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DOI
10.1080/15213269.2024.2400571

Publication date
2025

Document Version
Final published version

Published in
Media Psychology

MEDIA PSYCHOLOGY
2025, VOL. 28, NO. 4, 516–547
https://doi.org/10.1080/15213269.2024.2400571

Is Bedtime Media Use Good or Bad? A Competitive Analysis Between the Sleep Displacement Hypothesis and the Media Recovery Hypothesis

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ABSTRACT

Bedtime media use is often maligned in research and pop culture. However, the evidence for the relationship between bedtime media use and sleep for adults has been mixed – sometimes sleep quality is negatively affected by media use, sometimes it is positively affected. Competing explanations include the sleep displacement hypothesis (i.e. media use leads to later sleep onset, less total sleep, and lower sleep quality) and the media recovery hypothesis (i.e. media use helps reduce stress, and this relaxation helps people fall and stay asleep). Two retrospective diary studies test these competing hypotheses in an undergraduate sample ($n = 200$) and a general population U.S. adult sample ($n = 202$). Overall, results provide more support for the sleep displacement hypothesis than for the media recovery hypothesis. However, some evidence suggests potential for positive relationships between media use and sleep. More work is needed to explicate the complicated relationship between bedtime media use and sleep.

Technology use has been well-established as a predictor of nighttime sleep, and is often found to be negatively related to sleep amount and quality in both children and adults (Carter et al., 2016; Eggermont & Van den Bulck, 2006; King et al., 2014; Suganuma et al., 2007). Entertainment media use such as television, games, or smartphones shortly before sleep onset has received particular attention for its influence on sleep. Media use up to two hours before bedtime has been associated with sleep disturbances (Custers & Van den Bulck, 2012; Exelmans & Van den Bulck, 2016; Hale & Guan, 2015). However, despite the general doom and gloom about bedtime media use and sleep outcomes, there is also some evidence that the relationship between entertainment media use and sleep can be either beneficial or detrimental –

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depending on the context and attributions users make for their media use (A. Eden et al., 2021; Ellithorpe et al., 2022; Tucker et al., 2008). For example, users turn to media to cope with or distract from stress and strain, which may lead to better sleep quality or improved alertness via stress recovery processes (Reinecke & Rieger, 2020; Tucker et al., 2008). Therefore, more research is needed to understand the complexities of stress, bedtime media use, and sleep association.

Although various mechanisms have been suggested to explain the relationship between media use and sleep, two major competing explanations are 1) the sleep displacement hypothesis and 2) the media recovery hypothesis. The sleep displacement hypothesis predicts that bedtime media pushes back sleep onset and thus time that would have been spent sleeping is instead spent using media (Exelmans & Van den Bulck, 2017). Not only is sleep displacement due to media associated with less total sleep time, but also with worse sleep quality (Custers & Van den Bulck, 2012). That said, many adults and adolescents turn to media before bed as a sleep aid (Eggermont & Van den Bulck, 2006; Exelmans & Van den Bulck, 2017), as media may serve as a low-effort, relaxing activity that can help users recover from workday stress and strain (Reinecke & Rieger, 2020). Recovery is the process of replenishing and rebalancing stressed systems so that individuals may return to normal functioning, and recovery experiences are those which provide psychological detachment from work, relaxation, mastery, and affect-regulation (Sonnentag et al., 2017). Recent media psychology research has shown that media use can serve as an effective recovery activity (Reinecke, 2009; Reinecke & Eden, 2017; Reinecke & Rieger, 2020; Reinecke et al., 2011). Yet despite circumstantial evidence linking recovery experiences to improved sleep (Tucker et al., 2008), the role of media in the stress recovery-sleep relationship has yet to be empirically validated (Fritz & Crain, 2016). That said, the media recovery hypothesis may offer an explanation for recent findings linking media use before bed to faster sleep onset or better sleep quality (Baselgia et al., 2023; Ellithorpe et al., 2022).

In the current paper, we examine both the sleep displacement and media recovery hypothesis more closely and present two studies, sampling an undergraduate student sample (Study 1) and the general population in the United States (Study 2), that test competing predictions of the sleep displacement and media recovery hypotheses. Both studies utilize a retrospective media diary and sleep diary method embedded within an online survey.

Media Use and Sleep Displacement

The sleep displacement hypothesis focuses on the effect of media use as a general behavior impacting sleep rather than emphasizing exposure to a certain content on sleep (Van den Bulck, 2010). Both survey studies and diary data have highlighted the negative impact of media use on sleep through numerous – direct or indirect – tests of the sleep displacement hypothesis (see Carter et al., 2016). For example, a longitudinal study found that children's sleep duration was significantly shortened by total screen time (Zhang et al., 2021). Another recent study looking at young working adults showed a similar effect: media use led to later bedtimes (Zhao & Wu, 2022). A 24-hour diary study found that visual media use (i.e., television) also led to bedtime delay (Asaoka et al., 2010). Similarly, digital media use before bed has been found to be associated with displaced bedtime, causing less total sleep time (Orzech et al., 2016).

Despite support of the sleep displacement hypothesis in various contexts, some studies suggest that the effect may be conditional and the mechanisms may not be well explicated. For example, a recent mixed-method study (Daniels et al., 2022) looking at media use as a coping mechanism has shown that those who were using media to cope with negative thoughts were more likely to report later bedtimes and poor sleep quality overall. Exelmans and Van den Bulck (2016) found worse overall sleep quality among adults who reported using media as a sleep aid, although sleep duration was not affected. The authors suggested that this was due to *time shifting* – that is, media use was related to later sleep onset, but also later wake times (see also Custers & Van den Bulck, 2012; Van den Bulck, 2004). Exelmans and Van den Bulck (2017) have suggested that sleep displacement may be a two-step process, with media use shifting bedtimes later (bedtime displacement) as well as time to fall asleep (shuteye latency). Thus, we broadly consider "sleep displacement processes," based on previous research in this area, as a cascade of decisions from media use, to bedtime delay, to sleep disruption. The sleep displacement literature therefore predicts that media use negatively affects sleep onset, duration, and quality (see Figure 1 for conceptual overview). Based on this literature, we hypothesize that:

H1: Sleep displacement will be evident in a serial mediation relationship, such that bedtime media enjoyment will be negatively associated with sleep

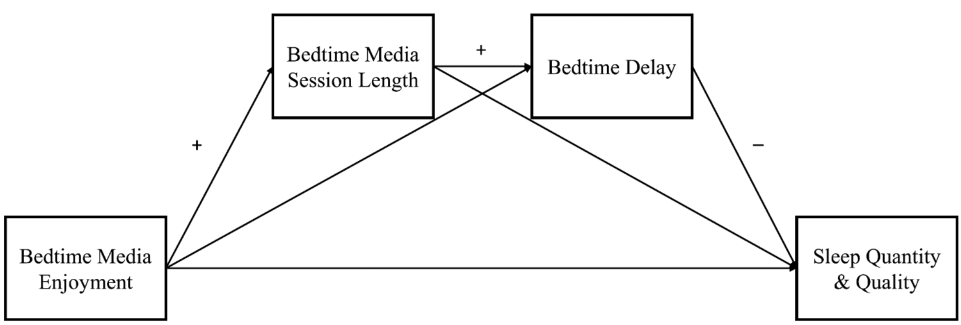

Figure 1. Conceptual model for sleep displacement (H1).

outcomes through the sequential mediators of session length (enjoyment will be positively associated with session length) and bedtime delay (session length will be positively associated with bedtime delay, which will be negatively associated with sleep).

