived Consequences of Insomnia	5.65	2.08	4.36	1.77	3.72	.001	0.79
Worry/Helplessness about Insomnia	4.34	2.13	3.73	1.84	1.52	.143	0.32
Sleep Expectations	6.14	2.38	5.14	2.36	2.06	.052	0.44
Medication	3.58	1.82	3.14	1.63	1.36	.188	0.29
Overall	4.83	1.68	3.99	1.30	3.12	.001	0.66

*Note.* Overall score *p*-value was adjusted for multiple comparisons using a Bonferroni correction.

### Changes in Sleep Hygiene Practices

The third hypothesis focused on changes in the practice of sleep hygiene behaviors as rated using the SHPS at baseline and at 4-weeks. Mean changes from pre-treatment to post-treatment were compared using paired samples *t*-tests. When pre- and post-test measures of sleep hygiene behaviors (pre-test:  $M=85.27$ ,  $SD=18.88$ ; post-test:  $M=73.46$ ,  $SD=16.41$ ) were compared, a significant improvement was found (SHPS  $t(21)= 3.26$ ,  $p=.001$ ,  $d=0.70$ ). Changes in sleep hygiene practices overall and by subscale can be seen in Table 3 below.

Table 3  
*Comparison of Pre-Post Scores for Sleep Hygiene Practice*

Variable	Pre-test		Post-test		<i>t</i>	<i>p</i>	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Arousal Related Behavior	29.64	7.53	22.50	6.71	4.49	.0001	0.96
Sleep Scheduling and Timing	24.23	6.87	21.55	6.29	1.93	.067	0.41
Eating/Drinking Behaviors	12.86	4.89	13.55	4.82	-0.65	.522	0.14
Sleep Environment	18.55	6.64	15.96	5.96	1.88	.074	0.40
Overall	85.27	18.88	73.46	16.41	3.26	.001	0.70

*Note.* Overall score *p*-value was adjusted for multiple comparisons using a Bonferroni correction.

### Changes in Sleep Efficiency

The fourth hypothesis stated that sleep efficiency would improve over the course of the study. Sleep efficiency was calculated using the daily sleep diary data. Total sleep time was calculated by adding the hours between a participant's reported time in bed intending to sleep and their final awakening after which sleep onset latency and total sleep disruption (total amount of time awake during awakenings) were subtracted. Time in bed was calculated by adding the hours between a participant's reported time he or she got in bed and what time he or she got out of bed for the day. The quotient of total sleep time and time in bed is converted to a percentage to achieve a sleep efficiency score. Changes in sleep efficiency were evaluated using the daily sleep efficiency calculations for the pre-treatment week to the final post-treatment week using a paired samples *t*-test. As hypothesized, when pre- and post-treatment weeks of sleep efficiency data (pre-treatment:  $M=83.14$ ,  $SD=9.05$ ; post-treatment:  $M=90.56$ ,  $SD=5.83$ ) were compared, a significant improvement was found ( $t(21)=-4.93$ ,  $p<.001$ ,  $d=1.05$ ). Improvements were observed in sleep onset latency with the pre-treatment week sleep onset latency having a mean score of 36 minutes ( $SD=33.6$  minutes) and the final post-treatment week at 20 minutes ( $SD=18.6$  minutes). Number of awakenings significantly decreased from pre-treatment ( $M=1.28$ ,  $SD=0.94$ ) to post-



treatment ( $M=0.46$ ,  $SD=0.55$ ). No change was found in total sleep time. Changes in overall sleep efficiency and by component can be seen in Table 4 below.

Table 4  
*Comparison of Pre-Post Scores for Sleep Efficiency and related components*

Variable	Pre-test		Post-test		$t$	$p$	$d$
	$M$	$SD$	$M$	$SD$			
Sleep Onset Latency	0.60	0.56	0.34	0.31	3.16	.005	0.67
Number of Awakenings	1.28	0.94	0.46	0.55	4.89	.00007	1.04
Total Sleep Time	8.22	0.92	7.88	1.01	1.45	1.63	0.31
Sleep Efficiency	83.14	9.05	90.56	5.83	-4.93	.00001	1.05

*Note.* The Sleep Efficiency  $p$ -value was adjusted for multiple comparisons using a Bonferroni correction.

### Attitudes toward CBT-I Coach

The MARS survey indicated participants' overall positive attitudes toward the CBT-I Coach app. On a scale of 0 to 5 (1 = *inadequate* and 5 = *excellent*), participants rated the app as moderate to high. The overall score was consistent with the subscale breakdowns including engagement, functionality, aesthetics, and information quality with a range of means from 3.27 to 4.12. The highest rated objective components were functionality ( $M= 4.06$ ,  $SD= 0.80$ ) and information quality ( $M= 4.12$ ,  $SD= 0.66$ ). Means and standard deviations for each quality scale can be seen in Table 5 below.

Table 5  
*Means and Standard Deviations for Mobile App Rating Scale (MARS) Quality Scales*

MARS Scale	$M$	$SD$
Engagement	3.27	0.84
Functionality	4.06	0.80
Aesthetics	3.71	0.75
Information Quality	4.02	0.74
Overall Quality	3.81	0.66

*Note.* All items were scored on a 0 to 5 Likert scale (1 = *inadequate* and 5 = *excellent*).

When participants were asked whether they would recommend the CBT-I Coach app to others, the majority (45%) reported that there are several people whom they would recommend the app to and 27% reported they would recommend the app to everyone. Participants reported the estimated frequency of app use after the study and the majority (a combined 46%) reported that they thought they would use the app 10 or more times.

