# The Effect of a Six-Week Mindfulness Meditation Stress Reduction Course on the Effect of Mobile Phone Use on Sleep Quality in Master Students at the University of Twente

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**Abstract**

This research examines the effect of mindfulness on the effect mobile phone use has on sleep quality. More specifically, it investigates three effects. First, the effect of mobile phone use, conceptualized into duration and frequency, on sleep quality. Second, the effect of mindfulness on sleep quality. And third, which is the main focus of this thesis, the effect of mindfulness on the effect of mobile phone use on sleep quality. The primary goal of this study is to explore these effects in a sample of master's students at the University of Twente that are enrolled in a mindfulness meditation stress reduction course. The mindfulness course implemented at the University of Twente is based on the mindfulness training by Kabat-Zinn, called mindfulness-based stress reduction (MBSR).

It was hypothesised that sleep quality and mindfulness will improve after the students participated in the course. Additionally, it was hypothesised that mindfulness improves sleep quality, while mobile phone use impairs sleep quality. Lastly, it was hypothesised that mindfulness moderates the effect of mobile phone use on sleep quality. To assess these expectations an online questionnaire measuring mindful awareness, mobile phone use, and sleep quality was conducted. The students in the sample were asked to fill in the questionnaire at the beginning of their mindfulness course and after they finished the mindfulness course.

Results showed that mindfulness remained constant, and sleep quality scores improved during the mindfulness course. Moreover, the results indicate that the frequency and duration of mobile phone use impaired sleep quality. Lastly, the hypothesised moderation effect of mindfulness on mobile phone use and sleep quality has not been found within this sample.

Concluding, this study indicated a negative influence of mobile phone use on sleep quality, which was not moderated by mindfulness. Despite the limitations, such as a small sample size and no control group, these results provide a starting point for further research in a more stringent experimental design.

*Keywords:* Sleep, Mobile phone use, Mindfulness, MBSR

## Introduction

Mindlessly scrolling through social media or checking messages before going to sleep occurs more frequently with the continuing accessibility of smartphones, but how does that affect the quality of our sleep? Poor sleep is associated with a variety of critical health outcomes, such as cardiovascular disease, obesity, poor mental health, and neurodegenerative disease (Hale et al., 2020). It also affects mood, immune function, and metabolism (Levenson et al., 2016). Unfortunately, sleep problems are common and likely to increase (Adams et al., 2017). The reason for this is that people are overburdened with competing demands on their time, with a quarter of all adults reporting in a national survey of Australian adults that their usual schedules prevent them from getting enough sleep (Adams et al., 2017). Demands at work such as overtime and constant accessibility are risk factors for sleep problems, but also habits such as watching a movie or using the phone before bed impair sleep (Adams et al., 2017, DAK-Gesundheit, n.d.).

The important role of sleep is suggested by the point that sleep deprivation has been shown to have negative effects on humans, both mentally and physically (Hale et al., 2020, Levenson et al., 2016, Walker, 2008), while healthy sleep habits ensure recovery in many aspects of life (Peach et al., 2016). It is hypothesised that sleep contributes to the processes of learning, memory, and brain plasticity (Walker & Stickgold, 2006). Correspondingly, poor sleep can lead to cognitive impairing consequences. Evidence suggests a bi-directional and symbiotic relationship between sleep and memory (Walker, 2008). Overall, sleep plays a crucial role in moderating and regulating memory processes, both before and after learning. Sleep before learning has been shown to be necessary for the encoding of certain knowledge, while sleep after learning positively affects the consolidation of numerous forms of memory (e.g., declarative and nondeclarative) (Walker, 2008).

As mentioned before, sleep not only affects cognitive functions but also impacts mental health. For instance, improving sleep led to improvement in mental health regardless of the severity of mental health difficulty (clinical vs. non-clinical) (Scott et al., 2017). Research predominantly studies the association between insomnia, depression, and anxiety (e.g., Alvaro et al., 2013, Taylor et al., 2005). However, there is evidence that sleep disturbances are linked to a variety of mental health difficulties (Scott et al., 2021) such as post-traumatic stress (Harvey et al., 2003), eating disorders (Lauer & Krieg, 2004), and psychosis spectrum experiences (e.g., delusions, hallucinations) (Reeve et al., 2015, Scott et al., 2017).

Wang and Bíró (2021) in a literature review stated that several studies and reports concluded that over the past years, sleep quality among young adults has been significantly decreasing. Sleep duration loss, sleep initiation and maintenance problems, as well as morning tiredness, are the main features of poor sleep quality (Wang & Bíró, 2021). A survey investigating short sleep duration (<9h for children aged 6-12 years; <8h for teens ages 13-18 years; and <7 h for adults aged 18-60 years) in US citizens found a high prevalence rate (72.2%) (Wang & Bíró, 2021). In a large study ($n$ = 1125) by Lund et al. (2010), the Pittsburgh Sleep Quality Index (PSQI) classified more than 60% of college students as poor-quality sleepers.

Sleep problems become more and more common among college and university students (Wang & Bíró, 2021, Lund et al., 2010). During university and college, young adults go through a period of psychological challenges and adaptation. Sometimes, resulting in sacrificing important dimensions of their lives, such as maintaining good sleep quality (Dinis & Bragança, 2018). Great academic responsibility, stress, social pressure, and an irregular schedule make students prone to sleep disturbances and deprivation (Wang & Bíró, 2021). University life brings substantial freedom, autonomy, minimal supervision, and many opportunities for outside entertainment (e.g., student clubs, concerts, and night bars). Balancing an academic career and a healthy social life while entertainment opportunities are conveniently available could interfere with sleep quality. Consequently, the student might go late to sleep and wake up early to go to classes, resulting in insufficient sleep duration. In sum, university life increases stress (e.g., high academic pressure) and irregular sleep-wake patterns (e.g., irregular schedules) then decreases overall sleep quality.