Media Use and Recovery

A separate line of research situated in the organizational literature on work stress recovery (Sonnentag et al., 2017), defines recovery as the process of replenishing and rebalancing stressed systems so that individuals may return to normal functioning after encountering stressors. Recovery occurs during time periods with low or no job demands, for instance during breaks at work, vacations, or in the evenings, and has been linked to next-day positive affect and morning serenity (Sonnentag et al., 2008). Four central recovery experiences are *psychological detachment*, in which individuals detach from workday stressors; *relaxation*, in which individuals experience low physical and emotional activation, *mastery experiences*, which require opportunities to learn and broaden our horizons, and a sense of autonomy or *control* over our free time (Sonnentag & Fritz, 2007).

There is substantial evidence linking media use to recovery experiences (Reinecke & Rieger, 2020). For example, people use media to escape from problems (Halfmann & Reinecke, 2021), to regulate their affective states (Bryant & Zillmann, 1984), and to intervene in aversive mood states (Rieger et al., 2015; Zillmann, 1988). Survey data suggests that individuals use media strategically to relax and recover from the day's difficulties or to cope with both acute and long-term stressors such as the COVID-19 pandemic, adverse health conditions, or relational stress (A. L. Eden et al., 2020; Grady et al., 2022; Prestin & Nabi, 2020). Therefore, media use may serve as a general stress reduction technique, and lead to improved sleep via affective regulation.

However, a growing body of evidence explicitly tests the recovery potential of media as a specific type of experience which affords psychological detachment, affect regulation, mastery, and control to users (Reinecke & Rieger, 2020). For example, a series of studies (Reinecke, 2009; Reinecke et al., 2011; Wulf et al., 2019) illustrated that video games can serve as a recovery experience. Other studies similarly found that first-person shooter and action games served to increase recovery outcomes (Collins & Cox, 2014). Still others have studied the recovery effects of short film clips, YouTube videos, and longer films, broadly finding that media outperformed control tasks in terms of providing recovery experiences (Janicke et al., 2018; Rieger & Bente, 2018). Across both television and video games, Reinecke et al. (2014) found that media enjoyment was associated with greater recovery after a stressful workday.

Both Tucker et al. (2008) and Fritz and Crain (2016) link recovery experiences through technology to sleep quality and quantity, suggesting that leisure activities which facilitate recovery should be positively associated with better sleep. Fritz and Crain (2016) suggest that technology may negatively impact sleep quantity and quality when it allows users to access work related e-mails during leisure hours, thereby disrupting leisure time. Tucker et al. (2008) examined this relationship empirically, via a study comparing active leisure (shopping, socializing), quiet leisure (television, books, a bath) or working in the evening on sleep quality. Tucker et al. (2008) found that both active and quiet leisure improved self-reported sleep quality, as long as the media was not work-related. Therefore, we would argue that non-work-related media may instead serve to provide recovery experiences during leisure time, by providing psychological detachment and relaxation for users. This suggests it is not simply media use, which is disruptive to sleep, but the content and function of that media which impacts its potential to influence stress and recovery processes.

Using a diary study supplemented with EEG sleep tracking, Ellithorpe et al. (2022) showed that media use before sleep positively affected sleep onset. That is, individuals who spent time watching television in bed an hour before sleep ended up falling asleep earlier and staying asleep for longer than those who did not. Similarly, Baselgia et al. (2023) showed that individuals watching a suspenseful TV show before bed had a faster sleep onset latency than those watching a documentary. Moreover, individuals watching a suspenseful show ending with a cliffhanger fell asleep faster than those watching a suspenseful show without cliffhanger. This pattern of results is consistent with the hypothesis that media use prior to bedtime may facilitate sleep onset by distracting users from their personal stressors as their thoughts are directed to the media content. Although this distraction may delay sleep onset or shuteye latency (as noted in Exelmans & Van den Bulck, 2017), positive media experiences may support greater stress reduction and also may improve morning alertness by aiding recovery processes (Sonnentag et al., 2008). Thus, we consider "media recovery processes," based on previous research, to be a path linking increased stress to increased recovery motivation, and that these motivations can increase enjoyable media use, which increases recovery experience reported, which might lead to improved sleep outcomes (see Figure 2). Based on this literature, we hypothesize that:

H2: Media recovery will be evident in a serial mediation relationship, such that daytime stress will be positively associated with sleep quality outcomes through the sequential mediators of motivation to use media for recovery (stress will be positively associated with motivation) and recovery experience (motivation for recovery will be positively associated with recovery experience, which will be positively associated with sleep).

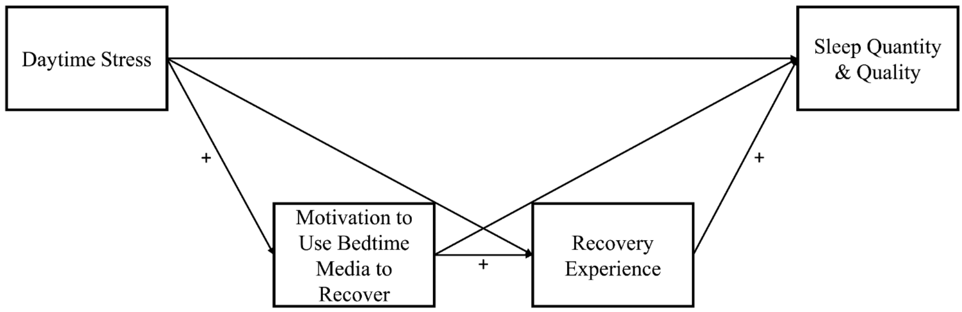

Figure 2. Conceptual model for media recovery (H2).

