Association Between Electronic Media Usage and Sleep Disturbances

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Abstract

The average U.S. adult fails to regularly attain the quantity and quality of sleep recommended by the Center for Disease Control (2019). One potential contributor to this epidemic is the increasing rate at which individuals utilize electronic media devices (e.g., smartphones, tablets, and televisions) before sleep. Usage of these devices has been reported to impair both overall sleep quality and the time it takes to fall asleep after entering bed (sleep onset latency; SOL) in American college students as well as in non-American adults. The present study examined the relationship between electronic media device usage after bedtime on sleep quality and SOL across a broad range of U.S. adults. Adult participants ($M_{age} = 39$ years, $SD_{age} = 11$ years) residing across the U.S. were recruited from a national crowdsourcing web service (Amazon Mechanical Turk). Participants ($N = 98$, 60% men) completed demographic measures as well as questions related to sleep quality and SOL. There was a significant positive correlation between electronic media device usage after bedtime and poor sleep quality, $r(96) = .28$, $p = .005$. The relationship between electronic media device usage after bedtime and SOL was also statistically significant, $r(96) = .59$, $p < .001$. These results are consistent with previous research examining the relationship between electronic media device usage after bedtime and both sleep quality and SOL. These results contribute to previous literature, which suggests limiting nighttime electronic media device usage as part of positive sleep hygiene and overall healthier sleep.
Association Between Electronic Media Usage and Sleep Disturbances

Sleep is an essential part of maintaining physiological health and psychological well-being, yet many people are not getting an adequate amount of sleep. Poor sleep is estimated to cost the U.S. approximately $411 billion annually. For example, lost productivity, accidents, disease burden, and several social determinants underlying health and health disparities are associated with sleep deficiency (Kiley, Twery, & Gibbons, 2019). The Centers for Disease Control and Prevention (CDC) and The National Sleep Foundation recommend getting seven or more hours of sleep per night for people 18 years or older; however, the optimal amount of sleep for a person to perform at their best is as “individual as the amount of food we need” (Ferrara & De Gennaro, 2001). The National Sleep Foundation reported 6 out of 10 Americans (13-64 years old) are not getting enough sleep to function well (Gradisar et al., 2013). Several factors likely contribute to inadequate sleep, such as societal changes in shift work schedules, extended working hours, and the belief that sleep can easily be disregarded. Over the past two decades, sleep insufficiency has likely been exacerbated by technology use (Bixer, 2009; Cappuccio & Miller, 2011).

An emerging field of sleep research has investigated the interplay between electronic media and sleep. A 2011 National Sleep Foundation poll indicated that 95% of 1508 participants (13-64 years old) used electronic media devices within the hour before bed (Gradisar et al., 2013), and Kubiszewski, Fontaine, Rusch, and Hazouard (2014) reported that 70% of teens indicated electronic media use was the final activity of the night. Previous studies examining children and adolescents have consistently found an inverse relationship between sleep outcomes and the use of electronic media devices near bedtime (Exelmans & Van den Bulck, 2016; Hale & Guan, 2015; Hysing et al., 2015). Electronic media devices appear to impact sleep quality
through mediators such as the effects of blue light on circadian rhythm and alertness, psychological and physiological arousal from the content of the media and social interaction, and sleep displacement (e.g., using device in place of sleep; Hale & Guan, 2015). To date, the majority of research on the association between electronic media devices and sleep disturbances has focused on adolescents and children, leaving a gap in the data for the adult population. Further, overall smartphone ownership in the U.S. increased from 35% in 2011 to 84% in 2018 (Jiang, 2018).

The purpose of the present study was to examine the relationship between electronic media devices and sleep quality in an adult U.S. population. Also, the present study attempted to replicate and extend Exelmans and Van den Bulk., (2018) study examining the mismatch between the modernization of our bedtime rituals and the conceptualization and operationalization of commonly used sleep variables in self-report sleep measures [e.g., delayed bedtime, sleep latency (i.e., time it takes to fall asleep), and sleep duration]. The first part of this paper examines the increase in technological device ownership and the impact of poor sleep quality on health and wellbeing. Next, this paper will address previous research on the association of electronic media devices and sleep quality. Finally, how current bedtime rituals are impacting the validity of sleep onset latency measures will be reviewed.

**Technology Adoption**

Technological devices are being developed and produced at an astronomical pace, making electronic media devices more affordable and accessible to the general population. Electronic media devices such as smartphones and tablets allow real-time interaction with the internet and social media, giving users continuous stimulation (Exelmans et al., 2018). In 2016, the Pew Research Center reported that 84% of American households contained at least one
smartphone, and a third of American families own multiple devices. Streaming devices, laptops, and desktop computers increase the percent of American households owning electronic media devices to a staggering 90%. Many believe the increase of electronic media device ownership is occurring mostly in the Millennial generation (ages 23-37) or younger; however, data from the Pew Research Center found significant growth in the adoption and use of technology from Gen Xers (ages 38-53) and Baby Boomers (ages 54-72; Anderson & Perrin, 2017). Jiang (2018) reported overall ownership of smartphones increased from 35% in 2011 to 84% in 2018, and tablet ownership increased from 3% to 53%. Ninety-two percent of Millennials, 85% of Gen Xers, and 67% of Baby Boomers now own smartphones.