**Mobile phone use and sleep**

With recent technological advancements, screen-based technologies are more commonly used among people of all ages, especially university students (Steffens et al., 2017). It is crucial to have screen-based technologies available to partake at university. Even for small things such as communication between the university and students, it is essential to be able to receive emails. Students use mobile phones for academic purposes as well as for watching videos, browsing social media or listening to music. Screen-based technologies open a world of many possibilities of entertainment conveniently and readily available just a click away. Consequently, college-age students spent up to ten hours on average per day on their mobile phones (Roberts et al., 2014).

Ultimately, there is no consensus over a recommended amount of screen time for adults, but rather the perception of individual users and their use of their mobile phones (what

they do and how they use it) is what determines whether screen time is unhealthy (Twenge & Campbell, 2018). As of today, there are no guidelines for adults regarding screen time. However, until age-specific guidelines are developed, adults should not be prevented from following the screen time guidelines for children and youth (LeBlanc et al., 2017). For instance, guidelines for children recommend that screen time should be limited to no more than two hours per day outside of school (Tremblay et al., 2016).

With all these entertainment options and the rise in sleep problems among university students (Lund et al., 2010), it may seem reasonable to believe that electronic media use is linked to poor sleep. There are many reasons for reduced sleep quality, however, night-time media use is commonly cited as one probable cause (Wang & Bíró, 2021). Literature suggests electronic media use to be a contributing factor to impaired sleep, such as later bedtimes, longer sleep latency, reduced sleep duration, and disturbed sleep (Hale & Guan, 2015). Mobile phones in particular affect sleep since they can be easily used in bed.

There are three common lines of explanation for the effect of electronic media on sleep (Bartel & Gradisar, 2016). First, is the *displacement effect*. The displacement effect mostly relates to sleep duration and means that media use may displace sleep in the sense that time spent on media before bedtime leaves less time available for sleep (Van den Bulck, 2005). Second, the *blue light* emitted from media screens. It has been found that the blue light emitted from media screens may impair sleep quality by suppressing melatonin secretion (Chang et al., 2014). The suppression of melatonin increases alertness at a time when the body needs to unwind and get ready to sleep. Third, *pre-sleep somatic and cognitive arousal* (Van den Bulck et al., 2016). The media content we expose ourselves to can evoke somatic and cognitive arousal which impairs the ability to fall asleep and might induce nightmares (Van den Bulck et al., 2016).

**Mindfulness-Based Stress Reduction and Sleep**

While some habits like mobile phone use negatively impact sleep quality, other habits can positively influence and, therefore, improve sleep quality. Mindfulness meditation is one of those habits that can improve sleep quality, increase concentration, and improve memory (Geethika & Priya, 2016). A common definition is Jon Kabat-Zinn's, which describes mindfulness as cultivated moment-to-moment awareness achieved by paying attention without judgment to what is happening at the moment (Khoury et al., 2015). Various psychological disorders and medical conditions such as chronic pain (Kabat-Zinn et al., 1987), or fatigue (Surawy et al., 2005) can be effectively treated with mindfulness-based interventions.

A well-established mindfulness training called mindfulness-based stress reduction (MBSR) has been shown to reduce stress, anxiety, and depression (Kabat-Zinn, 2013). Initiated by Professor Jon Kabat-Zinn in the 1970s, MBSR teaches individuals to observe situations and thoughts without judgment. As part of its training programme, MBSR offers formal mindfulness practices such as body scans, sitting meditation, yoga, and a mindfulness-retreat-day. By reducing emotional reactivity and improving cognitive appraisal, MBSR aims to change one's relationship with stressful thoughts and events (Teasdale et al., 1995). MBSR is conducted over an eight-week period, with its central focus being group practices and discussions regarding the experience of meditation and its application to life (Kabat-Zinn, 2013).

Several studies have been conducted regarding the effectiveness of MBSR. A meta-analysis by Khoury et al. (2015) has found that MBSR reduces distress, depression, and anxiety, and enhances the quality of life. A systematic review by Winbush et al. (2007) focusing on the effectiveness of MBSR on improving sleep quality found a link between MBSR and improved sleep quality. MBSR participants were found to experience a decrease in sleep-interfering cognitive processes (e.g., worry), that in turn improve sleep quality. Additionally, research investigating the relationship between the use of body scan meditation and the effectiveness of insomnia treatment found body scan mindfulness meditation to have a positive effect on sleep in adolescents (de Bruin et al., 2020). There was a shorter subjective sleep onset latency for the body scan group, as well as a higher total sleep time and sleep efficiency than for the non-body scan group.

Due to MBSR's effectiveness, some universities started to implement MBSR-like courses in their curricula. For instance, the University of Twente offers a similar course in the master track Positive Clinical Psychology and Technology within the module "Personal Reflection and Development" (PRD). Here, the students participate in a six-week mindfulness meditation stress reduction course that is based on the principles of MBSR. The programme includes weekly group meetings, homework, walking and sitting mindfulness meditation, and the body scan. However, yoga and the mindfulness-day are not implemented at the University of Twente. Some of the goals of the course, for example, are to build a relation to difficult emotions with greater moment-to-moment acceptance, and, to learn how to integrate core mindfulness and self-compassion exercises into daily life (*Positive Clinical Psychology & Technology | Courses & Research | Psychology*, n.d.).

**Current research**

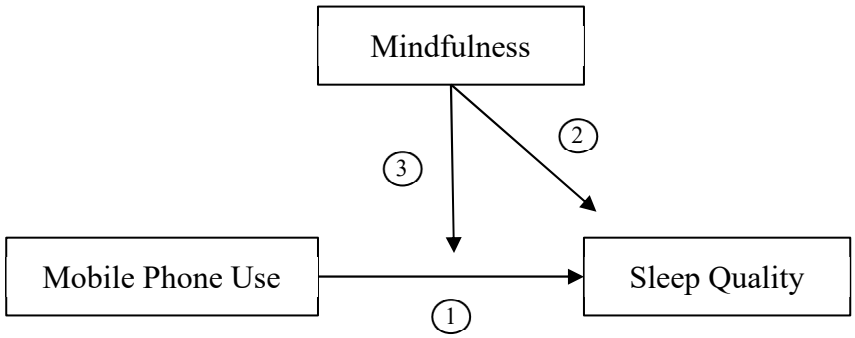
Healthy sleep habits are important for a physically and mentally healthy state, however, maintaining healthy sleep habits is sometimes compromised due to the stressful lives of university students. Mobile phone use has been shown to have a negative effect on sleep quality (e.g., Hale & Guan, 2015), while mindfulness activities (e.g., meditation) positively affect sleep (e.g., Winbush et al., 2007). One possible solution to the problem of poor sleep quality could be to use the mobile phone more rarely and engage in more mindfulness activities. However, the life we live does not particularly make it easy to just leave your phone out of your daily activities when you need to be accessible for work or your studies.