Competing Hypotheses

Previous work on these two hypotheses about how bedtime media use influences sleep tends to examine them separately. Yet, both sleep displacement and recovery experiences may co-occur in everyday media use. We therefore suppose that these processes could compete with one another, and this could lead one to reduce or eliminate the effect of the other on sleep outcomes (see Figure 3). For example, if one begins the evening with a motivation to recover from stress and experiences desired recovery, that should positively impact sleep. However, to the extent that the media used for recovery is enjoyable, the individual might decide to continue consuming the media for longer, thus delaying bedtime and counteracting the sleep benefits of recovery through sleep displacement. It is also possible that the benefits of stress recovery are

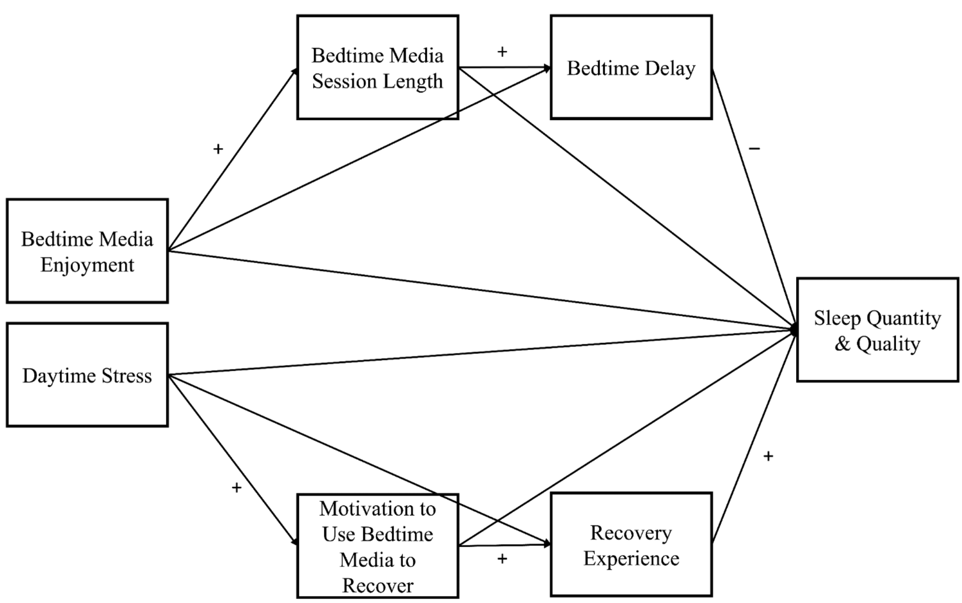

Figure 3. Conceptual model for sleep displacement and media recovery combined.

strong enough to overcome the potential negatives of sleep displacement. However, this direct competition of both processes enacted simultaneously has not been tested. Therefore, we present a non-directional research question:

RQ1: Will both sleep displacement and media recovery processes be supported when they are combined in the same model, or will one or both processes lose support?

It should be noted that while measures of sleep quality such as hours slept, onset latency, night waking, etc. are often correlated with subjective feeling measures such as next-day alertness, mood, and subjective sleep quality, there is often a disconnect between them, with a small-to-moderate effect size of objective sleep measurement predicting next day subjective outcomes (Della Monica et al., 2018). Thus, we may find that these different aspects of sleep quality may be differentially associated with sleep displacement and media recovery. For example, might sleep displacement be more likely to be associated with the actual sleep measures such as hours slept, while media recovery might be more likely to be associated with the more subjective feeling measures of being more alert, positive mood, etc.? Sonnentag et al. (2008), for example, found no direct effects of evening recovery on sleep onset or duration but did find positive effects of recovery on next-day positive affect. Therefore, finally, we ask;

RQ2: Will sleep-related quality measures and next-day quality measures be differentially associated with sleep displacement and media recovery processes?

Study 1

Study 1 Method

Participants

Participants were 200 undergraduates (M_{age} = 19.76, SD = 1.15, range 18 to 23) at a large Mid-Atlantic University who participated for course credit through the Department of Communication participant pool. Of those, 153 (76.00%) identified as women, 43 (21.50%) identified as men, and four (2.00%) identified as non-binary or preferred their own terminology. Racial and ethnic identities were 152 (74.15%) White, 20 (10.00%) multiracial, 10 (5.00%) Asian or Asian American, nine (4.50%) Black or African American, five (2.50%) Hispanic or Latino, one (0.50%) Arab or Middle Eastern, and three (1.50%) preferred not to answer. All reported using media within one hour of bedtime at least once in the past, with 168 (85.71%) reporting the most recent time they used media within one hour of bed was the previous evening (less than 24 hours ago), and 151 (75.50%) reporting that they used media within one hour of bed every day for the past seven days.

Procedure

The procedures in both studies were determined exempt by the Institutional Review Board at [UNIVERSITY]. An online survey asked participants to indicate informed consent, then asked demographic questions followed by a filter question asking if participants have ever used media within an hour of bed. No participants responded in the negative. Participants answered the questions regarding how often and how recently participants used media before bed. They were then asked to think of the most recent day that they used media before bed, and completed a thought listing about their day to help them recall it in detail. They filled out a measure of how stressed they were that day, followed by asking how many media events (one, two, three or more) they engaged in within an hour before falling asleep that night. Participants were told to consider different media events to be changes from one medium to another, and given the example, “for example, maybe you watched *House of Dragons* on television until 30 minutes before falling asleep, and then scrolled on Tik Tok on your smartphone from 30 minutes to 10 minutes before falling asleep. Even if watching television and scrolling social media happened on the same device, please consider them to be distinct media use events.” The number of events reported by each participant varied, with 65 (31.71%) reporting three or more, 90 (43.90%) reporting two, and 41 (20.00%) reporting one.[1]

For each event (up to three) that participants reported within an hour of falling asleep, participants were asked to indicate the content type and device type. Participants reported mostly social media use ($n = 261$, 63.20% of events reported), followed by television/film ($n = 123$, 29.78%), internet browsing ($n = 9$, 2.18%), video games ($n = 8$, 1.94%), e-book reading ($n = 2$, 0.33%) and “other” ($n = 10$, 2.42%). Devices used were primarily smartphones ($n = 274$, 66.34%), followed by televisions ($n = 75$, 18.16%), laptop or desktop computer ($n = 53$, 12.83%), tablet ($n = 7$, 1.69%), portable gaming device such as Nintendo Switch ($n = 1$, 0.24%), e-reader ($n = 1$, 0.24%), smartwatch ($n = 1$, 0.24%), and “other” ($n = 1$, 0.24%).

Once these instances of media use were captured, participants were asked to report their motivations for using the content to recover from stress, whether they experienced any goal conflict in their use of media, how much they enjoyed the content, how long they used the content for, whether they pushed back bedtime to continue using the content, and the extent to which the content helped them with recovery. Finally, they filled out measures for sleep quantity and quality that night before being debriefed and providing their participant pool IDs for credit.

Measures

Stress. Same-day stress was measured using the global perceived stress scale (Cohen et al., 1983), which is a 14-item scale that we measured on a 0 (never) to 10 (very often) response scale ($M = 4.51$, $SD = 1.37$, Cronbach α=.84). Participants were asked to answer the items specifically thinking about the day they most recently used media within an hour of falling asleep, "The questions in this scale ask you about your feelings and thoughts during the day when you last used screen media within an hour of falling asleep."

Motivation for recovery. Participants answered a single item measure of motivation to use media to recover (Reinecke & Hofmann, 2016) for each media event, "I used that media to recover from work or other exhausting tasks" on a 0 (does not apply at all) to 10 (fully applies) response scale ($M = 7.76$, $SD = 2.38$).

Enjoyment. Enjoyment was measured for each event with a single item, "how much did you enjoy this media content you were using?" on a 0 (not at all) to 10 (very much) response scale ($M = 8.52$, $SD = 1.55$).