Data from previous studies indicate that along with an increase in electronic media devices, there has also been an increase in social media and internet use across all generations. According to the Pew Research Center, 85% of Millennials, 75% of Gen Xers, 57% of Baby Boomers, and 23% of people over 72 years old report using social media at least occasionally (Berenguer et al., 2017; Jiang, 2018). Perrin and Jiang (2018) reported that 77% of Americans go online daily, and 26% report they are online “almost constantly”, and these numbers will likely increase as more people use mobile connectivity (e.g., smartphone, tablet, or another mobile device). The growth of electronic media device ownership has plateaued over the last two years, which is likely because of the near-saturation levels of technology adoption among American households (Hitlin, 2018). Technological advancement and electronic media device adoption have typically outpaced researchers’ ability to study the impact electronic media use may have on our daily lives and sleep schedules. The plateaued growth level of technology adoption may give researchers the chance to develop a more accurate assessment of the possible negative interactions between electronic media usage and sleep.
The adoption of electronic media devices appears to be ubiquitous across nations, socioeconomic status, and demographic age generations (Berenguer et al., 2017). The functionalities of electronic media devices continue to evolve rapidly and exponentially, allowing users to perform multiple types of activities on one device. Electronic media devices provide instant access to information and communication, internet access, health applications, streaming services, games, and GPS map applications (Lanaj et al., 2014). Electronic media devices allow users the convenience to work from home at night; however, the benefits may be offset by their potential to negatively impact sleep and reduce a person’s ability to recover regulatory resources (i.e., energy metabolism, inflammation/immune response, and neural plasticity) for executive functioning (Lanaj et al., 2014; Pearson, 2017). While previous research has indicated a negative association between electronic media devices and sleep disturbances in youth (Arora et al., 2014; Carter et al., 2016; Hale & Guan, 2015), few studies have examined the relationship between electronic media devices and sleep disturbances in adults.

**Impact of Sleep and Sleep Mechanisms on Well-Being**

 Previous research has estimated that Americans are sleeping one to two hours less per night than they were 50 to 70 years ago, and suboptimal sleep duration and poor sleep quality are widespread in modern society (Attia, 2019; Bixler, 2009). Current evidence supports the existence of a “sleep recession” with more than one in three adults now sleeping less than seven hours per night (Exelmans & Van den Bulck, 2018; Ferrara & De Gennaro, 2001; Hale & Guan, 2015; Twenge et al., 2018). Data from a 1942 poll by Gallup found the national average of sleep per night for Americans was 7.9 hours; whereas, recent data indicates an average of 6.8 hours of sleep per night (Jones, 2013). Poor sleep can have deleterious effects on physical and mental health and overall quality of life, and can increase mortality (Grandner et al., 2010). Sleep
deficiency is linked to increased risk for the development of mood and anxiety disorders and higher reported psychological distress (Fabrizio et al., 2018; Goldstein & Walker, 2014; Kubiszewski et al., 2014). Physiological and neurobehavioral problems may start to develop when the average person is getting less than 7 hours of sleep per night and become progressively worse under chronic conditions of insufficient total sleep time (Attia, 2019; Ferrara & De Gennaro, 2001; Van Dongen, Maislin, Mullington, & Dinges, 2003). Inadequate sleep has been associated with significant drops in glucose levels, reduced immune response, inflammation, and decreased cerebral metabolic rates in the prefrontal cortex, which is responsible for executive functioning (Adams et al., 2013; Schnyer et al., 2009). An estimated 20% of severe car accidents are associated with driver sleepiness (Exelmans & Van den Bulck, 2017), and lack of sleep is connected to fatigue induced technical errors, reduced memory function, learning ability, negative mood states, risk behavior, overall quality of life, and increased mortality related to obesity, insulin resistance, increased cortisol level, hypertension, and cardiovascular disease (Exelmans & Van den Bulck, 2018; Grandner et al., 2010; Twenge et al., 2018).

Sleep is a complex and highly coordinated process regulated through an interaction between three main factors: homeostatic, endogenous circadian, and behavioral. Sleep homeostasis reflects the average level of sleep depth, and its activity depends on the duration of prior sleep and wakefulness. The circadian factor mainly affects the timing and overall length of sleep entrained by external zeitgebers (i.e., external cues) to a 24-hour cycle (Aschoff, 1965), and the environmental light-dark cycle is considered the primary synchronizer. Another element that can impact the circadian factor is a person’s chronotype (i.e., extent to which someone can be categorized as a morning or evening type; Exelmans & Van den Bulck, 2018; Roenneberg et al., 2003). Morning types and evening types differ in the timing of sleep and wakefulness (i.e.,
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circadian rhythm). Evening types tend to have a higher sleep need, prefer to stay up later, and function at their peak later in the day. Morning types have an advanced internal clock and prefer earlier bedtimes and rise times (Taillard et al., 2002). Behavioral factors can override both circadian and homeostatic factors (Fabrizio et al., 2018; Fossum, Nordnes, Storemark, Bjorvatn, & Pallesen, 2014; Li et al., 2018). For example, previous studies have shown that behaviors close to bedtime that increase arousal and/or involve exposure to bright light are associated with sleep disturbances (Fabrizio et al., 2018; Fossum et al., 2014; Gracisar et al., 2013; Rosen et al., 2016).

Sleep architecture occurs in cycles and can be broadly divided into rapid eye movement (REM) sleep and non-REM (NREM) sleep (e.g., deep slow-wave sleep) (Li et al., 2018; Pearson, 2017; Zhong et al., 2019). Previous studies indicate that age is associated with decreased ability to maintain sleep due to cortical thinning, white matter degeneration, neurotransmitter dysregulation, and circadian disorganization (Zhong et al., 2019). The circadian cycle is disorganized through the suprachiasmatic nucleus (SCN; a group of neurons above the optic chiasm) progressively losing its ability to produce precise rhythms, which leads to disrupted circadian cycles with reduced amplitude. Many older adults will start to experience an advance of their sleep schedule (i.e., phase shift) of approximately one hour earlier compared with younger adults. The phase shift impacts the sleep-wake cycle, body temperature rhythm, and the timing of secretion of melatonin and cortisol (Duffy et al., 2015; Kim et al., 2014; Kripke et al., 2007). As people age, they experience reduced total sleep time (TST) through nocturnal awakenings, prolonged nocturnal awakenings, and decreased deep sleep (Li et al., 2018; Vitiello, 2006). Results from studies examining the relationship between electronic media use and sleep quality in youth may not generalize to the adult population because of biological differences in
the sleep process between adults and youth. The use of electronic media devices near bedtime likely exacerbates the reduced quality of sleep in older adults.