Mindfulness might help with habitual behaviour patterns that could be potentially harmful. Habitual behaviour patterns include behaviours that are in essence normal and common experiences, such as worrying, which can turn into mental habits that occur repetitively and automatically (Verplanken & Fisher, 2013). The characteristics of mental habits include persistence and ruminative thinking, unintentional tendencies, and the difficulties of changing them once established. The placement of mindful attention on the mediate experience and adopting a curious, open, and accepting attitude toward that experience (Bishop et al., 2004) positively affects habitual worrying (Verplanken & Fisher, 2013). Literature suggests mindfulness to perform as a general antidote for the consequences of multiple habitual behaviours such as habitual mobile phone use (Trub & Starks, 2017) and substance use disorders (Brewer et al., 2010). For instance, habitual phone use describes a feeling of reliance on the phone. Furthermore, maladaptive habits can interfere with other acts as a result of external or internal cues, for example, checking a smartphone in dangerous situations such as while driving (van Deursen et al., 2015). Since mindfulness has been shown to mediate habitual mobile phone use (Trub & Starks, 2017), it can be suggested that mindfulness might also influence mobile phone use which, for example, influences sleep.

An extensive body of literature devotes attention to the relationship between electronic media and sleep, as well as mindfulness and sleep. Yet, scholars have devoted little to no attention to their interplay so far. Hence, the question arises whether there is an interactive effect of mindfulness on the relationship between mobile phone use and sleep, which is exactly what this research is investigating. Moreover, this study explores three key themes and their effects on each other which is illustrated in Figure 1. The key themes are 1) the effect of mobile phone use on sleep quality, 2) the effect of mindfulness on sleep quality, and 3) the effect of mindfulness on the effect of mobile phone use on sleep quality.

**Figure 1**

*Key themes and their relationship in this study*




*Note.* This figure displays the examined variables and the examined relationships.

All in all, resulting in the following research questions:

RQ1: To what extent does the mindfulness meditation stress reduction course affect sleep quality in master students at the University of Twente?

RQ2: To what extent does mobile phone use affect sleep quality in master students at the University of Twente?

RQ3: To what extent does a mindfulness meditation stress reduction course affect the relationship between the duration of mobile phone use and sleep quality in master students at the University of Twente?

And the associated hypotheses are formulated as followed:

H1: Master students with higher mindfulness scores have better sleep quality scores than students with low mindfulness scores.

H2: Master students with lower mobile phone use have better sleep quality scores than students with high mobile phone use.

$H3_a$: Students' mindfulness scores will be higher after the PRD course.

$H3_b$: Students' sleep quality scores will be better after the PRD course.

H4: Mindfulness activities decrease the effect of the duration of mobile phone use on sleep quality in master students at the University of Twente.

## Method

### Participants

In this study, the participants were students enrolled in the master's track "Positive Clinical Psychology and Technology" (PCPT) at the University of Twente. More specifically, those students had to be enrolled in the course "Personal Reflection and Development" (PRD). Participants that did not finish the pre-test questionnaire or the post-test questionnaire

were excluded from the sample. Additionally, respondents that withdrew their consent at the beginning, during, and after the study had been finished, were also excluded.

The inclusion criteria for this study were English reading skills and comprehension of the English language, being above the age of 18, having access to a functioning internet connection, and being enrolled in the course "Personal Reflection and Development". Only the answers of respondents that accepted the conditions of the informed consent and, thereby, allowed the usage of their data in this study were analysed. The overall sample comprised 35 individuals and consisted of German citizens ($n$ = 26, 74.3%), Dutch citizens ($n$ = 8, 22.9%), and other nationalities ($n$ = 1, 2.9%). The distribution of gender was as followed, seven of the respondents were male ($n$ = 7, 20%), 28 of the respondents were female ($n$ = 28, 80%), and zero respondents identified as non-binary ($n$ = 0, 0%). Overall, the respondents were between 21 and 29 years old ($M$ = 23.74, $SD$ = 1.77).

The sample size and characteristics varied between the pre-test and post-test. In the pre-test, the sample included 33 respondents. The sample comprised primarily German citizens ($n$ = 25, 75.76%), Dutch citizens ($n$ = 7, 21.21%), and other nationalities ($n$ = 1, 3.03%). Additionally, different genders were represented, six of the respondents were male ($n$ = 6, 18.18%), 27 of the respondents were female ($n$ = 27, 81.81%), and zero respondents identified as non-binary ($n$=0, 0%). Overall, the respondents were between 21 and 29 years old ($M$ = 23.64, $SD$ = 1.76). The post-test showed a lower participation rate with 22 respondents. 13 respondents that took part in the pre-test did not start the post-test questionnaire. The sample in the post-test consisted primarily of German citizens ($n$ = 17, 77.3%), secondarily of Dutch citizens ($n$ = 3, 13.6%), and non-other nationality ($n$ = 0, 0%). Moreover, the sample contained predominantly females ($n$ = 17, 77.3%) and males ($n$ = 5, 22.7%). The respondents were between 22 and 26 years old ($M$ = 23.546, $SD$ = 1.405). For the post-test, the data of the remaining 22 respondents had been used, since none withdrew their consent, and all 22 respondents finished the post-test questionnaire fully.