Session length. Session length was measured for each event by asking, "approximately how long did you use this content? Include if it started before the hour before falling asleep window (e.g., if you went to bed at 11pm and started watching TV at 9:30pm you would put 'more than 60 minutes' and then specify 90 minutes)." Participants answered on a 1 to 7 scale with the following response options: less than 10 minutes, 11 to 20 minutes, 21 to 30 minutes, 31 to 40 minutes, 41 to 50 minutes, 51 to 60 minutes, more than 60 minutes ($M = 4.21$, $SD = 1.40$).

Pushing back bedtime. An ordinal scale was used to measure whether participants pushed back their bedtime to continue each media event; over $n = 413$ events, 186 (45.04%) reported, "no, I went to bed on time," 185 (44.79%) reported, "yes, I stayed up a little bit later to continue using this media content," and 42 (10.17%) reported, "yes, I stayed up a lot later to continue using this media content" ($M = 1.67$, $SD = 0.58$).

Recovery experience. Recovery experience for each event was measured using the Recovery Experience Questionnaire (Sonnentag & Fritz, 2007), modified as in previous research (Reinecke et al., 2011). The measure is 16 items measured on a scale from 0 (not at all) to 10 (very much) that can be used as four subscales or as a single factor. The scale was reliable as a single factor (Cronbach α=.85), so this version was used for parsimony. The prompt was, "when I used this media in the hour before falling asleep, I . . . ," and sample items include "distanced myself from work/school" and "kicked back and relaxed" ($M = 7.02$, $SD = 1.43$).

Sleep quantity & quality. Sleep was measured with a series of items that make up the Pittsburgh Sleep Diary (Monk et al., 1994). For subjective ratings of sleep quantity, total sleep time was measured by asking participants to report the clock time when they fell asleep and when they woke up and calculating total amount of sleep in half-hour increments. For example, between 8:00pm and 8:29pm was the earliest sleep onset time reported, so this was given a code of 0. 8:30 to 8:59pm was coded as 0.5, 9:00 to 9:29 was 1.0, 9:30 to 9:59 was 1.5, and so on, up to 23.5 hours from 8:00pm. Wake times were calculated on the same scale (e.g., a wake time of 8:00am to 8:29am was coded as 12, as it is 12 hours from the initial start time of 8:00-8:29pm). Therefore, if a participant reported they fell asleep at 11:45pm and woke up at 7:15am, their sleep time was coded as 3.5, their wake time was coded as 11, and their total sleep time was calculated by subtracting their sleep time from their wake time (11–3.5 = 7.5), and thus we knew they slept approximately 7.5 hours. The average sleep amount for the sample was 7.99 hours ($SD = 1.44$). Sleep onset latency asked participants to report, “approximately how many minutes did it take you to fall asleep once you started to try (e.g., got in a comfortable position and closed your eyes)?” ($M = 15.39$, $SD = 14.00$). Number of night wakings asked participants to report, “after falling asleep how many times did you wake up during the night?” ($M = 1.05$, $SD = 1.19$). Subjective sleep quality was measured by asking participants “what was the overall quality of your sleep that night?” with response options from 1 (very poor) to 4 (very good). Alertness and mood the next day were asked with the items, “how alert were you that day after waking?” with 1 (very sleepy) to 4 (very alert) as response options, and “what was your mood when you got up for the next day?” with 1 (very tense) to 4 (very calm) as response options, (alertness $M = 2.51$, $SD = 0.80$; mood $M = 2.77$, $SD = 0.77$). Items were included separately as representing various dimensions of sleep quality and subjective assessment of sleep.

Study 1 Analysis

Three models were tested using path analysis in SEM in Stata 17 using maximum likelihood estimation. The models for sleep displacement (Figure 1) and media recovery (Figure 2) as separate processes were saturated because they incorporated all paths in a sequential mediation model. The combined model (Figure 3) included both processes simultaneously. The indirect effects were tested for the theoretical pathways for each of the sleep displacement and media recovery hypotheses. For sleep displacement, this theoretical path was enjoyment → session length → bedtime delay → sleep outcomes. For media recovery, this theoretical path was stress → recovery motivation → recovery experience → sleep outcomes. Indirect effects tests were conducted using the nlcom command in Stata 17 and 5,000 bootstrap samples. We report both the percentile-based and bias-corrected bootstrapping results in this study.[2]

Study 1 Results

Statistical details can be found in Table 1, with full output available on OSF.[3] Coefficients reported for both studies are unstandardized, but versions with standardized coefficients are available on OSF as well.

Sleep Displacement Only Model

H1 predicted that bedtime media enjoyment will be associated with worse sleep, through the mediating mechanisms of session length and bedtime delay. As expected, enjoyment of bedtime media was significantly positively associated with session length, and session length was significantly positively associated with bedtime delay. Bedtime delay was significantly associated with fewer hours slept, more night wakings, worse subjective sleep quality, less next day alertness, and worse next day mood. To contextualize, the difference between going to bed on time and staying up "a bit later" to continue using media was associated with approximately half an hour less sleep time. Interestingly, enjoyment had a significant and negative direct effect on sleep onset latency, meaning more media enjoyment was associated with faster time falling asleep. This is consistent with earlier research finding that content which distracts from one's problems, like suspenseful content with a cliffhanger, was associated with better sleep (Baselgia et al., 2023).

Indirect effects of enjoyment on each of the six sleep outcomes through session length and bedtime delay were then estimated: sleep time, b=-0.02, 95% bias-corrected CI (BCCI; −0.05, −0.004), 95% percentile-based CI (PCI; −0.04, 0.003); sleep onset latency, $b = 0.09$, 95% BCCI (−0.02, 0.31), 95% PCI (−0.02, 0.31); night wakings, $b = 0.02$, 95% BCCI (0.004, 0.05), 95% PCI (−0.002, 0.04); subjective sleep quality, b=-0.01, 95% BCCI (−0.02, −0.002), 95% PCI (−0.02, 0.001); next day alertness, b=-0.01, 95% BCCI (−0.03, −0.01), 95% PCI (−0.03, −0.002); next day mood, b=-0.01, 95% BCCI (−0.03, −0.005), 95% PCI (−0.03, −0.001). Note that both the BCCI and PCI both do not contain zero in the cases of next day alertness and next day mood, but only the BCCI does not contain zero for sleep time, night wakings, and subjective sleep quality.

As a whole, these results provide support for H1 and the sleep displacement hypothesis.

Table 1. Study 1 results for all three models. Note: coefficients reported are unstandardized. Tables with standardized variables are available on OSF. Coefficients that are significant at p<.05 are **bolded** for ease of interpretation.

Model 1: Sleep displacement only				
	Session Length		Bedtime Delay	
	b	95% CI	*b*	95% CI
Enjoyment	**0.22**	**0.09, 0.35**	-0.05	-0.11, 0.003
Session Length			**0.16**	**0.10, 0.21**
R^2	.06		.15	
Model 2: Media recovery only				
	Recovery Motivation		Recovery Experience	
	b	95% CI	*b*	95% CI
Stress	**0.28**	**0.03, 0.54**	**-0.27**	**-0.41, -0.13**
Recovery motivation			**0.32**	**0.24, 0.40**
R^2	.03		.29	

Table 1. (Continued).