### **Discussion**

In one of the first studies investigating the effect of app-delivered CBT-I on sleep quality in a non-clinical population, we found that the CBT-I Coach significantly improved sleep quality, decreased dysfunctional beliefs about sleep, decreased problematic sleep behaviors, and improved sleep efficiency. The primary aim of the study was to investigate the effectiveness of the CBT-I Coach for educating participants about the importance of healthy sleep practices and dysfunctional beliefs about sleep and targeting sleep quality among college aged participants. College students are a vulnerable population for the development of sleep problems and disorders due to their newfound autonomy, inconsistent schedules, and high levels of stress surrounding educational needs and social demands. Sleep problems have been identified as a significant factor affecting academic success, and have been associated with increased stress, substance use, motor vehicle crashes, and higher prevalence of mood and anxiety disorders (Valerio, Jin Kim, & Sexton-Radek, 2016). Overall, the improvement in outcome measures due to the CBT-I Coach app is comparable to other internet delivered CBT-I and traditional face-to-face CBT-I treatments (Blom et al., 2015; Eidelman et al., 2016; Geiger-Brown et al., 2015; Kaldo et al., 2016).

Dysfunctional beliefs about sleep are powerful influencers on the critical indicators of good and poor quality sleep and the current study findings indicate that beliefs can be

significantly modified through CBT-I intervention (Ohayan et al., 2017). Participants in this study endorsed fewer dysfunctional beliefs about sleep over the course of the intervention. Even after a brief, three-week intervention period, these results were consistent with reductions in dysfunctional beliefs about sleep in participants who completed eight weeks of cognitive therapy (CT), behavioral therapy (BT), or CBT (Eidelman et al., 2016; Harvey et al., 2007). Furthermore, when compared to a study with a college population that used two psychoeducation workshops on sleep, the current study found similar reductions in dysfunctional beliefs but with larger effect sizes (Kloss et al., 2016).

A similar study utilizing app-delivered CBT-I with pre-treatment DBAS scores matching those of the current study, found no reduction in mean scores after 6 weeks of intervention for dysfunctional beliefs about sleep (Horsch et al., 2017). Horsch and colleagues (2017) posit that this is due to their app having no component that directly targeted cognitions. The similarity of these interventions and the clear difference in outcomes provide preliminary support for the efficacy of the cognitive interventions delivered through the CBT-I Coach. However, the durability of the treatment effect is not known. Future studies should focus on follow-up assessments at 3-months, 6-months, and 12-months to investigate long term effects of a brief intervention.

Sleep hygiene behaviors were addressed as part of the psychoeducation components and the tools component of the CBT-I Coach. Sleep scheduling was specifically targeted through the scheduling and in-app reminder of a wind-down time prior to sleeping, which has been established in past research to promote relaxation before bed and regularity in sleep and wake times (Kaplan & Harvey, 2014). The practice of sleep hygiene behaviors significantly improved over the course of the study. These benefits were also found in Kloss and colleagues' (2016)

study with a college population. This significant improvement is preliminary evidence supporting the use of the app to promote, troubleshoot, and remind participants of healthy sleep hygiene behaviors.

Self-reports of sleep quality were significantly improved over the course of the study which offers consilience with significant decreases in endorsement of dysfunctional sleep beliefs and increases in sleep hygiene behaviors. Significant improvements in pre-treatment and post-treatment on the current study's PSQI scores were similar to score differences in studies involving longer treatment intervention and regular meetings with a licensed professional (Geiger-Brown et al., 2015). Sleep quality differences were larger, statistically significant, and garnered a larger effect size than that of a similar study with the college population utilizing psychoeducation as an intervention alone (Kloss et al., 2016). Additionally, when compared to another app-delivered intervention study, PSQI changes and effect sizes were consistent (Horsch et al., 2017).

Pre-treatment and post-treatment self-report measures were corroborated the results found through daily sleep diary entries. When baseline and post-treatment sleep efficiency percentages were compared, there was a 7% increase. This improvement in sleep efficiency is substantiated by Geiger-Brown et al.'s meta-analysis (2015) which reported an average 9% increase in sleep efficiency. However, the studies included in the meta-analysis were face-to-face individual or group delivered CBT-I over a four- to eight-week time frame. Participants in the current study saw nearly the same sleep efficiency improvements with no continued professional contact over a shorter amount of time with a large effect size. Participants' average sleep efficiency percentage at pre-treatment fell below the recommended 85% or above for good quality sleep as outlined by the National Sleep Foundation but exceeded the recommended

efficiency score at post-treatment (Ohayan et al., 2017). Improvements were also observed in sleep onset latency, showing a 16-minute reduction overall, and awakenings after sleep onset, bringing both factors within the recommended ranges indicative of good quality sleep (Ohayan et al., 2017). Previous research has also demonstrated a significant reduction in sleep onset latency with the use of CBT-I ranging from a reduction of 15 to 21 minutes (Harvey et al., 2007; Geiger-Brown et al., 2015).

While there are several mobile apps that target and track sleep, there is little information available about their empirical basis or overall quality (Miner et al., 2016). Attitudes about quality were assessed for the CBT-I Coach through use of the MARS. Overall, participants indicated positive attitudes toward the CBT-I Coach app. Participants rated information quality and functionality highest among the quality subscales which is a reflection of participant satisfaction and may have also enhanced the impact of the intervention. While still indicating positive impressions, participants did report lower ratings for app aesthetics and engagement. This may also be reflected in participants reported average time spent in the app which ranged from 33-39 minutes per week.