**Design**

This quantitative longitudinal research design investigated the relationship between mobile phone use, sleep quality, and mindfulness with the use of questionnaires. More specifically, it investigated whether mindfulness moderates the effect of the duration of mobile phone use on sleep quality. The independent variables were mobile phone use and mindfulness, while the dependent variable was sleep quality. The study consisted of a pre- and post-test questionnaire. Mobile phone use was researched regarding the factor's 'duration' and 'frequency'. At the same time, sleep quality was measured using the Pittsburgh

Sleep Quality Index (PSQI). The factor mindfulness was measured using the Mindfulness Attention Awareness Scale (MAAS). This study had been ethically approved (221179) by the ethics committee of the Faculty of Behavioural, Management and Social Sciences of the University of Twente.

For the construction and distribution of the pre- and post-test questionnaire, Qualtrics was used. Qualtrics is a web-based software that was selected, since the platform is easy to use, secure, and provides helpful tools to develop surveys and collect data. It creates web-based surveys that can be easily distributed using a (personalized) link or via email. The distribution of both, pre- and post-test, was done using email. The researcher also made use of personalised links.

In the developed questionnaire (see Appendix) the researcher assessed the demographics of the respondents, their mindfulness (MAAS), sleep quality (PSQI), and their mobile phone use (MPU). Before the respondents were able to fill in the questionnaire, they had to accept the informed consent form, if the participant did not want to consent they were forwarded to the end of the questionnaire. The respondent was able to fill in the pre-test questionnaire at the beginning of their PRD course. The pre-test was open for responses for 14 days (08.11.2022 - 23.11.2022). At the same time, the respondent was free to fill in the questionnaire whenever they wanted, as long as it was within these 14 days. The respondents were asked to fill in the post-test questionnaire at the end of their PRD course (15.12.2022 - 29.12.2022). The post-test had identical items to the pre-test; however, the post-test did not have items concerning informed consent.

## Materials

### *Pittsburgh Sleep Quality Index (PSQI)*

The Pittsburgh Sleep Quality Index (PSQI) is a self-rated questionnaire designed to measure sleep quality in a clinical setting over a 1-month time interval (see Appendix). It consists of 19 self-rated items and five items rated by a bed partner or roommate. For this research, only the self-rated items had been assessed. The 19 items are grouped into seven components, which are the standardized version of areas that are routinely assessed in clinical interviews of patients with sleep complaints (Buysse et al., 1989). Namely, the seven components are *subjective sleep quality*, *sleep latency*, *sleep duration*, *habitual sleep efficiency*, *sleep disturbances*, *use of sleeping medication*, and *daytime functioning*. While scoring the PSQI, every item is grouped into one of the seven component scores, each measured on a 0-3 scale. Each component score is summed to yield a global PSQI score, ranging from 0 to 21, where a higher score indicates worse sleep quality (Buysse et al., 1989).

In their 18-month field assessment of clinical and clinimetric properties of the PSQI Buysse et al. (1989) found that the overall measures of internal homogeneity, consistency (test-retest reliability), and validity were good. As for the internal homogeneity, their research obtained a score that indicated a high degree of internal consistency between all seven components ($\alpha = 0.83$), as well as between all individual items ($\alpha = 0.83$). To measure the test-retest reliability Buysse et al. (1989) tested 91 respondents on two occasions ($T_1$, $T_2$). Paired t-tests for the global PSQI score and the seven components showed no significant differences between both occasions. As a result, the $T_1$ -$T_2$ correlation coefficient for global PSQI scores was 0.85 ($p < 0.001$), and for the individual components the coefficient scores ranged from 0.84 (sleep latency) to 0.65 (medication use) ($p < 0.001$ for each component score). Buysse et al. (1989) conclude from their 18-month assessment that the clinimetric and clinical properties of the PSQI suggest the usefulness of the index in clinical practice and research activities.

***Mobile Phone Use***

Mobile Phone Use (MPU) was measured using two items (see Appendix). The items were formulated in a self-report manner, where the respondents had to subjectively estimate their MPU themselves. The items were based on two aspects of MPU, namely, *duration* and *frequency*. For duration, the participant had to indicate how much time they spent (on average) on their phone during the day. Here, the participant could choose between five options ranging from ‘Less than 1 hour’ to ‘7 hours or more’. For the frequency of MPU, the participant was asked to assess how often they picked up their phone during one hour on an (average) study day. There were no specifications regarding what the hour should look like. For this item, the participant could choose between five options ranging from ‘0 - 1 time’ to ‘20 times or more’.

***Mindfulness Attention Awareness Scale (MAAS)***

The Mindfulness Attention Awareness Scale (MAAS) is a self-report questionnaire (Appendix). The MAAS consists of 15 statements that measure the individual differences in the frequency of mindful activities over time (Brown & Ryan, 2003). It focuses on the dispositional factors of the presence or absence of what is occurring in the present moment, rather than on attributes, such as acceptance, trust, and empathy, that are associated with mindfulness. More specifically, the MAAS focuses on present-centred attention-awareness (Brown & Ryan, 2003). Here, the respondent should indicate how much they could identify themselves with each statement on a 6-point Likert scale ranging from one (‘Almost always’) to six (‘Almost never’), a higher score indicating more mindful awareness.

Research by Brown and Ryan (2003) concludes that the MAAS has a good degree of internal consistency with an $\alpha = 0.85$ for the student sample and an $\alpha = 0.87$ for the adult sample. In both cases, all scale items were significantly related to the latent factor ($p < 0.001$). Additionally, analyses by MacKillop and Andersen (2007) also conclude that the internal reliability of the MAAS is good ($\alpha = 0.89$). Validity is demonstrated by the MAAS by displaying convergent and determinant correlations in the expected direction compared to other measures such as the MMS which assesses individual differences in proneness to achieve mindful states (Brown & Ryan, 2003).

**Procedure**

Potential participants were informed about this research in a short segment of the introductory lecture for the PRD course. After the lecture was finished, the researcher had a few minutes to give a short presentation regarding the study to recruit future participants. The students were informed verbally during the presentation and in written form via announcements on Canvas.