**How Sleep is Measured**

Researchers and health providers measure sleep through Polysomnography (PGS), actigraphy (e.g., wristwear), informant reports, diagnostic interviews, and commonly used self-report measures such as sleep diaries and the Pittsburgh Sleep Quality Index (PSQI). The PGS is considered the “gold standard” for measuring objective sleep and requires an overnight stay in a laboratory setting with trained technicians or sleep researchers (Van De Water et al., 2011). It can be costly and impractical for people with sleep difficulties to be tested with the PGS, and actigraphy’s are approximately 50% accurate at estimating REM and NREM sleep with current technology. The most commonly used methods of measuring sleep are subjective self-report sleep diaries and questionnaires because of their practicality and low cost. Studies comparing objective sleep measures and self-report measures have shown that self-reports offer a valid way to measure sleep variables, are superior to actigraphy for predicting fatigue, and as important as objective measures for some sleep issues (Pilcher et al., 1997; Short et al., 2012).

Self-report sleep questionnaires typically gauge sleep through several different dimensions over a period ranging from 1-week to 1-month (Buysse et al., 2006). The PSQI is one of the most commonly used self-report sleep questionnaires and has been empirically supported as a valid and reliable measure (Buysse, Reynolds, Monk, Berman, and Kupfer, 1989; Buysse et al., 2006; Mollayeva et al., 2016). The PSQI consist of 19 items grouped into seven equally weighted component scores: Subjective Sleep Quality, Sleep Onset Latency (SOL), Sleep Duration, Habitual Sleep Efficiency (HSE), Sleep Disturbances, Use of Sleeping Medication, and Daytime Dysfunction. The seven component scores are weighted equally on a
0-3 scale and summed together to create a global PSQI score ranging from 0-21. Higher scores indicate worse sleep quality with an empirically derived global cutoff score greater than five indicating severe difficulty in at least two domains or moderate difficulties in more than three domains. Despite the excellent psychometric properties of the PSQI, there is emerging evidence that modern-day bedtime rituals related to electronic media devices may be causing a mismatch between sleep behavior and common sleep variables (e.g., SOL, HSE, and sleep disturbances) measured on sleep questionnaires (Exelmans et al., 2018).

Before the age of electronic media devices, bedtime may have been more synonymous with going to sleep (Exelmans & Van den Bulck, 2017). In the past few decades, the portability and accessibility of electronic media devices have given people the ability to use them in while lying in bed (Exelmans & Van den Bulck, 2015, 2017; Fossum et al., 2014; Gradisar et al., 2013). Engaging in electronic media use after going to bed delays sleep onset (e.g., SOL). Sleep onset latency greater than 30 minutes may indicate sleep-onset insomnia (Lichstein et al., 2003); however, engaging in electronic media use introduces potential measurement error on sleep variables such as SOL. To address the potential mismatch between sleep behavior and common sleep variables, Exelmans and Van den Bulck (2017) introduced a new measure: Bedtime and Shuteye Time (BTST). The assessment measures bedtime as a two-step process by examining the types of activities people may be doing between the time they report going to bed and trying to fall asleep (e.g., SOL). The time spent engaging in activities between going to bed and falling asleep was labeled as Shuteye Latency (SEL).

In creating the measure, participants were offered a list of electronic media and non-media activities and asked to report how long they engaged in them after going to bed and before falling asleep. Participants reported an average of 39 minutes of SEL with a large portion of that
time engaged in media usage. SEL was related to a significant decrease in sleep quality. Participants engaging in SEL activities up to 30 minutes were 3.3 times more likely to be rated as poor sleepers on the PSQI (scores > 5), with 45% of the incidence of poor sleep due to the amount of SEL. SEL beyond 30 minutes steadily increased the participants’ odds of being rated as poor sleepers. In sum, engaging in electronic media activities introduces the potential for measurement error for common sleep variables, and using scales like the BTST may help researchers and clinicians to better account for all the possible mediators of poor sleep.

**The Relationship Between Electronic Media Devices and Sleep**

Previous studies have shown a strong negative correlation between the quality of sleep and electronic media usage among adolescents. Hale and Guan’s (2015) systematic literature review found that 90% of the studies examining youth reported a significant association between screen time, and reduced sleep duration and increased sleep problems across a range of screen types and sleep outcomes. Data from a 2016 meta-analysis indicated that 72% of children and 89% of adolescents had at least one electronic media device in their sleep environment and most reported using the device near bedtime (Carter et al., 2016). Data from a nationally representative survey of sleep duration and time use among adolescents from 2009-2015 found that adolescents in 2015 were 16%–17% more likely to report sleeping less than 7 hours compared to 2009 and the decrease in sleep had an association with increased electronic media usage (Twenge et al., 2018). Calamaro, Yang, Ratcliffe, and Chasens (2012) found that children ages 6-10 with three technology devices in their bedroom achieved 45 minutes less sleep than those without devices. While data supports a negative association between electronic media usage and sleep quality for youth, only a few studies have been conducted using an adult population. Youth are at risk for sleep deprivation and are typically thought to be more
preoccupied with electronic media devices than adults. The perception that youth are more engaged with electronic media devices than adults are presumed to be is likely contributing to the lack of studies conducted with adults (Exelmans & Van den Bulck, 2018).