Despite seemingly low engagement, the outcome measures of sleep were significantly improved. While most comparison studies were structured and involved therapeutic contact, they also included four to eight hours of planned intervention over a four- to eight-week period. The current study found improvements consistent with previous research but with reported use as low as 33 minutes per week. The in-app components are brief in the moment interventions and the results of the study combined with participants reported use of the app provide preliminary evidence that time in the app does not directly reflect sleep improvement or more broadly, the effectiveness of the intervention.

**Limitations**

Certain limitations should be noted. First, there was no control group and thus no definitive way to rule out that improvement was due to passage of time or increased awareness of sleep-related behaviors and cognitions from participants. We controlled for this by having participants fill out a sleep diary every day before the introduction of any intervention so that the sample group also served as their own control. Second, this study relied solely on participants' self-report for data collection in the pre-treatment measures, daily sleep diaries, app use, and post-treatment measures. Daily sleep diaries do demonstrate some convergent validity when compared to physiological measures of sleep (Tonetti, Mingozzi, & Natale, 2016), and future research can be improved by utilizing objective methods of data collection to compare against this sample's self-report measures. Third, it is unknown if frequency of use, total time in app, and/or engagement in particular components of the app were specific variables affecting change. Thus, future research would include an objective measure of interaction and engagement in the app to have access to richer information about content that produced the most interest and affected change.

**Conclusions**

This is the first known study to evaluate a mobile app for treatment of sleep difficulties among a non-clinical college-aged population. The results of this study are consistent with the improvements seen with face-to-face CBT-I, internet-delivered CBT-I, and group CBT-I. This study achieved significant results with large effect sizes even within a condensed timeframe suggesting that even a brief intervention with no structured, clinical involvement can lead to changes in sleep quality indicators. The findings are encouraging and support the use of app-delivered psychoeducation and CBT to reduce maladaptive beliefs about sleep, increase sleep

hygiene knowledge and practice, and improve overall sleep quality. Furthermore, this is a cost-effective and easily disseminated way to improve sleep (even when clinical criteria for a sleep disorder may not be met), and perhaps serve as a protective measure against the development of a sleep disorder. The results of this study support the use of technology for improving sleep quality, reducing sleep onset latency and number of awakenings, aiding in creating consistent healthy sleep behaviors, and can serve as a preventative strategy for non-clinical populations and clinical populations alike.

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**Appendix A****Daily Sleep Diary**

1. Enter your Participant ID (first and last initial and last 4 digits of your WU ID; ex. JL0922): \_\_\_\_\_
2. Did you nap or doze yesterday?
  - Yes
  - No
3. What time did you get into bed yesterday? \_\_\_\_\_
4. What time did you try to go to sleep? \_\_\_\_\_
5. How long did it take you to fall asleep? \_\_\_\_\_
6. How many times did you wake up, not counting your final awakening? \_\_\_\_\_
7. In total, how long did those awakenings last? \_\_\_\_\_
8. What time was your final awakening? \_\_\_\_\_
9. Did you wake up earlier than you desired?
  - Yes
  - No
10. What time did you get out of bed for the day? \_\_\_\_\_
11. How would you rate the quality of your sleep from yesterday?
  - Very Poor
  - Poor
  - Fair
  - Good
  - Very Good

## Appendix B

### Pittsburgh Sleep Quality Index (PSQI)

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.

#### During the past month,

1. When have you usually gone to bed? \_\_\_\_\_
2. How long (in minutes) has it taken you to fall asleep each night? \_\_\_\_\_
3. What time have you usually gotten up in the morning? \_\_\_\_\_
4. A. How many hours of actual sleep did you get at night? \_\_\_\_\_  
 B. How many hours were you in bed? \_\_\_\_\_

5. During the past month, how often have you had trouble sleeping because you:	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
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. Have bad dreams				
I. Have pain				
J. Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s):				
6. During the past month, how often have you taken medicine (prescribed or “over the counter”) to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				
9. During the past month, how would you rate your sleep quality overall?	<b>Very good (0)</b>	<b>Fairly good (1)</b>	<b>Fairly bad (2)</b>	<b>Very bad (3)</b>

### Appendix C

#### Dysfunctional Beliefs and Attitudes about Sleep Scale (DBAS-16)

Several statements reflecting people's beliefs and attitudes about sleep are listed below. Please indicate (by circling the number) to what extent you personally agree or disagree with each statement. There is no right or wrong answer. For each statement, **circle a number that best reflects your personal experience**. Consider the whole scale, rather than only the extremes of the continuum.

	Strongly Disagree					Strongly Agree				
I need 8 hours of sleep to feel refreshed and function well during the day.	1	2	3	4	5	6	7	8	9	10
When I do not get proper amount of sleep on a given night, I need to catch up on the next day by napping or on the next night by sleeping longer.	1	2	3	4	5	6	7	8	9	10
I am concerned that chronic insomnia may have serious consequences for my physical health.	1	2	3	4	5	6	7	8	9	10
I am worried that I may lose control over my abilities to sleep.	1	2	3	4	5	6	7	8	9	10
After a poor night's sleep, I know that it will interfere with my daily activities on the next day.	1	2	3	4	5	6	7	8	9	10
In order to be alert and function well during the day, I am better off taking a sleeping pill rather than having a poor night's sleep.	1	2	3	4	5	6	7	8	9	10
When I feel irritable, depressed, or anxious during the day, it is mostly because I did not sleep well the night before.	1	2	3	4	5	6	7	8	9	10
When I sleep poorly on one night, I know that it will disturb my sleep schedule for the whole week.	1	2	3	4	5	6	7	8	9	10
Without an adequate night's sleep, I can hardly function the next day.	1	2	3	4	5	6	7	8	9	10
I can't ever predict whether I will have a good or poor night's sleep.	1	2	3	4	5	6	7	8	9	10
I have little ability to manage the negative consequences of disturbed sleep.	1	2	3	4	5	6	7	8	9	10