Data collection started via Qualtrics on the 8th of November 2022, so that the students completed the pre-test questionnaire before, or at the beginning of their PRD course. The students were sent an email with a corresponding link to the pre-test questionnaire. Within the pre-test questionnaire, the respondents were asked to accept or deny the conditions of the informed consent. Then, they were asked to fill in some items concerning the demographics, and afterwards, the students were asked to fill in the PSQI, MAAS, and MPU. Between the pre-test and the post-test was a six-week time frame, in which the students participated in their practice phase of the PRD course. At the end of the PRD course phase, the students were provided with the link for the post-test via email. The post-test questionnaire was similar to the pre-test, with the exception of the informed consent. Data collection ended on the 28th of December 2022.

**Data analyses**

After the data collection had been finished data analysis was performed using the statistical programme SPSS. One respondent that did not finish the questionnaire was excluded from the data set. Multiple analyses were conducted for both, the pre-test and the post-test. At first, to assess the relationship between the variables MAAS and PSQI a simple linear regression analysis had been conducted. Afterwards, two simple linear regression analyses were performed to test the relationship between the duration of MPU and PSQI, and the frequency of MPU and PSQI. Then, a regression analysis with a moderation interaction effect was done to estimate the interaction effect of MAAS on the relationship between MPU

and PSQI. Lastly, a dependent t-test was used to analyse the variables MAAS and PSQI, controlling for the values of the pre-test measurements.

## Results

For all variables different analyses had been conducted. Simultaneously, all analyses were done for both measurements, pre- and post-test measurements, as shown in Table 1.

**Table 1**

*Descriptive statistics of Raw Scores*

| Variable | *n* | *M* | *SD* |
|---|---|---|---|
| Pre-Test | | | |
| PSQI | 33 | 6.45 | 2.51 |
| MAAS | 33 | 3.63 | .69 |
| Duration MPU[a] | 33 | 3.03 | .95 |
| Frequency MPU[b] | 33 | 2.97 | 1.10 |
| Post-Test | | | |
| PSQI | 22 | 5.50 | 2.26 |
| MAAS | 22 | 3.64 | .75 |
| Duration MPU[a] | 22 | 3.32 | .78 |
| Frequency MPU[b] | 22 | 3.05 | .99 |

*Note*. Overall participants were on average 24 years old (*SD* = 1.77).

[a] Five options ranging from ‘Less than 1 hour’ to ‘7 hours or more’.

[b] Five options ranging from ‘0 - 1 time’ to ‘20 times or more’.

### Pre-Test

*H1: Master students with higher mindfulness scores have better sleep quality scores than students with low mindfulness scores.*

To test the hypothesis that students with high mindfulness sleep better than students that did not engage in mindfulness activities a simple linear regression analysis had been

conducted. In line with the hypothesis, mindfulness scores did significantly predict sleep quality scores in master students, $b$ = -1.684, $SE$ = .573, $t(32)$ = -2.937, $p$ = .006, 95% CI [-2.853, -.515]. This implies the rejection of the null hypothesis that there is no effect since a significant effect had been found.

*H2: Master students with lower mobile phone use have better sleep quality scores than students with high mobile phone use.*

The hypothesis states that low mobile phone use during the day predicts good sleep quality scores in master students, while students with high mobile phone use have worse sleep quality scores. To ascertain the effect of mobile phone use on sleep quality scores two simple linear regressions were conducted. Contrary to the hypothesis, neither time spent on mobile phones, $b$ = .675, $SE$ = .459, $t(32)$ = 1.471, $p$ = .151, 95% CI [-.261, 1.610], nor the frequency of mobile phone use, $b$ = -.245, $SE$ = .407, $t(32)$ = -.602, $p$ = .551, 95% CI [-1.074, .585], significantly predicts sleep quality scores. Overall, the null hypothesis cannot be rejected, because the p-value is in each case above the cut-off point (p > .05).

*H4: Mindfulness activities decrease the effect of the duration of mobile phone use on sleep quality in master students at the University of Twente.*

Moreover, it has been hypothesised that mindfulness has a moderating effect on the relationship between mobile phone use and sleep quality. To determine this effect a regression analysis with a moderation interaction effect was conducted, which found a non-significant interaction effect depicted in Table 2, $b$ = -.015, $SD$ = .655, $t(32)$ = -.023, $p$ = .982, 95% CI [-1.356, 1.325]. The null hypothesis that there is no interaction effect between mindfulness and the relationship between mobile phone use and sleep quality cannot be rejected.

**Table 2**

*Regression coefficients for the interactive effect of mindfulness on mobile phone use and sleep quality*

| Variable | Estimate | *SE* | *t* | *p* | 95% CI | |
|---|---|---|---|---|---|---|
| | | | | | LL | UL |
| MAAS | -1.523 | 1.905 | -.799 | .431 | -5.420 | 2.374 |
| Duration MPU[a] | .273 | 2.377 | .115 | .909 | -4.588 | 5.135 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Interaction[b] | -.015 | .655 | -.023 | .982 | -1.356 | 1.325 |

*Note.* Dependent variable: PSQI. CI = Confidence interval; LL = lower limit, UP = upper limit.

[a] Five options ranging from 'Less than 1 hour' to '7 hours or more'.

[b] Interaction effect = MAAS*Duration MPU.

**Post-Test**

*H1: Master students with higher mindfulness scores have better sleep quality scores than students with low mindfulness scores.*

Similar to the pre-test, it had been hypothesised that students with higher mindfulness scores would have better sleep quality scores, than students with low mindfulness scores. To test whether there is a relationship between mindfulness and sleep quality scores, a simple linear regression analysis was conducted. Contradicting the hypothesis, the results show no significant effect, $b$ = -1.028, $SE$ = .627, $p$ = .117, 95% CI [-2.336, .279]. Therefore, the null hypothesis that there is no effect between mindfulness and sleep quality cannot be rejected.

*H2: Master students with lower mobile phone use have better sleep quality scores than students with high mobile phone use.*

In line with the pre-test, it had been hypothesised that low mobile phone use predicts good sleep quality scores in master students, and high mobile phone use predicts worse sleep quality scores. To investigate this relationship two simple linear regressions had been conducted. Inferring from the results indicate a marginally significant relationship between the duration of mobile phone use, $b$ = 1.057, $SE$ = .604, $p$ = .096, 95% CI [-203, 2.317], and frequency of mobile phone use, $b$ = .931, $SE$ = .462, $p$ = .058, 95% CI [-.033, 1.894], with sleep quality scores in master students. Therefore, the null hypothesis that there is no effect between mobile phone use and sleep quality could be rejected, meaning that there might be an effect between MPU and PSQI in the post-test measurement.