Data from Pew Research indicated that adults have adopted technology on pace with youth, and the average video gamer is between 30 and 35 years old; however, adults often use electronic media devices for more than just relaxation or leisure (i.e., work activities). Because the literature indicates different processes for sleep between adults and youth (i.e., biological/environmental factors), findings from youth samples should not be extrapolated to the adult population without further research (Exelmans & Van den Bulck, 2016, 2018). For example, adults are likely dealing with far more responsibilities compared with youth (e.g., work, paying bills, childcare). Also, adults typically set their own sleep schedules (unlike typical youth) and may engage in work-related electronic media use in bed.

The Impact of Electronic Media on Sleep

Electronic media devices offer users numerous benefits such as entertainment, communication, music, games, and work; however, studies conducted on youth indicate using electronic media devices near bedtime can have adverse effects on sleep quality. Sleep researchers theorize having electronic media devices in the sleep environment truncates TST through three possible mediators: the effect of light on circadian rhythms and alertness, psychological/physiological arousal, and sleep displacement (i.e., activities done before falling asleep; Exelmans & Van den Bulck, 2018; Gradisar et al., 2013; Lemola et al., 2015; Rosen et al., 2016; Twenge et al., 2018).

Arousal. The first possible mediator from electronic media devices and poor sleep is from psychological and physiological arousal. Electronic media devices may be associated with
cognitive, emotional, and physiological arousal that may impair sleep (Exelmans & Van den Bulck, 2018; Fossum et al., 2014; Gradisar et al., 2013). Media can induce excitement, fright, and stress, which may be associated with difficulties falling asleep and poor sleep quality (Exelmans & Van den Bulck, 2018). Studies have indicated “poor” sleepers show more state and trait anxiety and poorer executive functioning than “good” sleepers (Rosen et al., 2016). Whipps, Byra, Gerow, and Hill Guseman, (2018) found that first-semester college students testing, mobile gaming, and using social media while in bed were correlated with sleep disturbances. Engaging in more “active” media use such as games, shopping, messaging, or social media may cause users to become more emotionally invested (i.e., flow, transportation of information, and fear of missing out), which has been shown to delay bedtime and decrease subjective sleepiness (Exelmans & Van den Bulck, 2018; Lemola et al., 2015). Media content can create strong autonomic responses such as increased heart rate, rapid breathing, cortisol secretion, and increased body temperature, which may counteract the biological cycle of sleep (i.e., reduced body temperature & melatonin secretion) (Lemola et al., 2015).

**Effect of light.** The circadian clock aligns with our sleep-wake cycle to help obtain the optimal sleep quality and duration. The internal circadian clock rest in the hypothalamus just above the point where optic nerves cross, which is why a potent external time cue is from light (Exelmans & Van den Bulck, 2018; Grønli et al., 2016; Heo et al., 2017). Blue light from electronic media devices produces slow wavelengths that significantly increases alertness and disrupts sleep initiation through suppressing the body’s natural release of melatonin (Fossum et al., 2014; Gringras et al., 2015; Heo et al., 2017; Nagare et al., 2018). Bright light in the evening, especially short wavelengths, can cause phase delays and disruption of the homeostatic sleep regulation by postponing sleep onset (Fossum et al., 2014). Recent studies found that adolescents
viewing self-luminous devices for three hours before their regular bedtimes indicated that one-hour and two-hour exposures suppressed melatonin by 23% and 38%, respectively, increasing sleep latency and decreasing sleep efficiency (Fossum et al., 2014; Green et al., 2018). The results from previous studies also indicated that changing the spectral composition of self-luminous displays (i.e., night shift mode) without changing the brightness settings may be insufficient for preventing impacts on melatonin suppression (Chang et al., 2015; Heo et al., 2017; Nagare et al., 2018).

Sleep Displacement. Any event that takes the place of sleep results in sleep displacement. For example, reading books, writing, watching TV, and media device use can contribute to sleep displacement. Additionally, the more interactive the device, the more likely sleep displacement is to occur. The notification of text messages or emails is more invasive and interactive than watching TV. Research indicates that people check email and text messages far more often on smartphones than other devices, which may prompt them to engage in work-related responsibilities over needed sleep (Lanaj et al., 2014). Users engaged in media involving other people (e.g., games, messaging) may feel obligated to co-determine the termination of media usage, creating longer sleep displacement (Exelmans & Van den Bulck, 2018).

Exelmans and Van den Bulck (2017) found an average of 39 minutes of sleep displacement in a sample of Belgium adults with electronic media use taking up a significant portion of that time. These participants reported having delayed bedtime, shorter sleep time, longer sleep latency, increased daytime fatigue, nighttime awakenings, and nightmares. In two different meta-analyses of adolescent and children studies, television was found to have a significant association with delayed bedtime in 78% of studies (Carter et al., 2016; Hale & Guan, 2015). Results from these meta-analyses indicated screen time from multiple electronic media
devices had a significant negative association with TST (i.e., sleep displacement). Sleep displacement related to screen time has been linked to reduced work performance the following day in a sample of students enrolled in weekend MBA classes at a large university located in the Midwest region of the U.S. (Lanaj et al., 2014).

**The Current Study**

Poor sleep has been linked to numerous diseases, reduced cognitive functioning, and technical errors (e.g., driving errors, work errors). Electronic media devices may create a much higher risk for sleep disturbances than bedtime rituals of the past. The interactive nature of electronic media devices in bed may be more detrimental to sleep quality than “passive” media such as TV. Specifically, modern bedtime rituals related to electronic media devices may impact the accuracy of commonly measured sleep variables (i.e., SOL, HSE, & sleep disturbances). Data from studies on adolescents and children support an inverse relationship between electronic media devices near bedtime and quality (as well as quantity) of sleep; however, to date, few studies have investigated the adult population, and the results from youth studies should not be extrapolated to the adult population without more research.