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When I feel tired, have no energy, or just seem not to function well during the day, it is generally because I did not sleep well the night before.	1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	---	----

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I believe that insomnia is essentially a result of a chemical imbalance.	1	2	3	4	5	6	7	8	9	10
--	---	---	---	---	---	---	---	---	---	----

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I feel that insomnia is ruining my ability to enjoy life and prevents me from doing what I want.	1	2	3	4	5	6	7	8	9	10
--	---	---	---	---	---	---	---	---	---	----

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Medication is probably the only solution to sleeplessness.	1	2	3	4	5	6	7	8	9	10
--	---	---	---	---	---	---	---	---	---	----

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I avoid or cancel obligations (social, family, occupational) after a poor night's sleep.	1	2	3	4	5	6	7	8	9	10
--	---	---	---	---	---	---	---	---	---	----

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## Appendix D

### Sleep Hygiene Practice Scale (SHPS)

Please indicate (by circling the number) how frequently you engage in the behavioral practices and sleep habits listed below. For each statement, **circle a number that best reflects your personal experience.**

Consider the whole scale, rather than only the extremes of the continuum.

	Never					Always
<b>Domain 1: Arousal-Related Behaviors</b>						
Doing sleep-irrelevant activities in bed (e.g., watching TV, reading).	1	2	3	4	5	6
Worry about not being able to fall asleep in bed.	1	2	3	4	5	6
Unpleasant conversation prior to sleep.	1	2	3	4	5	6
Not enough time to relax prior to sleep.	1	2	3	4	5	6
Falling asleep with TV or music on.	1	2	3	4	5	6
Pondering about unresolved matters while lying in bed.	1	2	3	4	5	6
Check the time in the middle of the night.	1	2	3	4	5	6
Worry about night-time sleep during the day.	1	2	3	4	5	6
Vigorous exercise during the two hours prior to sleep.	1	2	3	4	5	6
<b>Domain 2: Sleep Scheduling and Timing</b>						
Bedtime not consistent daily.	1	2	3	4	5	6
Get out of bed at inconsistent times.	1	2	3	4	5	6
Stay in bed after waking up in the morning.	1	2	3	4	5	6
Sleep in on weekends.	1	2	3	4	5	6
Napping or resting in bed for over one hour during the day.	1	2	3	4	5	6
Lack of exposure to outdoor light during the day.	1	2	3	4	5	6
Lack of regular exercise.	1	2	3	4	5	6

<b>Domain 3: Eating/Drinking Behaviors</b>						
Going to bed hungry.	1	2	3	4	5	6
Drinking caffeinated drinks (e.g. coffee, tea, Coca-Cola) within the four hours prior to bedtime.	1	2	3	4	5	6
Drinking alcohol within the two hours prior to bedtime.	1	2	3	4	5	6
Consuming stimulating substances (e.g. nicotine) during the two hours prior to bedtime.	1	2	3	4	5	6
Drinking a lot during the hour prior to sleep.	1	2	3	4	5	6
Eating too much food during the hour prior to sleep.	1	2	3	4	5	6
<b>Domain 4: Sleep Environment</b>						
Sleep environment is either too noisy or too quiet.	1	2	3	4	5	6
Sleep environment is either too bright or too dark.	1	2	3	4	5	6
Sleep environment is either humid or too dry.	1	2	3	4	5	6
Feeling too hot or too cold during sleep.	1	2	3	4	5	6
Poor ventilation of bedroom.	1	2	3	4	5	6
Uncomfortable bedding and/or pillow.	1	2	3	4	5	6
Too many sleep-unrelated items in bedroom.	1	2	3	4	5	6
Sleep is interrupted by bed partner.	1	2	3	4	5	6

## Appendix E

### Mobile Application Rating Scale (MARS)

The Rating scale assesses app quality on four dimensions. All items are rated on a 5-point scale from “1. Inadequate” to “5. Excellent”. Circle the number that most accurately represents the quality of the app component you are rating. Please use the descriptors provided for each response category.

#### **SECTION A Engagement – fun, interesting, customizable, interactive (e.g. sends alerts, messages, reminders, feedback, enables sharing), well-targeted to audience**

**1. Entertainment: Is the app fun/entertaining to use? Does it use any strategies to increase engagement through entertainment (e.g. through gamification)?**

- 1 Dull, not fun or entertaining at all
- 2 Mostly boring
- 3 OK, fun enough to entertain user for a brief time (< 5 minutes)
- 4 Moderately fun and entertaining, would entertain user for some time (5-10 minutes total)
- 5 Highly entertaining and fun, would stimulate repeat use

**2. Interest: Is the app interesting to use? Does it use any strategies to increase engagement by presenting its content in an interesting way?**

- 1 Not interesting at all
- 2 Mostly uninteresting
- 3 OK, neither interesting nor uninteresting; would engage user for a brief time (< 5 minutes)
- 4 Moderately interesting; would engage user for some time (5-10 minutes total)
- 5 Very interesting, would engage user in repeat use

**3. Customization: Does it provide/retain all necessary settings/preferences for apps features (e.g. sound, content, notifications, etc.)?**