*H4: Mindfulness activities decrease the effect of the duration of mobile phone use on sleep quality in master students at the University of Twente.*

A positive effect of mindfulness on the relationship between the duration of mobile phone use and sleep quality scores had been hypothesised. To examine this moderating effect a regression analysis with a moderation interaction effect had been conducted, focusing on the

interaction effect between mindfulness and the duration of mobile phone use. The results illustrated in Table 3 imply no significant interaction effect between mindfulness and duration of mobile phone use, $b$ = -.291, $SD$ = 1.001, $p$ = .775, 95% CI [-2.395, 1.813]. This means that the null hypothesis that there is no moderating effect cannot be rejected.

**Table 3**

*Regression coefficients for the interactive effect of mindfulness on mobile phone use and sleep quality*

| Variable | Estimate | *SE* | *t* | *p* | 95% CI | |
|---|---|---|---|---|---|---|
| | | | | | LL | UL |
| MAAS | .238 | 3.199 | .074 | .942 | -6.483 | 6.959 |
| Duration MPU[a] | 1.763 | 3.538 | .489 | .624 | -5.670 | 9.197 |
| Interaction[b] | -.291 | 1.001 | -.290 | .775 | -5.670 | 9.197 |

*Note.* Dependent variable: PSQI. CI = Confidence interval; LL = lower limit, UP = upper limit.

[a] Five options ranging from ‘Less than 1 hour’ to ‘7 hours or more’.

[b] Interaction effect = MAAS*Duration MPU.

**Pre-Post Test**

It has been hypothesised that the students’ mindfulness scores will be higher, while the students’ sleep quality scores will be better after finishing the practice phase of the PRD course. Both hypotheses were tested with a dependent t-test. To conduct the dependent t-test the sample needed adjustments. Hence, from the original overall sample size of 35 respondents, a sub-sample of 20 (57.14%) respondents was used for the dependent t-test. Two (5.71%) respondents were excluded since they did not participate in the pre-test. The remaining 13 (37.14%) respondents from the pre-test were excluded since they did not partake in the post-test.

*H3a: Students’ mindfulness scores will be higher after the PRD course.*

A dependent t-test had been conducted to compare the students' mindfulness scores before the PRD course (Pre) and after the PRD course (Post). The results from the pre-test ($M$ = 3.573, $SD$ = .753) and post-test ($M$ = 3.689, $SD$ = .780) for mindfulness scores indicate that the PRD course did not significantly result in an improvement of mindfulness scores, $t(19) = -.963$, $p = .174$. Thus, the null hypothesis indicating no effect between both measurements cannot be rejected.

*H3b: Students' sleep quality scores will be better after the PRD course.*

To assess the students' sleep quality scores before the PRD course (Pre) and after the PRD course (Post), a dependent t-test had been conducted. It was hypothesised that the sleep quality scores will be better after the PRD course. There was a significant positive effect on the sleep quality scores between the pre-measurement ($M$ = 6.9, $SD$ = 2.732) and post-measurement ($M$ = 5.7, $SD$ = 2.273), $t(19) = 2.987$, $p = .005$. Therefore, the null hypothesis can be rejected.

## Discussion

This study aimed to offer insights regarding the interactive effect of a mindfulness course on the effect of the duration of mobile phone use on sleep quality in master students enrolled at the University of Twente. For this research, three key themes have been investigated. First, the effect of mindfulness on sleep quality. Second, the effect of mobile phone use on sleep quality. Lastly, the interactive effect of mindfulness on the effect of mobile phone use on sleep quality. All three key themes were assessed before the mindfulness course and after. It was found that mindfulness improved sleep quality, while mobile phone use impaired sleep quality. Additionally, the results indicate no significant interactive effect of mindfulness on the effect of the duration of mobile phone use on sleep quality.

In line with the first hypothesis, the results indicate that higher mindfulness is related to better sleep quality scores. Hence, students that engage in mindfulness meditation sleep better than students that did not. This finding not only verifies the first hypothesis but also is in line with the literature that was reviewed within this study (Geethika & Priya, 2016, Winbush et al., 2007).

The second hypothesis implied that more mobile phone use is related to worse sleep quality. Here, mobile phone use had been divided into frequency and duration of use. In this research, an increase in the duration of mobile phone use is related to worse sleep quality. This means that students that spent more time on their phones during the day appeared to sleep worse than students that spent less time on their phones. Hence, this finding is in line with the hypothesis. Additionally, this finding replicates the results from already established

research (Van den Bulck, 2005, Van den Bulck et al., 2016). However, the results concerning frequency seem ambiguous. For the measurement conducted before the mindfulness course, the results indicate that students that used their phones more frequently had better sleep quality scores. The measurements conducted after the mindfulness course imply the opposite, although none of these analyses of the relations between MPU and sleep quality were significant.

Additionally, it had been investigated whether sleep quality and mindfulness changed during the time period of the mindfulness course. Here, it had been hypothesised that sleep quality scores as well as mindfulness scores will be better at the end of the mindfulness course. The results indicate that the mindfulness scores remain constant over the mindfulness course, however, not significantly. In line with the hypothesis, the sleep quality scores improved after the mindfulness course.

Moreover, the main focus of this research was the hypothesis that mindfulness had a moderating effect on the effect of the duration of mobile phone use on sleep quality. This had been derived from research indicating that mindfulness improved sleep (Geethika & Priya, 2016), mobile phone use impaired sleep (Hale & Guan, 2015), and mindfulness improved habitual mobile phone use (Trub & Starks, 2017). Contrary to the hypothesis, the findings of this research suggest that there is no moderation effect of mindfulness on the duration of mobile phone use and sleep quality. One possible explanation is that mobile phone use and mindfulness are not mutually exclusive. Because someone engages in many mindfulness activities and, for instance, meditates a lot, it does not necessarily mean that that person does not use their phone as much as someone that does not meditate. Being more mindful does not replace mobile phone use or vice versa.