The aim of the present study was to replicate and extend Exelmans et al. (2018) study examining sleep latency versus shuteye latency by examining a U.S. adult population recruited from Amazon Mechanical Turk (MTurk), a crowdsourcing webservice. First, the study examines the association between post-bedtime electronic media device usage and sleep quality given that 90% of people aged 13–64 years old use technology around bedtime and six out of ten adults report taking their phone to the bedroom (Gradisar et al., 2013; Exelmans & Van den Bulck, 2016). Second, the study examined the moderating effect of age on the relationship between the frequency of post-bedtime electronic media use and sleep quality given the literature indicates
sleep quality declines as people age. Third, the relationship between shuteye latency (i.e., SEL) and two variables commonly used in sleep measures was examined (i.e., sleep onset latency and sleep quality). The current study will finish by examining whether chronotype (i.e., morningness/eveningness) predicts SEL time.

**Hypothesis 1** – A significant positive correlation will exist between the global score of the PSQI (i.e., higher scores indicate poor sleep quality) and post-bedtime electronic media usage.

**Hypothesis 2** – The relationship between frequency of post-bedtime electronic media use and sleep quality will be moderated by age. There will be a larger effect of post-bedtime electronic media use on PSQI global scores in adults 50 years or older than those under 50 years old.

**Hypothesis 3** – A significant positive correlation will exist between SEL time and SOL.

**Hypothesis 4** – Participants with an evening type chronotype will have significantly longer SEL times than participants who identify as morning types.

**Method**

**Participants**

A total of 100 participants (60 men, 39 women, 1 declined to answer) were recruited from a crowdsourcing web service, Amazon Mechanical Turk (MTurk). The participants were men and women residing in the U.S. with an age range of 24–72 years ($M_{age} = 39.09\text{ years}, \, SD_{age} = 10.77\text{ years}$). Participants were paid $1.00 at survey completion with average completion times ranging from 10 to 18 minutes. Inclusion criteria included the following: (a) participants currently residing in the United States; and (b) they are over the age of 18. Common qualification requirements in MTurk studies were also used to increase the likelihood of valid responses, which included requirements that a given participant has an acceptance rate of 95%
overall across other MTurk work completed (i.e., confirmed validity of responses) and has completed a minimum of 50 other tasks in the course of their work with MTurk.

**Measures**

**Shuteye latency.** The BedTime Shuteye Time (BTST) is a measure designed by Exelmans and Van den Bulck (2017) to identify what activities are being done between the time a person reports going to bed and falling asleep. Participants were asked to read a definition of *bedtime* (i.e., the time at which you decide to go to bed) and *shuteye time* (i.e., the time at which you decide to go to sleep) and described a situation in which they were equal (i.e., a person goes to bed, switches off the lights and attempts to sleep) and a situation where both differed (i.e., a person goes to bed, reads a book for half an hour and tries to sleep afterward). Next, participants were asked to report how long bedtime and shuteye time were separated from each other on weekday nights (Sunday–Thursday) and weekend nights (Friday and Saturday). This is referred to as shuteye latency (SEL). Due to the recent development of the BTST, the psychometric properties of the BTST have yet to be established.

**Shuteye latency activities.** Respondents were offered a list of 11 activities comprising both media (e.g., smartphone, TV, tablets) and non-media activities (e.g., books, sex, talking) and indicated how frequently they engaged in those activities (0 = never, 1 = about once a month, 2 = 2-3 times a month, 3 = about once a week, 4 = 2-3 times a week, 5 = (almost) every day). Three blank text boxes were provided for participants to list activities not listed in media or non-media categories (Exelmans & Van den Bulck, 2017). Scores for media activities were summed with a range of 0 to 25 in which higher scores indicated a higher frequency of electronic media use after going to bed. Scores for non-media activities were summed with a range of 0 to 25 in which higher scores indicated a higher frequency of non-media activities after going to bed.
Due to the recent development of shuteye latency activities, the psychometric properties have not been established.

**Sleep Quality.** The Pittsburgh Sleep Quality Index (PSQI) is an assessment designed by Buysse et al. (1989) to provide a reliable and valid standardized measure of sleep quality. The PSQI consists of 19-items grouped into seven equally weighted component scores: Subjective Sleep Quality, Sleep Latency, Sleep Duration, Habitual Sleep Efficiency, Sleep Disturbances, Use of Sleeping Medication, and Daytime Dysfunction. The seven component scores are weighed equally on a 0-3 scale and summed together to create a global PSQI score ranging from 0-21. Higher scores indicate worse sleep quality, and an empirically derived global cutoff score greater than five indicates severe difficulty in at least two domains or moderate difficulties in more than three domains ($\alpha = .64$; Buysse et al., 1989; Mollayeva et al., 2016; Smith & Wegener, 2003).

**Morningness-eveningness.** The Diurnal Scale (DS; Torsvall & Akerstedt, 1980) assesses one’s chronotype (i.e., morningness-eveningness) dimension with seven items. Each item requires the respondent to choose one of four items that best matches their preferred time for conducting certain activities (e.g., “When do you usually begin to feel the first signs of tiredness and need for sleep?”). Scores range from 7 to 28 with higher scores indicating a preference to go to bed early and wake up early. Questions 1, 3, 6, and 7 are reverse scored. ($\alpha = .75$; Greenwood, 1991).