- 1 Does not allow any customization or requires setting to be input every time
- 2 Allows insufficient customization limiting functions
- 3 Allows basic customization to function adequately
- 4 Allows numerous options for customization
- 5 Allows complete tailoring to the individual's characteristics/preferences, retains all settings

**4. Interactivity: Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)? Note: these functions need to be customizable and not overwhelming in order to be perfect.**

- 1 No interactive features and/or no response to user interaction
- 2 Insufficient interactivity, or feedback, or user input options, limiting functions
- 3 Basic interactive features to function adequately

- 4 Offers a variety of interactive features/feedback/user input options
  - 5 Very high level of responsiveness through interactive features/feedback/user input options
- 5. Target group: Is the app content (visual information, language, design) appropriate for your target audience?**
- 1 Completely inappropriate/unclear/confusing
  - 2 Mostly inappropriate/unclear/confusing
  - 3 Acceptable but not targeted. May be inappropriate/unclear/confusing
  - 4 Well-targeted, with negligible issues
  - 5 Perfectly targeted, no issues found

**SECTION B Functionality – app functioning, easy to learn, navigation, flow logic, and gestural design of app**

- 6. Performance: How accurately/fast do the app features (functions) and components (buttons/menus) work?**
- 1 App is broken; no/insufficient/inaccurate response (e.g. crashes/bugs/broken features, etc.)
  - 2 Some functions work, but lagging or contains major technical problems
  - 3 App works overall. Some technical problems need fixing/Slow at times
  - 4 Mostly functional with minor/negligible problems
  - 5 Perfect/timely response; no technical bugs found/contains a 'loading time left' indicator
- 7. Ease of use: How easy is it to learn how to use the app; how clear are the menu labels/icons and instructions?**
- 1 No/limited instructions; menu labels/icons are confusing; complicated
  - 2 Useable after a lot of time/effort
  - 3 Useable after some time/effort
  - 4 Easy to learn how to use the app (or has clear instructions)
  - 5 Able to use app immediately; intuitive; simple
- 8. Navigation: Is moving between screens logical/accurate/appropriate/ uninterrupted; are all necessary screen links present?**
- 1 Different sections within the app seem logically disconnected and random/confusing/navigation is difficult
  - 2 Usable after a lot of time/effort
  - 3 Usable after some time/effort
  - 4 Easy to use or missing a negligible link
  - 5 Perfectly logical, easy, clear and intuitive screen flow throughout, or offers shortcuts

**9. Gestural design: Are interactions (taps/swipes/pinches/scrolls) consistent and intuitive across all components/screens?**

- 1 Completely inconsistent/confusing
- 2 Often inconsistent/confusing
- 3 OK with some inconsistencies/confusing elements
- 4 Mostly consistent/intuitive with negligible problems
- 5 Perfectly consistent and intuitive

**SECTION C Aesthetics – graphic design, overall visual appeal, color scheme, and stylistic consistency**

**10. Layout: Is arrangement and size of buttons/icons/menus/content on the screen appropriate or zoomable if needed?**

- 1 Very bad design, cluttered, some options impossible to select/locate/see/read device display not optimized
- 2 Bad design, random, unclear, some options difficult to select/locate/see/read
- 3 Satisfactory, few problems with selecting/locating/seeing/reading items or with minor screen- size problems
- 4 Mostly clear, able to select/locate/see/read items
- 5 Professional, simple, clear, orderly, logically organized, device display optimized. Every design component has a purpose

**11. Graphics: How high is the quality/resolution of graphics used for buttons/icons/menus/content?**

- 1 Graphics appear amateur, very poor visual design - disproportionate, completely stylistically inconsistent
- 2 Low quality/low resolution graphics; low quality visual design – disproportionate, stylistically inconsistent
- 3 Moderate quality graphics and visual design (generally consistent in style)
- 4 High quality/resolution graphics and visual design – mostly proportionate, stylistically consistent
- 5 Very high quality/resolution graphics and visual design - proportionate, stylistically consistent throughout

**12. Visual appeal: How good does the app look?**

- 1 No visual appeal, unpleasant to look at, poorly designed, clashing/mismatched colors
- 2 Little visual appeal – poorly designed, bad use of color, visually boring
- 3 Some visual appeal – average, neither pleasant, nor unpleasant
- 4 High level of visual appeal – seamless graphics – consistent and professionally designed
- 5 As above + very attractive, memorable, stands out; use of color enhances app features/menus

**SECTION D Information – Contains high quality information (e.g. text, feedback, measures, references) from a credible source. Select N/A if the app component is irrelevant.**

**13. Accuracy of app description (in app store): Does app contain what is described?**

- 1 Misleading. App does not contain the described components/functions. Or has no description
- 2 Inaccurate. App contains very few of the described components/functions
- 3 OK. App contains some of the described components/functions
- 4 Accurate. App contains most of the described components/functions
- 5 Highly accurate description of the app components/functions

**14. Goals: Does app have specific, measurable and achievable goals (specified in app store description or within the app itself)?**

N/A Description does not list goals, or app goals are irrelevant to research goal (e.g. using a game for educational purposes)

- 1 App has no chance of achieving its stated goals
- 2 Description lists some goals, but app has very little chance of achieving them
- 3 OK. App has clear goals, which may be achievable.
- 4 App has clearly specified goals, which are measurable and achievable
- 5 App has specific and measurable goals, which are highly likely to be achieved