Model 3: Combined Model

	Enjoyment		Session Length		Bedtime Delay		Recovery Motivation		Recovery Experience	
	b	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI
Enjoyment			**0.22**	**0.09, 0.35**	-0.05	-0.11, 0.003				
Session Length					**0.16**	**0.10, 0.21**				
Delayed Bedtime										
Stress	**-0.32**	**-0.47, -0.16**					**0.28**	**0.03, 0.54**	**-0.27**	**-0.41, -0.13**
Recovery motivation	**0.31**	**0.22, 0.40**							**0.31**	**0.23, 0.39**
R^2	.25		.06		.15		.03		.28	

Table 1. (Continued).

Model 1: Sleep displacement only

	Total Sleep Time		Sleep Onset Latency		Number of Night Wakings		Subjective Sleep Quality		Perceived Alertness		Subjective Mood	
	b	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI
Enjoyment	0.06	-0.08, 0.20	**-1.74**	**-3.14, -0.33**	-0.04	-0.15, 0.08	**0.11**	**0.04, 0.17**	**0.11**	**0.04, 0.19**	0.05	-0.02, 0.13
Session Length	0.06	-0.11, 0.24	1.07	-0.62, 2.76	0.01	-0.13, 0.15	-0.02	-0.10, 0.06	0.04	-0.05, 0.13	-0.01	-0.10, 0.08
Delayed Bedtime	**-0.54**	**-0.95, -0.12**	2.51	-1.62, 6.63	**0.53**	**0.19, 0.88**	**-0.24**	**-0.42, -0.05**	**-0.44**	**-0.66, -0.22**	**-0.40**	**-0.62, -0.18**
R^2	.05		.06		.07		.11		.14		.10	

Model 2: Media recovery only

	Total Sleep Time		Sleep Onset Latency		Number of Night Wakings		Subjective Sleep Quality		Perceived Alertness		Subjective Mood	
	b	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI
Stress	**-0.18**	**-0.34, -0.01**	**3.08**	**1.47, 4.68**	0.13	-0.01, 0.27	**-0.16**	**-0.23, -0.08**	**-0.14**	**-0.23, -0.05**	-0.17	-0.25, 0.08
Recovery motivation	-0.02	-0.12, 0.09	-0.01	-1.06, 1.04	-0.03	-0.12, 0.06	0.03	-0.02, 0.08	**0.06**	**0.01, 0.12**	-0.04	-0.10, 0.02
Recovery experience	**0.18**	**0.01, 0.36**	0.69	-1.01, 2.39	0.05	-0.10, 0.19	-0.01	-0.08, 0.08	0.03	-0.06, 0.13	0.06	-0.03, 0.15
R^2	.07		.08		.02		.10		.10		.12	

Model 3: Combined Model

	Total Sleep Time		Sleep Onset Latency		Number of Night Wakings		Subjective Sleep Quality		Perceived Alertness		Subjective Mood	
	b	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI
Enjoyment	-0.01	-0.17, 0.15	**-1.70**	**-3.25, -0.14**	-0.02	-0.15, 0.12	**0.09**	**0.02, 0.16**	0.06	-0.03, 0.14	0.04	-0.04, 0.12
Session Length	0.09	-0.08, 0.26	0.59	-1.07, 2.25	0.00	-0.14, 0.14	-0.00	-0.08, 0.07	0.04	-0.05, 0.13	0.02	-0.07, 0.11
Delayed Bedtime	**-0.47**	**-0.88, -0.06**	1.86	-2.17, 5.88	**0.53**	**0.18, 0.87**	**-0.21**	**-0.39, -0.03**	**-0.43**	**-0.65, -0.21**	**-0.35**	**-0.56, -0.14**
Stress	-0.16	-0.33, 0.01	**2.41**	**0.75, 4.08**	0.10	-0.05, 0.24	**-0.12**	**-0.20, -0.04**	**-0.10**	**-0.19, -0.01**	**-0.13**	**-0.22, -0.05**
Recovery motivation	-0.02	-0.13, 0.10	0.31	-0.81, 1.44	-0.04	-0.14, 0.06	0.01	-0.04, 0.06	0.05	-0.01, 0.12	-0.05	-0.11, 0.01
Recovery experience	0.15	-0.03, 0.32	0.88	-0.82, 2.58	0.07	-0.07, 0.11	-0.03	-0.11, 0.05	0.01	-0.08, 0.11	0.04	-0.05, 0.13
R^2	.08		.11		.08		.15		.18		.16	

Media Recovery Only Model

H2 predicted that when media is used to recover from stress it will be associated with better sleep. In our model we operationalize this by testing the path from stress to sleep through the mediators of motivation to use media to recover from stress and recovery experience. As expected, stress reported that day was significantly positively associated with motivation to use bedtime media to recover from stress. Motivation to use media to recover from stress was significantly positively associated with recovery experience. Recovery experience was significantly associated with more hours slept – approximately 18 minutes more for every one unit increase in recovery on a zero to 10 scale. However, there were no other significant associations between recovery experience and sleep outcomes. Additionally, stress had significant direct associations with fewer hours slept, longer sleep onset latency, worse subjective sleep quality, lower next day alertness, and worse next day mood. Thus, while media recovery does appear to help in terms of total sleep time, it does not appear to fully negate the negative influence of stress.

Indirect effects of stress on each of the six sleep outcomes through recovery motivation and recovery experience were then estimated: sleep time, $b = 0.02$, 95% bias-corrected CI (BCCI; 0.002, 0.05), 95% percentile-based CI (PCI; −0.01, 0.04); sleep onset latency, $b = 0.06$, 95% BCCI (−0.08, 0.38), 95% PCI (−0.14, 0.26); night wakings, $b = 0.004$, 95% BCCI (−0.01, 0.03), 95% PCI (−0.01, 0.02); subjective sleep quality, b=-0.0003, 95% BCCI (−0.01, 0.01), 95% PCI (−0.01, 0.01); next day alertness, $b = 0.003$, 95% BCCI (−0.01, 0.02), 95% PCI (−0.01, 0.02); next day mood, $b = 0.01$, 95% BCCI (−0.001, 0.02), 95% PCI (−0.01, 0.02). Note that the BCCI for sleep time was the only confidence interval that did not contain zero.

As a whole, these results provide very weak support for the media recovery hypothesis.

Combined Model

The initial combined model, which kept all processes in the sleep displacement and media recovery paths separate except for where they converged on sleep outcomes. This model had poor model fit (Hu & Bentler, 1999), $\chi^2(8) = 53.79$, $p < .001$, CFI = .86, RMSEA = 0.19, SRMR = 0.08. Modification indices suggested large improvements in model fit would be gained by adding paths from stress and recovery motivation to enjoyment. It is reasonable that stress and recovery motives would both relate to media enjoyment, and given the exploratory nature of our research question, modifying the model was cautiously undertaken. Adding these two paths resulted in acceptable model fit, $\chi^2(7) = 14.24$, p=.05, CFI = .98, RMSEA = 0.08, SRMR = 0.04.