**Procedure**

Participants anonymously accessed the study through the MTurk site, and participants who met qualifications were redirected to the Qualtrics survey site after agreeing to the informed consent (see Appendix A). A group of 10 surveys was released at a time. This process was done
10 times over one week. Each group was released with an 8-hour block over 24 hours across one week as follows:

- Two surveys from 08:00-16:00 Saturday-Sunday
- Two surveys from 16:00-24:00 Saturday-Sunday
- One survey from 24:00-08:00 Sunday
- One survey from 08:00-16:00 and one survey from 16:00-24:00 on Monday
- One survey from 08:00-16:00 and one survey from 16:00-24:00 on Tuesday
- One survey from 24:00-08:00 on Friday

Data was collected in this format to aid in generalizability by accounting for different work shifts, chronotype, and weekday/weekend availability. Upon accessing the link to Qualtrics, participants filled out the PSQI, DS, BTST, SEL, and demographic information (see Appendix B). An attention-seeking question was asked at the end of the FAS to ensure valid responses. After completing the survey, participants were given a code to enter on the MTurk website. Participants were then paid $1.00 for participating in the study.

**Results**

**Statistical Analyses**

Descriptive analyses were conducted for the variables of interest. Demographic information is presented in Table 1. Notable characteristics of the participants were as follows: 75% Caucasian, 60% men, and 47% reported having earned a bachelor’s degree. Eighty percent of participants reported being in good to excellent health, and 96% of participants denied being formally diagnosed with a sleep disorder. Participants reported getting between three and nine hours of actual sleep per night during the past month ($M = 6.7\text{ hours}, SD = 1.2\text{ hours}$). Forty percent of participants reported having an SOL of 30 minutes or longer, which is the cut-off score used
for sleep-onset insomnia (Lichstein et al., 2003). Forty-three percent of participants reported SEL weekday night times of 30 minutes or longer, and 44% reported SEL weekend night times of 30 minutes or longer.

First, a Pearson correlation was used to examine the relationship between post-bedtime electronic media use and sleep quality. Then, two additional Pearson correlations were used to examine the relationship between SOL and SEL weekday night and the relationship between SOL and SEL weekend night. Afterward, a moderation model was used to test the effect of age on the relationship between post-bedtime electronic media use and sleep quality. Finally, two linear regressions were used to test if chronotype (i.e., morning/evening type) predicted SEL weekday night and SEL weekend night times. Of the participants who began the study (N = 100), two participants provided inconsistent responses and were removed from the analyses resulting in a final sample size of 98 data sets.

The goal of the first hypothesis was to examine the relationship between post-bedtime electronic media use (i.e., SEL activities) and sleep quality (i.e., PSQI global score). Results of a Pearson correlation indicated a significant positive correlation between the global score of the PSQI (M = 5.88, SD = 3.52) and post-bedtime electronic media use (M = 8.81, SD = 6.41), r(96) = .28, p = .005.

The goal of the second hypothesis was to examine the effect age had on the relationship between frequency of post-bedtime electronic media use and sleep quality. A multiple regression revealed a significant effect of post-bedtime electronic media use and age on PSQI global scores, F(3, 97) = 2.967, p = .036, R² = .086, with post-bedtime electronic media use providing a significant unique contribution to the model, b = .179, p = .004. However, there was no significant electronic media use by age interaction, p = .391.
The goal of the third hypothesis was to examine the relationship between SEL weekday night times and SOL, and the relationship between SEL weekend night times and SOL. A significant positive correlation was found between SOL ($M = 26.15$, $SD = 25.47$) and weekday night SEL ($M = 20.92$, $SD = 21.11$), $r (96) = .591$, $p < .001$. There was also a significant positive correlation found between SOL ($M = 26.15$, $SD = 25.47$) and weekend nights SEL ($M = 19.77$, $SD = 18.9$), $r (96) = .485$, $p < .001$.

The goal of the fourth hypothesis was to examine if chronotype could predict SEL times. Chronotype ($M = 19.03$, $SD = 2.66$; i.e., morning or evening types) was not found to significantly predict SEL on weekday nights, $F(1,97) = 3.17$, $p = .078$, $R^2 = .032$. Also, chronotype was not found to significantly predict SEL on weekend nights, $F(1,97) = .109$, $p = .742$, $R^2 = .001$.

**Discussion**

The present study examined the relationship between post-bedtime electronic media use and sleep quality in an attempt to replicate and extend Exelmans et al., (2018) research. Modern bedtime rituals may no longer mean going to bed as an intention to sleep but an intention to use electronic media devices. Results of the current study replicated in part Exelmans and Van den Bulck (2017) and Exelmans et al.’s (2018) findings. Specifically, people who spent more time using electronic media devices after going to bed had a lower quality of sleep compared to those who spent less time using electronic media devices after bedtime. Also, a significant positive relationship between SEL and SOL was found. In other words, activities people are engaging in after going to bed should be taken into account when measuring SOL. This finding supports the idea of measuring sleep displacement as a two-step process (i.e., the time you go to bed and the time you decide to sleep), as proposed by Exelmans and Van den Bulck (2017). Contrary to
predictions, age did not have a significant impact on the relationship between post-bedtime electronic media use and sleep quality. Further, chronotype did not significantly predict SEL times.

The average global score, which is used to rate overall quality sleep, for the PSQI in this study sample was 5.88. Scores higher than five typically identify a person as a “poor” sleeper and may indicate severe difficulties in at least two areas or moderate difficulties in more than three areas of sleep. The cutoff score of five has typically compared favorably to the “gold standard” of clinical and laboratory diagnosis of a sleep disorder (e.g., PGS; Backhaus et al., 2002; Buysse et al., 1989). Results from this study found a moderate relationship between post-bedtime electronic media use and sleep quality (i.e., PSQI global score) supporting previous findings from Exelmans et al. (2018) establishing a similar relationship. In other words, it is likely that the more one engages in post-bedtime electronic media use, the lower that person’s sleep quality. Also, this finding likely contributes to reduced TST (i.e., total sleep time), which conceivably increases participants’ PSQI global score. Exelmans et al. (2018) found that participants that engaged in media activity after going to bed for 15 to 30 minutes were 4.01 more likely to have a sleep onset latency greater than 30 minutes, and 17.85 times more likely for those engaging in media for greater than 30 minutes.