**15. Quality of information: Is app content correct, well written, and relevant to the goal/topic of the app?**

N/A There is no information within the app

- 1 Irrelevant/inappropriate/incoherent/incorrect
- 2 Poor. Barely relevant/appropriate/coherent/may be incorrect
- 3 Moderately relevant/appropriate/coherent/and appears correct
- 4 Relevant/appropriate/coherent/correct
- 5 Highly relevant, appropriate, coherent, and correct

**16. Quantity of information: Is the extent coverage within the scope of the app; and comprehensive but concise?**

N/A There is no information within the app

- 1 Minimal or overwhelming
- 2 Insufficient or possibly overwhelming
- 3 OK but not comprehensive or concise
- 4 Offers a broad range of information, has some gaps or unnecessary detail; or has no links to more information and resources
- 5 Comprehensive and concise; contains links to more information and resources

**17. Visual information: Is visual explanation of concepts – through charts/graphs/images/videos, etc. – clear, logical, correct?**

N/A There is no visual information within the app (e.g. it only contains audio, or text)

- 1 Completely unclear/confusing/wrong or necessary but missing
- 2 Mostly unclear/confusing/wrong
- 3 OK but often unclear/confusing/wrong
- 4 Mostly clear/logical/correct with negligible issues
- 5 Perfectly clear/logical/correct

**18. Credibility: Does the app come from a legitimate source (specified in app store description or within the app itself)?**

- 1 Source identified but legitimacy/trustworthiness of source is questionable (e.g. commercial business with vested interest)
- 2 Appears to come from a legitimate source, but it cannot be verified (e.g. has no webpage)
- 3 Developed by small NGO/institution (hospital/center, etc.) /specialized commercial business, funding body
- 4 Developed by government, university or as above but larger in scale
- 5 Developed using nationally competitive government or research funding (e.g. Australian Research Council, NHMRC)

**19. Evidence base: Has the app been trialed/tested; must be verified by evidence (in published scientific literature)?**

N/A The app has not been trialed/tested

- 1 The evidence suggests the app does not work
- 2 App has been trialed (e.g., acceptability, usability, satisfaction ratings) and has partially positive outcomes in studies that are not randomized controlled trials (RCTs), or there is little or no contradictory evidence.
- 3 App has been trialed (e.g., acceptability, usability, satisfaction ratings) and has positive outcomes in studies that are not RCTs, and there is no contradictory evidence.
- 4 App has been trialed and outcome tested in 1-2 RCTs indicating positive results
- 5 App has been trialed and outcome tested in > 3 high quality RCTs indicating positive results

**SECTION E App subjective quality**

**20. Would you recommend this app to people who might benefit from it?**

- 1 **Not at all** I would not recommend this app to anyone
- 2 There are very few people I would recommend this app to
- 3 **Maybe** There are several people whom I would recommend it to
- 4 There are many people I would recommend this app to
- 5 **Definitely** I would recommend this app to everyone

**21. How many times do you think you would use this app in the next 12 months if it was relevant to you?**

- 1 None
- 2 1-2
- 3 3-10
- 4 10-50
- 5 >50

**22. Would you pay for this app?**

- 1 No
- 2
- 3 Maybe
- 4
- 5 Yes

**23. What is your overall star rating of the app?**

- 1 ★ One of the worst apps I've used
- 2 ★★
- 3 ★★★ Average
- 4 ★★★★
- 5 ★★★★★ One of the best apps I've used



## Appendix F

### Informed Consent

The Department of Psychology supports the practice of protection for human subjects participating in research. The following information is provided so that you can decide whether you wish to participate in the present study. You should be aware that even if you agree to participate you are free to withdraw at any time, without penalty.

### Description of Study

Sleep quality has been well researched and supported as a predictor of physical and mental health. The aim of the current study is to test the effectiveness of an app-based Cognitive Behavior Therapy for Insomnia (CBT-I) approach, the CBT-I Coach, with a focus on educating participants about the importance of healthy sleep practices, dysfunctional beliefs about sleep, and then targeting sleep quality. The CBT-I app is available for individuals to access well-researched and supported psychoeducational information and self-management tools with little to no professional involvement.

The study is a 4-week time commitment and will involve a pretest set of questionnaires, 4 online sleep diary entries that will ask for your sleep data for the previous week, attendance of 90-minute in-person meeting, and a post-test set of questionnaires at the end of the 4-week period.

### By agreeing to participate, I understand that:

- This study seeks to increase the understanding of how using technology can help shape healthy sleep habits, attitudes, and improve overall sleep quality.
- My part in this research will be to complete a demographic questionnaire, pretest questionnaires, attend one 90 minute in-person training, fill out weekly sleep diaries, use the app as instructed daily for 3 weeks, and complete post-test questionnaires.
- It may take up to 1 hour to complete the pre/post-test questionnaires. It may take up to 15 minutes to complete the weekly sleep diaries.
- Participation is voluntary. I am free to discontinue my participation at any time.
- To protect my identity the surveys and demographic component are free of any identifying information. All data will contain my unique ID (first initial, last initial, last 4 digits of WU ID) and will not be tied to my name or any other identifying information.
- I understand that I will be asked to use components of the app every day and will set reminders to help keep me accountable.
- I agree to be contacted by phone via text to be sent surveys including the online sleep diary entry and pre/post-test questionnaires. I will also be texted reminders to complete the online components throughout the study.
- I understand the online components ask only about my sleep quality, sleep hygiene practices, attitudes about sleep, and information about my sleep from the previous week and does not contain embarrassing questions. However, my privacy is important to the

researcher. The materials in the study are anonymous and are kept separate from my name and any other identifying information. All information I provide the researcher will be kept in a password-protected file on a password-protected computer.