**Limitations**

The interpretations derived from the results have limitations due to the limited sample size and no control group. For instance, not all results had been statistically significant implying that not every effect has to be found in a bigger population. Hence, the results need to be interpreted with care. For the current study, some limitations need to be considered. The most impactful limitation is that the generalizability is limited by the sample size. It is important to mention that the highest participation consisted of 33 respondents, while the lowest participation consisted of 22 respondents. A small sample size is more dependent on the individual answers. For instance, one outlier can heavily change the outcome of an analysis. More respondents would have been ideal and beneficial for better conclusions. Furthermore, the results were not compared to a control group, so the influence of other

factors such as stress or workload cannot be accounted for in this study. This is something that needs to be tackled in future research.

Another limitation of this study refers to the conceptualization of mobile phone use. Both aspects of mobile phone use (i.e., duration and frequency) that had been investigated within this study were measured on a subjective self-report basis. This could have potentially skewed the results since mobile phone use might change the perception of time. This means that some people might evaluate the duration of time spent on their phone to be more or less than it actually is. Similarly, people might perceive their frequency of mobile phone use as more or less than it actually is. It is beyond the scope of this study to gather objective information about mobile phone use since this would have implied inferring the information from the mobile phones directly. Additionally, factors that might contribute to the effect of mobile phone use on sleep quality, such as the use of a blue-light filter (Chang et al., 2014) were not investigated in this study.

**Implications**

This research investigated a concept that has not been examined so far within the literature. Nevertheless, recent studies point to potential reasons why this concept needs to be investigated. Firstly, sleep problems are an ever-increasing societal health problem. Impaired sleep has been associated with many critical health outcomes like cardiovascular disease, poor mental health, and neurodegenerative disease (Hale et al., 2020). Moreover, recent research had found that, specifically in the population of university students, sleep problems have become more common (Wang & Bíró, 2021, Lund et al., 2010). Secondly, the literature displays a negative relationship between mobile phone use and sleep quality (Hale & Guan, 2015) and a positive relationship between mindfulness and sleep quality (Geethika & Priya, 2016). Lastly, it has been found that the more mindful a person is, the less that person is hindered by habitual behaviours that might have negative consequences (Trub & Starks, 2017). Hence, it is possible to suggest that mindfulness could change the effect that mobile phone use has on sleep quality. To the researchers' knowledge, this effect has not been investigated in the current scientific studies; it is important to explore this concept in the future. Especially since the limitations of this study impact generalizability the most, it would be important to investigate whether there is an interactive effect or not within a bigger sample.

**Future research**

While the insights of this study did not result in strong conclusions, this research could serve as a good starting point to employ further research into the implementation of mindfulness activities and its effect on mobile phone use and sleep quality. Future research

might make use of the results and limitations discussed within this study. For instance, future research could make use of a larger sample and a control group, and of more objective investigation methods, especially concerning the variable mobile phone use. Additional measures of MPU could be conceptualized as well. For instance, data concerning the use of a blue-light filter or an indication of whether the respondent used their phone shortly before falling asleep would be in line with the more common explanations of the reasons why mobile phone use impacts sleep quality (Chang et al., 2014, Van den Bulck et al., 2016).

**Conclusion**

Concludingly, this thesis investigates the effects of mobile phone use and mindfulness on sleep quality and explores the possibility of a moderating effect of mindfulness on the effect of the duration of mobile phone use on sleep quality. The results indicate that sleep quality improves, and mindful awareness remains stable over the course of the six weeks of the study programme, and there is no interactive effect of mindfulness on the effect of the duration of mobile phone use on sleep quality. Further research is suggested to investigate this concept in a larger sample size with a control group, and with possible more extensive operationalizations of mobile phone use.

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# Appendix

## Questionnaire used within Study, including PSQI, MAAS, MPU, informed consent, and demographics

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Start of Block: Informed Consent

Informed Consent
Consent Form for Participation

**The influence of mobile phone usage and mindfulness meditation on sleep in master students**

Thank you for agreeing to be part of the above-mentioned research project. This consent form is necessary for us to ensure that you understand the purpose of your involvement and that you agree to the conditions of your participation. Please select the according button to certify that you approve the following:

We are investigating the influence of mobile phone usage and mindfulness meditation on sleep in master students. This study is a mixed-method research project. The study consists of a pre-test that takes approximately 10 minutes to answer. Afterwards, the six-week meditation training will be accompanied by a daily sleep diary that takes about 5 minutes to fill in. Lastly, a post-test needs to be filled in, which will take around 10 minutes.

We don't anticipate that there are any risks associated with your participation, but you have the right to stop or withdraw from the research at any time without stating your reasons. The questionnaire will be saved by the program Qualtrics and transmitted to the researchers, further information will be stored via the mobile phone application Ethica. Access to the information gained in the questionnaires will be limited to the researchers and supervisors of this project. The answers to the questionnaires will be analysed and used in a bachelor's and master's thesis. Any content that is made available through academic publications or other academic outlets will be anonymised so that you cannot be identified, and care will be taken to ensure that the information is handled confidentially. I am voluntarily taking part in this research. I understand that I do not have to take part, and I can stop the research at any time. I do not expect to receive any benefit or payment for my participation. I understand that I am free to contact the researcher with any questions I may have in the future. In order to participate in this study, you need to agree to this informed consent. If you agree to these statements, please indicate so by selecting the according button.

If you have any further questions or concerns about this study, please contact:
Lisa Grassmann +4915786149164 l.m.grassmann@student.utwente.nl
Berta Kravcenko +4917634566720 b.kravcenko@student.utwente.nl

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Q5 Regarding this study:

- ○ I consent to participate. (1)
- ○ I do not consent to participate. (2)

*Skip To: End of Survey If Regarding this study: = I do not consent to participate.*

**End of Block: Informed Consent**

**Start of Block: Demographics**

D1 What is your sex?