In this combined model (Figure 4), the relationships between bedtime media use and sleep outcomes remained. Enjoyment significantly positively associated with session length, which remained significantly positively associated with bedtime delay. Bedtime delay remained significantly associated with fewer hours slept, more night wakings, worse subjective sleep quality, less next day alertness, and worse next day mood. Indirect effects of enjoyment on each of the six sleep outcomes through session length and bedtime delay were then estimated in this combined model: sleep time, b=-0.02, 95% bias-corrected CI (BCCI; −0.04, −0.003), 95% percentile-based CI (PCI; −0.04, 0.003); sleep onset latency, $b = 0.06$, 95% BCCI (−0.04, 0.26), 95% PCI (−0.08, 0.20); night wakings, $b = 0.02$, 95% BCCI (0.004, 0.05), 95% PCI (−0.002, 0.04); subjective sleep quality, b=-0.01, 95% BCCI (−0.02, −0.001), 95% PCI (−0.02, 0.002); next day alertness, b=-0.01, 95% BCCI (−0.03, −0.01), 95% PCI (−0.03, −0.002); next day mood, b=-0.01, 95% BCCI (−0.03, −0.004), 95% PCI (−0.02, −0.0002). Note that again both the BCCI and PCI both do not contain zero in the cases of next day alertness and next day mood, but only the BCCI does not contain zero for sleep time, night wakings, and subjective sleep quality.

However, including both sleep displacement and recovery processes in tandem negatively impacted the recovery outcomes observed in isolation.

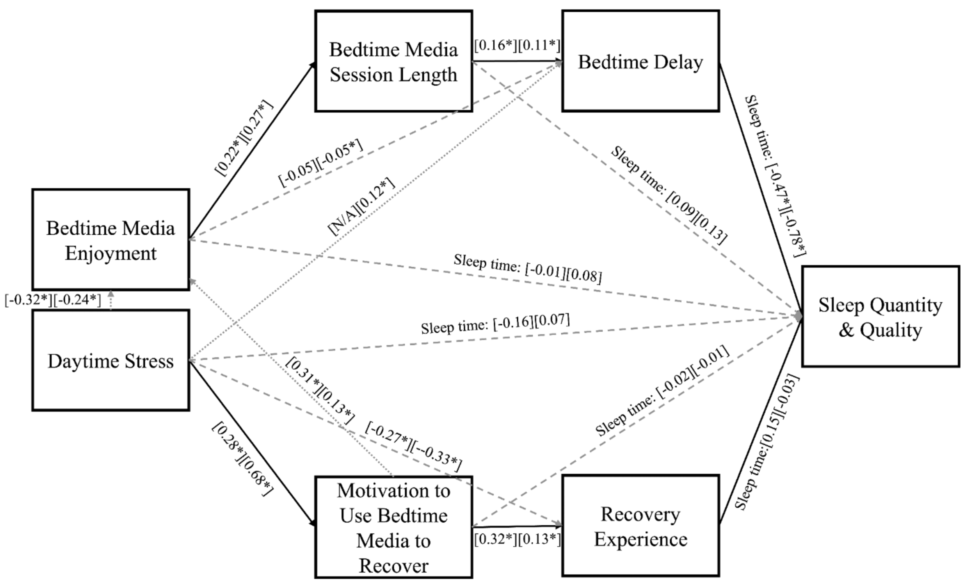

Figure 4. Statistical model for the combined model (RQ1). Greyed and dashed lines indicate direct effects included fromFigures 1 and 2. The three grayed and dotted lines represent paths added in response to modification indices to improve model fit during the analysis process. Path coefficients are included in brackets, study 1 first and study 2 second on each line. Because there are six outcome variables for sleep, for illustrative purposes sleep time is used as a proxy for all sleep outcomes. *p<.05.

Stress remained significantly positively associated with motivation to use media to recover, which remained significantly associated with recovery experience. However, recovery experience was no longer significantly associated with hours slept, and remained not significantly associated with any other sleep outcome. Indirect effects of stress on each of the six sleep outcomes through recovery motivation and recovery experience were then estimated: sleep time, 95% bias-corrected CI (BCCI; −0.0003, 0.04), 95% percentile-based CI (PCI; −0.01, 0.03); sleep onset latency, $b = 0.08$, 95% BCCI (−0.06, 0.35), 95% PCI (−0.11, 0.27); night wakings, $b = 0.01$, 95% BCCI (−0.003, 0.03), 95% PCI (−0.01, 0.02); subjective sleep quality, b=-0.002, 95% BCCI (−0.02, 0.01), 95% PCI (−0.01, 0.01); next day alertness, $b = 0.001$, 95% BCCI (−0.01, 0.02), 95% PCI (−0.01, 0.01); next day mood, $b = 0.003$, 95% BCCI (−0.003, 0.02), 95% PCI (−0.01, 0.01). All of the confidence intervals contained zero, indicating no support for the recovery hypothesis.

Overall, the results of the combined analysis suggest support for sleep displacement, but not for media recovery, providing an answer for RQ1. Additionally, there was little differentiation in terms of sleep-related quality measures and next-day quality measures, providing an answer for RQ2.

Study 1 Discussion

The results of Study 1 found that both the sleep displacement hypotheses and media recovery hypothesis were supported when they were considered separately (though, effects supporting sleep displacement were stronger than for recovery). However, when combined into the same model the sleep displacement hypothesis processes remained significant while the media recovery hypothesis did not. Therefore, in this sample we conclude that sleep displacement via media is more likely when both factors are driving media use (as is presumably the case in real world settings). Additionally, there was little differentiation in these effects whether we were examining subjective sleep quality or sleep quantity – both were negatively associated with sleep displacement processes, though the effects were more robust for the next day quality measures compared to the sleep-related quality measures.

Importantly, this sample consisted of college students, who are in the "emerging adult" developmental stage, and may have unique sleep pressures (or lack thereof) based on their life stage (Eggermont, 2006; Exelmans & Van den Bulck, 2016). An adult sample from the general population may be less likely to push back bedtime to continue using media, because they are more likely to experience external sleep constraints such as jobs and caretaking responsibilities. In addition, emerging adults, while very similar in many ways to general population adults, still have some difficulties with executive function that may influence their likelihood of engaging in bedtime procrastination compared to a general adult population (Hochberg & Konner, 2020; Taber-Thomas & Pérez-Edgar, 2015). Therefore, it is necessary to test these processes in a general adult population in order to understand whether the results of Study 1 replicate.

Study 2

Study 2 Method

Participants

Participants were 202 adults residing in the United States (*M*age = 37.60, *SD* = 13.23, range 19 to 80) who were recruited through survey panel Prolific and paid $3.00 USD for a 15-minute survey. Of those, 96 (47.52%) identified as women, 101 (50.00%) identified as men, and five (2.48%) identified as non-binary or preferred their own terminology. Racial and ethnic identities were 150 (74.26%) White, 16 (7.92%) multiracial, 13 (6.44%) Asian or Asian American, 11 (5.45%) Black or African American, 10 (4.95%) Hispanic or Latino, one (0.50%) Native American or Indigenous, and one (0.50%) preferred not to answer. All reported using media within one hour of bedtime at least once in the past, with 181 (89.60%) reporting the most recent time they used media within one hour of bed was the previous evening (less than 24 hours ago), and 136 (67.66%) reporting that they used media within one hour of bed every day for the past seven days.