The average TST of 6.7 hours per night found in this study is similar to the most recent findings of average American TST (6.8 hours) by the National Health Interview Survey and Gallup poll (Khubchandani & Price, 2019; Jones, 2013; Sheehan et al., 2019). This finding supports the growing concern that Americans are sleep deprived. While a 20 to 25 percent reduction in the recommended TST may not seem like much, research indicates that the accumulation of reduced TST can have deleterious effects on overall well-being. Matthew
MEDIA USE and SLEEP DISTURBANCE

Walker, a leading sleep researcher, cautions against underestimating the reduction of TST because, while a person may only be losing 20 to 25 percent of TST, they may be losing up to 70% of the REM stage of sleep (Attia, 2019). Current evidence indicates that REM sleep appears to be an essential component in the process of affective brain homeostasis to optimally prepare us for the next day’s social and emotional functioning (Attia, 2019; Goldstein & Walker, 2014).

The second hypothesis predicted that age would moderate the relationship between post-bedtime electronic media use and sleep quality. The literature examining sleep and aging shows overall sleep quality (e.g., TST, less deep sleep, fragmented sleep, SOL) worsens as we age (Pearson, 2017). Several meta-analyses found that age was linearly associated with decreased TST with a reduction of approximately 10- to 12-minutes per decade. The literature indicates the magnitude of change becomes significantly noticeable entering the fifth decade of life (Li et al., 2018; Mander et al., 2017); therefore, a cutoff age of 50 was chosen. Results from this study did not find age to have a significant unique contribution to the relationship between post-bedtime media use and sleep quality. These findings are inconsistent with previous research indicating age moderates the relationship between post-bedtime electronic media use and sleep (Exelmans et al., 2018). This finding is likely from being underpowered; this study had very few participants over the age of 50 (N = 17) compared to those under the age of 50 (N = 81).

The goal of the third hypothesis was to examine the relationship between SEL (i.e., activities done after going to bed) and SOL (i.e., the time it takes to fall asleep). Results indicated a strong positive relationship between SOL and weekday night SEL as well as SOL and weekend night SEL. These results are consistent with previous findings indicating a relationship between SEL and SOL (Exelmans et al., 2018; Exelmans & Bulck, 2017). Forty percent of participants reported having both an SOL and SEL of 30 minutes or longer per night.
The average score for SOL was 26.15 minutes, and average scores for SEL weekday nights and SEL weekend nights were 20.92 and 19.77 minutes, respectively. When comparing participants’ SEL from the BTST to SOL from the PSQI, it appears that a significant amount of SOL is spent engaging in post-bedtime activities (i.e., SEL). Without taking SEL into account, 40% of these participants would appear to have sleep-onset insomnia (i.e., 30 minutes or longer to fall asleep; Lichstein et al., 2003). In other words, engaging in activities after going to bed can create measurement error for reported SOL times.

Lastly, this study hypothesized chronotype (i.e., morning or evening type) could predict SEL. Specifically, evening types would engage in activities after going to bed significantly longer compared to morning types. Yet, chronotype did not significantly predict SEL weekday night or SEL weekend times for participants in this study. These findings are inconsistent with previous research that found chronotype significantly predicted SEL times and longer electronic media use times in bed (Exelmans et al., 2018; Fossum et al., 2014). These findings may be due to the relatively small amount of diversity in this sample. For example, participants for this study were mostly male Caucasian’s with higher education. Another possible contributing factor is the potential cultural differences between the American population and the Belgium populations from Exelmans et al., (2018) study.

The multifunctionality and portability of modern technology appear to have extended the purpose of beds beyond just sleep and intimacy (e.g., working, playing games, watching videos, engaging in social media). Researchers studying sleep and health care providers treating sleep disorders should account for the activities that people are engaging in after going to bed (i.e., SEL) in order to have a more accurate assessment of SOL. Further studies should be done to identify how to differentiate between the two variables (including establishing the psychometric
properties of the BTST) and possibly updating the conceptualization and operationalization of instruments measuring SOL. Using electronic media devices post-bedtime had a small negative effect on sleep quality in this sample. However, electronic media devices have several potential factors that may contribute to poor sleep. For example, using devices in bed delays sleep, the media content may create psychological arousal, and light from electronic devices may suppress melatonin secretion (Carter et al., 2016; Chellappa et al., 2013; Hale & Guan, 2015; Heo et al., 2017; Nagare et al., 2018). Further, healthy sleep hygiene involves creating a strong association between the bed and sleep through a classically conditioned response. Using electronic media devices in the bed may weaken the association between bed and sleep, which may reduce sleep quality.

Limitations and Future Directions

There are several limitations to the present research. First, 96% of the sample reported not having a diagnosed sleep disorder, it is possible some participants could have undiagnosed sleep disorders. Also, this study did not account for possible medical disorders or prescribed medications that can impact sleep quality. Second, 75% of the sample population consisted of Caucasians, 60% identified as males, and over 68% had an associate degree or higher. These similar characteristics of the sample population may limit the generalizability of results. For example, a recent study from 2010-2018 examining working Americans found short sleep duration prevalence varied significantly by demographic characteristics (i.e., age, race, marital status, level of education, number of children in the household; Khubchandani & Price, 2019). For example, white educated males appeared to have longer sleep durations on average than minorities, females, and people with less education.
Third, psychometric properties have not been established for the BTST; therefore, the validity and reliability of the measure is unknown. Without established psychometric properties, it is unknown if an instrument is able to reliably and accurately measure what it claims to. Further, retrospective self-report measures asking a person to estimate how much technology use they engaged in may not be accurate due to recall bias. Research has demonstrated that humans are “inherently bad” at estimating the amount of time they spend on a wide variety of activities (e.g., screen-time), and Orben and Przybylski (2020) study examining adolescence in the United Kingdom makes a claim that the impact of electronic media devices has on sleep may be overinflated. Further, estimating the amount of screen-time does not account for how the type of media content can impact sleep displacement differently (e.g., violent video games/TV, passive music, work materials; Boase & Ling, 2013; Orben & Przybylski, 2020). Time-use diaries used in conjunction with consensus sleep diaries may give a more accurate representation of the relationship between sleep quality and electronic media use. Lastly, given that this study recruited participants using an online platform, it could be that these individuals have a unique propensity to engage in digital media compared to other American adults.