- There is no cost to me for being in this study.
- Should I complete the entire study, I will be put in a drawing to win one of two \$25 Amazon gift cards.
- I will earn up to 50 research participation points (PY100 students) or extra credit points determined by my professor for my participation in this study. Choosing to participate or to withdraw from the study will not affect my academic standing or grade in the course.

This study has been approved by the WU campus Institutional Review Board (IRB) at Washburn University.

Your participation is solicited, but strictly voluntary. Do not hesitate to ask any questions about the study. Be assured that your name will not be associated in any way with the research findings. We appreciate your cooperation very much. A copy of this consent form is available upon request.

By agreeing to this consent form, I hereby grant the researcher permission to use the provided contact information to send me a link to the study described above. I understand that I will be prompted by the researcher to complete the components of the study, and after completion of those components, my contact information will be destroyed.

By choosing accept, I consent to the terms outlined above:

- Accept
- Decline

## Appendix G

### In-Person Meeting Materials

#### Sleep 101

Sleep/Wake Homeostasis – the body’s tendency to maintain a stable and relatively constant condition; responsible for creating sleep pressure. The longer you’re awake, the more pressure there is to fall asleep!

Circadian Rhythm – our internal ‘body clock’ which is synchronized with the Earth’s 24-hour rotation cycle. This ensures that we’re performing the right kinds of activities (sleeping, eating etc.) at the right times by using cues from the environment.

Responsible for:

- Changes in melatonin
- Temperature
- Alertness throughout the day

#### National Sleep Foundation’s Sleep Quality Recommendations

These characteristics of sleep indicate good sleep quality:

1. Taking 15 minutes or less to fall asleep.
2. 1 or fewer awakenings per night.
3. Awakening(s) last 20 minutes or less.
4. Sleep efficiency of 85% or above. \*

These characteristics of sleep indicate poor sleep quality:

1. Taking 45-60 minutes or more to fall asleep.
2. 4 or more awakenings per night.
3. Awakening(s) last 50 minutes or more.
4. Sleep efficiency of less than 65% for young adults and 75% for all other age groups. \*

\* Sleep efficiency is the total time asleep divided by the total time in bed (e.g. 7.5 asleep and 8 hours in bed –  $7.5/8 = 0.9375 = 94\%$  sleep efficiency).

#### Understanding Sleep Hygiene

- Remember, there is no magic number (i.e., 8 hours is not magic and many people need much less than this amount of sleep). No two people have the same sleep needs.
- As we age, we "normally" sleep less soundly (are woken up more easily), have more regular nighttime awakenings, and on average get fewer hours of sleep than when we were younger.

- Avoid caffeine. For some people, even one or two cups of coffee (or tea, or caffeinated soda, or chocolate) in the morning can have a significant effect on sleeping difficulties. At the absolute minimum, avoid caffeine in the afternoon/evening.
- Avoid alcohol. Although people often use alcohol to help themselves sleep at night, this is actually not helpful. Alcohol actually prevents us from sleeping through the night and causes us to wake up early. Even one or two alcoholic drinks can cause a restless night's sleep and can prevent the brain from entering into the deeper more restful stages of sleep. The result is that the quality of sleep is poor, and problems such as anxiety or depression often become worse.
- Avoid nicotine. Cigarettes and other tobacco products contain nicotine, which is a stimulant, meaning it wakes our brain and our bodies up. Having a cigarette too close to bedtime or having a cigarette when waking up in the middle of the night can actually prevent us from falling asleep.
- Many cold medications contain decongestants or caffeine. These are also stimulants that wake our bodies and brains up, making it harder to fall and stay asleep. Know what you are taking and avoid these stimulants. Many asthma or breathing medications can make sleep more difficult. Check with your doctor about this possibility.
- Regular moderate daily exercise is helpful for getting a good night's sleep. However, do not undertake vigorous exercise or eat heavy or sweet foods within 3 hours of your bedtime.
- Keep bedroom temperature comfortable (65 degrees is ideal, but anything over 75 will cause us to wake up) and make sure the room is dark and quiet. Wear loose-fitting, comfortable clothes to bed.
- If you wake up in the night or have difficulty falling asleep, do not check the clock. Set the alarm for your chosen wake-up time and turn the clock around so you can't see the time.

### **Sleep Hygiene “Rules”**

- Select a standard wake up time – 7 days a week. Remember, we can't control when we fall asleep, but we can control when we wake up. This will help us to reset our body's internal clocks and get our body to start working with us the help us sleep, instead of us struggling against our body to try and make ourselves sleep.
- Use bed only for sleeping or sex. No watching TV, reading, working, or being on a laptop while you are in bed. Doing these things in bed prevents our brain from associating being in bed with getting restful sleep. It also keeps our brains awake, making it more likely when we “try” to go to sleep that our brains will continue to be awake making it harder to fall and stay asleep.

- Get up when you can't sleep. Do not stay in bed if you are awake for more than about 20 minutes. Remember – don't clock watch, just use your best guess. If you don't fall asleep after about 20 minutes, get out of bed and leave the bedroom. Do a relaxing activity such as reading, listening to music, watching TV, etc., in another room and return to bed only when sleepy.
- Don't worry, plan, problem solve, do math in your head, or do anything else that wakes your brain up while you are in bed. If you are unable to put a particular thought or issue aside, go into another room while you are working through the issue in your mind and then return to bed when you are sleepy and no longer actively working on the issue.
- Avoid daytime napping. Remember, this decreases our sleep need, reducing the chances that we will be able to get quality, condensed sleep at night. Being tired during the day is okay, it is a sign that you are building up sleep need and will thus be able to sleep better at night, when you ideally would like to be spending your sleep need.
- Go to bed only when you are sleepy, but NOT before the time prescribed. Remember, spending more time in bed does not mean you will get more sleep, just like buying longer pants doesn't make me taller and trying to spread out the dough from a small pizza to fit the pan for a large pizza doesn't make it into a large pizza.