Procedure

The procedure was the same as that in Study 1. The number of events reported by each participant again varied, with 48 (23.76%) reporting three or more, 87 (43.07%) reporting two, and 67 (33.17%) reporting one. Similar to Study 1, participants reported social media use ($n = 165$, 43.08% of events reported), followed by television/film ($n = 115$, 30.03%), internet browsing ($n = 29$, 7.57%), video games ($n = 29$, 7.57%), e-book reading ($n = 14$, 3.66%) and "other" ($n = 31$, 8.09%). Devices used were once again primarily smartphones ($n = 233$, 60.68%), followed by televisions ($n = 86$, 22.40%), laptop or desktop computer ($n = 35$, 9.11%), tablet ($n = 19$, 4.95%), e-reader ($n = 8$, 2.08%), portable gaming device such as Nintendo Switch ($n = 1$, 0.26%), and "other" ($n = 2$, 0.52%).

Measures

The measures that remained the same from Study 1 were as follows: *stress* (M = 4.23, SD = 1.76, Cronbach α=.90); *motivation for recovery* (M = 5.08, SD = 3.36), *enjoyment* (M = 7.38, SD = 1.75); *session length* (M = 4.33, SD = 1.63); *pushing back bedtime* (over n = 380 events, 288 (60.00%) reported not pushing back bedtime, 123 (32.37%) reported pushing back bedtime a little, and 29 (7.63%) reported pushing back bedtime a lot); *recovery experience* (M = 6.22, SD = 1.58, Cronbach α=.95); *total sleep time* (M = 7.33 hours, SD = 1.93); *sleep onset latency* (M = 15.16, SD = 15.42); *night wakings* (M = 1.44, SD = 1.42); *subjective sleep quality* (M = 2.94, SD = 0.69) *mood the next day* (M = 3.02, SD = 0.76); *alertness the next day* (M = 2.78, SD = 0.91).

Study 2 Results

The same three models presented in Study 1 were again tested in Study 2 (Figures 1, 2 and 3). Statistical details can be found in Table 2, with full output available on OSF.

Sleep Displacement Only Model

As in study 1 we predicted that bedtime media enjoyment will be associated with worse sleep, through the mediating mechanisms of session length and bedtime delay. As expected, enjoyment of bedtime media was significantly positively associated with session length, and session length was significantly positively associated with bedtime delay. Bedtime delay was significantly associated with fewer hours slept, worse subjective sleep quality, less next day alertness, and worse next day mood. To contextualize, the difference between going to bed on time and staying up “a bit later” to continue using the media content was associated with approximately 42 minutes less sleep time.

Indirect effects of enjoyment on each of the six sleep outcomes through session length and bedtime delay were then estimated: sleep time, b=-0.02, 95% bias-corrected CI (BCCI; −0.05, −0.01), 95% percentile-based CI (PCI; −0.04, 0.001); sleep onset latency, b = 0.05, 95% BCCI (−0.04, 0.20), 95% PCI (−0.06, 0.17); night wakings, b=-0.01, 95% BCCI (−0.03, 0.003), 95% PCI (−0.02, 0.01); subjective sleep quality, b=-0.01, 95% BCCI (−0.02, −0.002), 95% PCI (−0.01, 0.01); next day alertness, b=-0.02, 95% BCCI (−0.03, −0.01), 95% PCI (−0.03, −0.001); next day mood, b=-0.01, 95% BCCI (−0.03, −0.005), 95% PCI (−0.02, −0.001). Note that both the BCCI and PCI both do not contain zero in the cases of next day alertness and next day mood, but only the BCCI does not contain zero for sleep time and subjective sleep quality.

As a whole, these results provide support for H1 and the sleep displacement hypothesis, and replicate the results of study 1.

Table 2. Study 2 results for all three models. Note: coefficients reported are unstandardized. Tables with standardized variables are available on OSF. Coefficients that are significant at $p<.05$ are **bolded** for ease of interpretation.

Model 1: Sleep displacement only				
	Session Length		Bedtime Delay	
	b	95% CI	*b*	95% CI
Enjoyment	**0.27**	**0.14, 0.40**	**-0.05**	**-0.10, -0.001**
Session Length			**0.11**	**0.06, 0.16**
R^2	.08		.08	
Model 2: Media recovery only				
	Recovery Motivation		Recovery Experience	
	b	95% CI	*b*	95% CI
Stress	**0.68**	**0.44, 0.92**	**-0.33**	**-0.45, -0.21**
Recovery motivation			**0.13**	**0.06. 0.20**
R^2	.14		.14	

Table 2. (Continued).

Model 3: Combined Model

	Enjoyment		Session Length		Bedtime Delay		Recovery Motivation		Recovery Experience	
	b	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI
Enjoyment			**0.27**	**0.14, 0.40**	-0.03	-0.07, 0.02			**0.44**	**0.33, 0.54**
Session Length					**0.09**	**0.04, 0.14**				
Delayed Bedtime										
Stress	**-0.24**	**-0.38, -0.10**			**0.12**	**0.08, 0.16**	**0.68**	**0.44, 0.92**	**-0.33**	**-0.45, -0.21**
Recovery motivation	**0.13**	**0.06, 0.21**							**0.13**	**0.06, 0.19**
R^2	.08		.08		.19		.14		.35	

Table 2. (Continued).

Model 1: Sleep displacement only

	Total Sleep Time		Sleep Onset Latency		Number of Night Wakings		Subjective Sleep Quality		Perceived Alertness		Subjective Mood	
	b	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI
Enjoyment	0.06	-0.10, 0.21	-0.57	-1.90, 0.76	-0.10	-0.22, 0.02	**0.10**	**0.04, 0.15**	0.06	-0.02, 0.13	**0.09**	**0.03, 0.15**
Session Length	-0.13	-0.30, 0.04	1.01	-0.44, 2.46	-0.05	-0.18, 0.09	0.00	-0.06, 0.06	0.03	-0.05, 0.11	0.00	-0.07, 0.07
Delayed Bedtime	**-0.70**	**-1.14, -0.25**	1.88	-1.97, 5.73	-0.23	-0.58, 0.12	**-0.21**	**-0.38, -0.05**	**-0.52**	**-0.74, -0.31**	**-0.44**	**-0.62, -0.27**
R^2	.07		.02		.03		.10		.12		.16	