Wearable wrist technology (e.g., Apple Watch or Fitbit) has become increasingly accurate as technology advances. Further, smartphones and tablets now have the capability of tracking how much screen-time a person is engaging in. Future studies should employ the use of wearable wrist technology or screen-time tracking apps in conjunction with self-report sleep measures, time-use diaries, or consensus sleep diaries. Pairing these measuring techniques may improve the accuracy and help determine the reliability and validity of self-report sleep measures attempting to measure technology use in bed, which could greatly improve the accuracy of studies investigating the relationship between electronic media use and sleep. Finally,
experimental designs and interventions should be done to help establish causality and expand the literature on healthy sleep hygiene.

Conclusion

Poor sleep can have deleterious effects on the overall health and well-being of individuals. The results from this study support the growing trend of a “sleep recession” in the American population and using electronic media devices in the sleep environment may be contributing to poor sleep quality. Also, findings from this study support claims from previous studies that modern-day bedtime rituals may introduce measurement error for common sleep variables (e.g., SOL; Exelmans et al., 2018; Exelmans & Van den Bulck, 2017, 2015). Therefore, current self-report sleep measures may need to update the operational definitions and conceptualization of sleep variables [e.g., “After going to bed, how long are you awake (doing other things than sleeping) before trying to go to sleep?”; Exelmans & Van den Bulck, 2017]. Importantly, even if the language is updated in sleep measures, it is imperative that health providers and sleep researchers get clarification on the type of media content that is being engaged. For example, mental health issues may at times be attributed to poor sleep, which in part is due to lack of sleep thanks to using the bed for things other than what would promote healthier sleep hygiene. The type of media content may have an added impact on sleep latency, fragmented sleep, and total sleep time. The results from this study contribute to previous literature, which suggests limiting nighttime electronic media device usage as part of positive sleep hygiene and overall healthier sleep.
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Table 1

*Characteristics of Participants*

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<thead>
<tr>
<th>Characteristic</th>
<th>Total (N = 100)</th>
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<tbody>
<tr>
<td>Age, years, <em>mean ± SD</em></td>
<td>39.09 ± 10.77</td>
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<tr>
<td>Gender</td>
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<tr>
<td>Male</td>
<td>60</td>
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<tr>
<td>Female</td>
<td>39</td>
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<td>Caucasian</td>
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<td>Native Hawaiian/Pacific Islander</td>
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<tr>
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<td>Education</td>
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<td>Some College</td>
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<td>Working part time</td>
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<tr>
<td>Unemployed not seeking work</td>
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<tr>
<td>Retired</td>
<td>4</td>
</tr>
<tr>
<td>Disabled</td>
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<tr>
<td>Health</td>
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</tr>
<tr>
<td>Good to Excellent Health</td>
<td>80</td>
</tr>
<tr>
<td>Denied being formally diagnosed with a Sleep disorder</td>
<td>96</td>
</tr>
</tbody>
</table>
Informed Consent Form

The Department of Psychology at Washburn University 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.

**Association Between Media Usage and Sleep Disturbances**

You are being asked to participate in a research study examining the relationship between bedtime rituals and the quality of sleep. During this approximately 15-minute survey, you will be asked questions about your quality of sleep, media device usage, and demographic information. To be eligible to participate you must be over the age of 18 and currently reside in the U.S. If you agree to participate in this study and meet the study’s inclusion criteria, you will be given a link to Qualtrics survey website.

All responses and information will remain anonymous and no identifying information will be used. The results of this study will also remain anonymous to protect your privacy. Participants will be paid $1.00 for the completion of this study. There may be attention checking questions within this survey, please read all information carefully before responding accordingly. Please do not close this browser, because you will receive a code to enter into the MTurk website at the end of the survey so that you can be paid.

If you do not wish to take the survey and or at any point wish to exit the survey, please exit and close.

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!

Principal Investigator:

Craig Lawless
craig.lawless@washburn.edu
Appendix B

Demographic Questionnaire

What is your biological sex?

- Male
- Female
- Other
- Decline to answer

What is the highest level of education that you have completed?

- Did not complete high school
- High school or General Educational Development (GED)
- Some college but no degree
- Vocational training after high school
- Associate’s degree
- Master’s degree
- Doctoral degree

What race do you identify as?

- Caucasian
- African American or Black
- Asian
- American Indian or Alaskan Native
- Native Hawaiian or Pacific Islander
- Multiple Races
- Other

What is your current age (years)?

Please indicate your employment status (select all that apply)

- Working full time (30 hours or more)
- Working part time (29 hours or less)
- Unemployed, not seeking employment
- Retired
- Disabled
- Student

Do you do shift work?

- Yes
- No
If you selected yes, indicating that you do shift work, please identify which shift(s) you normally work:

- First (0800-1600)
- Fair
- Good
- Very Good
- Excellent

Have you ever been formally diagnosed with a sleep disorder by a professional health provider?

- Yes
- No

What electronic devices (if any) do you regularly use in the hour before bed?

- Smartphone
- Electronic tablet/electronic reader
- Desktop/laptop
- Desktop/laptop
- Television
- Electronic gaming device (e.g., Nintendo Switch)