### **Understanding Beliefs about Sleep**

- Misattribution – when things go wrong, they are attributed insomnia or not sleeping
  - “I woke up feeling groggy, that means I didn't sleep well last night.”
  - “I am so tired I can barely function in the afternoon.”
- Emotional reasoning – when you use your feelings or emotions as facts
  - “I'm feeling really anxious today, I'm definitely not going to sleep tonight.”
  - “I feel fatigued during the day, I must not be getting enough sleep.”
- All-or-nothing thinking – black and white thinking, no in-between or gray areas
  - “If I don't sleep 8 hours, I'm worthless the next day.”
  - “I didn't sleep at all last night.”
- Self-fulfilling prophecy – predicting you will have a terrible day because you slept poorly the night before, increases the chances you will have a terrible day
  - “Today is going to be terrible, I barely slept last night.”
  - “I won't be able to get through this day.”
- Catastrophizing – when we jump to the worst-case scenario about us not sleeping

“If I don’t sleep, I won’t be able to handle my day or function ...I will get fired, I won’t be able to pay the rent/mortgage...I will be homeless.”

“If I keep not sleeping, I will ‘lose it’ or ‘go crazy.’”

- Overgeneralization – when we put too much emphasis on a single event or incident

“I had trouble completing my crossword puzzle today, so I will be mentally useless at work.”

“I didn’t sleep well last night; I’m going to sleep poorly again tonight.”

- Discounting the positive – focusing in on the instances where we “mess up” and ignoring the many times we do things well

“I almost got into a car accident while changing lanes today, I am sleep deprived.”

“I forgot to send an email today, I am barely functioning

**Appendix H**

*Sleep Study Participant Checklist*

IN-PERSON MEETING: MON. 11/06

SLEEP TIME: \_\_\_\_\_

WAKE TIME: \_\_\_\_\_

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
11/05	11/06 Meeting <input type="checkbox"/> Download App & Set Reminders	11/07 Week 1, Day 1	11/08 Week 1, Day 2	11/09 Week 1, Day 3	11/10 Week 1, Day 4	11/11 Week 1, Day 5
11/12 Week 1, Day 6	11/13 Week 1, Day 7	11/14 Week 2, Day 1  <input type="checkbox"/> Fill out link for week 1	11/15 Week 2, Day 2	11/16 Week 2, Day 3	11/17 Week 2, Day 4	11/18 Week 2, Day 5
11/19 Week 2, Day 6	11/20 Week 2, Day 7	11/21 Week 3, Day 1  <input type="checkbox"/> Fill out link for week 2	11/22 Week 3, Day 2	11/23 Week 3, Day 3  <i>Happy Thanksgiving!</i>	11/24 Week 3, Day 4	11/25 Week 3, Day 5
11/26 Week 3, Day 6	11/27 Week 3, Day 7	11/28 End ☺ <input type="checkbox"/> Fill out link for week 3 <input type="checkbox"/> Fill out post-tests link	11/29	11/30	12/01	12/02

## Appendix I

### Debriefing Form

This study is concerned with treatment of sleep difficulties and shaping healthy sleep behaviors and attitudes using a mobile application. Previous studies have found that through use of the Cognitive Behavior Therapy (CBT) techniques, individuals have less beliefs in sleep myths, have better sleep hygiene practices, and better sleep quality.

#### **How was this tested?**

In this study, you were asked to track elements of your sleep for four weeks overall. After tracking for one week, you attended a meeting to learn about healthy sleep practices, myths about sleep, and how to use the CBT-I Coach app. You were asked to use the app to shape healthy sleep habits through the sleep tracking, reminders, and tools to help quiet your mind. You took several questionnaires throughout the study with a focus on your sleep quality, sleep hygiene practices, and dysfunctional beliefs about sleep. Your sleep diary information was used to see how your sleep changed throughout the study and your pre-and post-test scores were also compared to look for any changes in your overall sleep quality, sleep hygiene, and beliefs about sleep.

#### **Hypotheses and main questions:**

We expect to find that using a sleep diary and using the app on a daily basis will have a positive effect on overall sleep quality, sleep hygiene practices, and beliefs about sleep.

#### **Why is this important to study?**

Sleep is a major component in overall health and wellbeing. It is important to shape good sleep behaviors in order to promote good sleep quality and daytime functioning. There aren't always easy ways to access a professional to help with sleep difficulties. Using technology to help improve sleep is an easy way, accessible to anyone who has a smart phone, to provide high quality information and practices without the barriers that exist with traditional sleep treatments. Technology can also be used by those who want to improve their sleep but do not feel that they have difficulties large enough to warrant seeing a sleep professional.

#### **What if I want to know more?**

If you would like to receive a report of this research when it is completed (or a summary of the findings) or want access to additional sleep resources, please contact Julia Leonard at [Julia.leonard@washburn.edu](mailto:Julia.leonard@washburn.edu).

If you have concerns about your rights as a participant in this experiment, please contact the WU IRB Secretary at (850) 644-8633.

Thank you again for your participation!