- ○ Male (1)
- ○ Female (2)
- ○ Non-binary / third gender (3)
- ○ Prefer not to say (4)

D2 What is your age?

| | 18 22 26 31 35 39 43 47 52 56 60 |
|---|---|
| Age in years () |  |

D3 What is your nationality?

- ○ Dutch (1)
- ○ German (2)
- ○ Other (3) _____

D4 Where did you do your bachelor?

○ University of Twente (1)

○ Other (2) _____

End of Block: Demographics

Start of Block: Pittsburgh Sleep Quality Index

Sleep habits during the past month

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

Please answer all questions.

PSQI Q1 During the past month, when have you usually gone to bed at night?
(please fill in format "22:00" for 10pm, or e.g., "01:00" for 1am)

_____

PSQI Q2 During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

_____

PSQI Q3 During the past month, when have you usually gotten up in the morning?
(please fill in format "8:00" for 8am, or e.g., "13:00" for 1pm)

_____

PSQI Q4 During the past month, how many hours of *actual sleep* did you get at night? (This may be different than the numbers of hours you spent in bed.)

_____

Instructions PSQI For each of the remaining questions, check the one best response.
Please answer all questions.

PSQI Q5 During the past month, how often have you had trouble sleeping because you...

| | Not during the past month (1) | Less than once a week (2) | Once or twice a week (3) | Three or more times a week (4) |
|---|---|---|---|---|
| Cannot get to sleep within 30 minutes (1) | ○ | ○ | ○ | ○ |
| Wake up in the middle of the night or early morning (2) | ○ | ○ | ○ | ○ |
| Have to get up to use the bathroom (3) | ○ | ○ | ○ | ○ |
| Cannot breathe comfortably (4) | ○ | ○ | ○ | ○ |
| Cough or snore loudly (5) | ○ | ○ | ○ | ○ |
| Feel to cold (6) | ○ | ○ | ○ | ○ |
| Feel too hot (7) | ○ | ○ | ○ | ○ |
| Had bad dreams (8) | ○ | ○ | ○ | ○ |
| Have pain (9) | ○ | ○ | ○ | ○ |
| Other reason(s); please describe (10) | ○ | ○ | ○ | ○ |

PSQI Q6 During the past month, how would you rate your sleep quality overall?

- ○ Very good (1)
- ○ Fairly good (2)
- ○ Fairly bad (3)
- ○ Very bad (4)

PSQI Q7 During the past month, how often have you taken medicine (prescribed or 'over the counter') to help you sleep?

- Not during the past month (1)
- Less than once a week (2)
- Once or twice a week (3)
- Three or more times a week (4)

PSQI Q8 During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

- Not during the past month (1)
- Less than once a week (2)
- Once or twice a week (3)
- Three or more times a week (4)

PSQI Q9 During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

- No problem at all (1)
- Only a very slight problem (2)
- Somewhat of a problem (3)
- A very big problem (4)

End of Block: Pittsburgh Sleep Quality Index

Start of Block: Mindfulness Attention Awareness Scale

Day-to-day experiences

Instructions: Below is a collection of statements about your everyday experience. Using the 1-6 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what really reflects your experience rather than what

you think your experience should be. Please treat each item separately from every other item.

| | Almost always (1) | Very frequently (2) | Somewhat frequently (3) | Somewhat infrequently (4) | Very infrequently (5) | Almost never (6) |
|---|---|---|---|---|---|---|
| I could be experiencing some emotion and not be conscious of it until some time later (1) | ○ | ○ | ○ | ○ | ○ | ○ |
| I break or spill things because of carelessness, not paying attention, or thinking of something else (2) | ○ | ○ | ○ | ○ | ○ | ○ |

| | | | | | | |
|---|---|---|---|---|---|---|
| I find it difficult to stay focused on what's happening in the present (3) | ○ | ○ | ○ | ○ | ○ | ○ |
| I tend to walk quickly to get where I'm going without paying attention to what I experience along the way (4) | ○ | ○ | ○ | ○ | ○ | ○ |
| I tend not to notice feelings or physical tension or discomfort until they really grab my attention (5) | ○ | ○ | ○ | ○ | ○ | ○ |
| I forget a person's name almost as soon as I've been told it for the first time (6) | ○ | ○ | ○ | ○ | ○ | ○ |

| | | | | | | |
|---|---|---|---|---|---|---|
| It seems I am 'running on automatic' without much awareness of what I'm doing (7) | ○ | ○ | ○ | ○ | ○ | ○ |
| I rush through activities without being really attentive to them (8) | ○ | ○ | ○ | ○ | ○ | ○ |
| I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there (9) | ○ | ○ | ○ | ○ | ○ | ○ |
| I do jobs or tasks automatically, without being aware of what I am doing (10) | ○ | ○ | ○ | ○ | ○ | ○ |
| I find myself listening to someone with one ear, doing something else at the same time (11) | ○ | ○ | ○ | ○ | ○ | ○ |
| I drive places on 'automatic pilot' and then wonder why I went there (12) | ○ | ○ | ○ | ○ | ○ | ○ |
| I find myself preoccupied with the future or the past (13) | ○ | ○ | ○ | ○ | ○ | ○ |

| | | | | | | |
|---|---|---|---|---|---|---|
| I find myself doing things without paying attention (14) | ○ | ○ | ○ | ○ | ○ | ○ |
| I snack without being aware that I'm eating (15) | ○ | ○ | ○ | ○ | ○ | ○ |

**End of Block: Mindfulness Attention Awareness Scale**

**Start of Block: Mobile Phone Use**

MPU 1 How much time on average do you spend on your phone on a daily basis?

- ○ Less than 1 hour (1)
- ○ 1 - 2 hours (2)
- ○ 3 - 4 hours (3)
- ○ 5 - 6 hours (4)
- ○ 7 hours or more (5)

MPU 2 How often do you pick up your phone within one hour on a normal study day?

- ○ 0 - 1 time (1)
- ○ 2 - 5 times (2)
- ○ 6 - 10 times (3)
- ○ 11 - 20 times (4)
- ○ 20 times or more (5)

**End of Block: Mobile Phone Use**