Model 2: Media recovery only

	Total Sleep Time		Sleep Onset Latency		Number of Night Wakings		Subjective Sleep Quality		Perceived Alertness		Subjective Mood	
	b	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI
Stress	-0.05	-0.21, 0.12	-0.15	-1.55, 1.25	-0.11	-0.23, 0.02	**-0.10**	**-0.16, -0.04**	**-0.16**	**-0.24, -0.08**	**-0.22**	**-0.28, -0.16**
Recovery motivation	-0.00	-0.09, 0.09	0.14	-0.60, 0.88	-0.01	-0.08, 0.05	0.02	-0.01, 0.05	-0.02	-0.06, 0.03	0.00	-0.03, 0.04
Recovery experience	-0.02	-0.20, 0.16	-1.29	-2.78, 0.21	-0.15	**-0.29, -0.02**	**0.06**	**0.002, 0.13**	0.07	-0.01, 0.15	0.05	-0.01, 0.11
R^2	.00		.02		.04		.11		.14		.29	

Model 3: Combined Model

	Total Sleep Time		Sleep Onset Latency		Number of Night Wakings		Subjective Sleep Quality		Perceived Alertness		Subjective Mood	
	b	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI	*b*	95% CI
Enjoyment	0.08	-0.10, 0.27	0.04	-1.53, 1.61	-0.05	-0.20, 0.09	0.06	-0.00, 0.13	0.01	-0.08, 0.10	0.05	-0.02, 0.11
Session Length	-0.13	-0.30, 0.03	1.01	-0.43, 2.45	-0.05	-0.18, 0.08	0.01	-0.05, 0.07	0.03	-0.05, 0.11	0.00	-0.06, 0.06
Delayed Bedtime	**-0.78**	**-1.26, -0.29**	2.23	-1.89, 6.35	-0.13	-0.50, 0.24	-0.14	-0.31, 0.03	**-0.37**	**-0.60, -0.15**	**-0.23**	**-0.40, -0.06**
Stress	0.07	-0.10, 0.25	-0.54	-2.02, 0.95	-0.09	-0.22, 0.05	**-0.08**	**-0.14, -0.02**	**-0.12**	**-0.20, -0.03**	**-0.19**	**-0.25, -0.13**
Recovery motivation	-0.01	-0.09, 0.08	0.15	-0.59, 0.89	-0.01	-0.08, 0.06	0.02	-0.01, 0.05	-0.01	-0.05, 0.03	0.00	-0.03, 0.03

Media Recovery Only Model

As in study 1 we predicted that when media is used to recover from stress it will be associated with better sleep. As expected, stress reported that day was significantly positively associated with motivation to use bedtime media to recover from stress. Motivation to use media to recover from stress was significantly positively associated with recovery experience. Recovery experience was significantly associated with fewer night wakings and higher subjective sleep quality. However, there were no other significant associations between recovery experience and sleep outcomes. Additionally, stress had significant direct associations with lower subjective sleep quality, lower next day alertness, and worse next day mood. Thus, as we found in study 1, while media recovery does appear to help in terms of some sleep outcomes, it does not appear to fully negate the negative influence of stress.

Indirect effects of stress on each of the six sleep outcomes through recovery motivation and recovery experience were then estimated: sleep time, b=-0.002, 95% bias-corrected CI (BCCI; −0.02, 0.02), 95% percentile-based CI (PCI; −0.02, 0.02); sleep onset latency, b=-0.11, 95% BCCI (−0.40, 0.01), 95% PCI (−0.30, 0.07); night wakings, b=-0.01, 95% BCCI (−0.04, −0.003), 95% PCI (−0.03, 0.002); subjective sleep quality, $b = 0.01$, 95% BCCI (0.0002, 0.02), 95% PCI (−0.002, 0.01); next day alertness, $b = 0.01$, 95% BCCI (−0.001, 0.02), 95% PCI (−0.003, 0.02); next day mood, $b = 0.004$, 95% BCCI (−0.001, 0.01), 95% PCI (−0.002, 0.01). Note that the BCCIs for night wakings and subjective sleep quality were the only confidence intervals that did not contain zero.

As a whole, these results broadly replicate study 1 and continue to provide weak support for the media recovery hypothesis.

Combined Model

Replicating the combined model from study 1 showed poor model fit (Hu & Bentler, 1999), $\chi^2(7) = 88.26$, $p < .001$, CFI = .84, RMSEA = 0.24, SRMR = 0.08. Modification indices suggested large improvements would be gained by adding a path from stress to bedtime delay and from enjoyment to recovery experience. Although we initially sought to keep the sleep displacement and media recovery mediations separate to test these as independent influences on sleep outcomes, it is not entirely surprising that stress would be associated with a delayed bedtime, a point which will be revisited in the discussion. With these paths added, model fit was then excellent, $\chi^2(5) = 4.70$, p=.45, CFI = 1.00, RMSEA = 0.00, SRMR = 0.02.

As in Study 1, enjoyment remained significantly positively associated with session length, which remained significantly positively associated with bedtime delay. Bedtime delay remained significantly associated with fewer hours slept, less next day alertness, and worse next day mood. Indirect effects of enjoyment on each of the six sleep outcomes through session length and bedtime delay were then estimated in this combined model: sleep time, b=-0.02, 95% bias-corrected CI (BCCI; −0.05, −0.005), 95% percentile-based CI (PCI; −0.04, 0.003); sleep onset latency, $b = 0.05$, 95% BCCI (−0.02, 0.21), 95% PCI (−0.05, 0.16); night wakings, b=-0003, 95% BCCI (−0.02, 0.01), 95% PCI (−0.01, 0.01); subjective sleep quality, b=-0.003, 95% BCCI (−0.01, 0.0002), 95% PCI (−0.01, 0.002); next day alertness, b=-0.01, 95% BCCI (−0.03, −0.002), 95% PCI (−0.02, 0.002); next day mood, b=-0.01, 95% BCCI (−0.02, −0.001), 95% PCI (−0.01, 0.001). Only the BCCI does not contain zero for sleep time, next day alertness, and next day mood.

In reassessing the media recovery hypothesis in this combined model, stress remained significantly positively associated with motivation to use media to recover, which remained significantly associated with recovery experience. However, recovery experience was no longer significantly associated with any sleep outcome. Indirect effects of stress on each of the six sleep outcomes through recovery motivation and recovery experience were then estimated: sleep time, b=-0.001, 95% bias-corrected CI (BCCI; −0.02, 0.01), 95% percentile-based CI (PCI; −0.01, 0.01); sleep onset latency, b=-0.07, 95% BCCI (−0.31, 0.003), 95% PCI (−0.21, 0.07); night wakings, b=-0.01, 95% BCCI (−0.02, 0.0004), 95% PCI (−0.01, 0.004); subjective sleep quality, b=-0.001, 95% BCCI (−0.002, 0.01), 95% PCI (−0.003, 0.01); next day alertness, $b = 0.003$, 95% BCCI (−0.001, 0.01, 95% PCI (−0.002, 0.01); next day mood, $b = 0.001$, 95% BCCI (−0.002, 0.01), 95% PCI (−0.003, 0.01). All of the confidence intervals contained zero, indicating no support for the recovery hypothesis.

Overall, the results of the combined analysis replicated study 1, suggesting some support for sleep displacement, but not for media recovery.

Study 2 Discussion

The results of Study 2 largely replicated those of Study 1. In general, the sleep displacement hypothesis was again more strongly supported than the media recovery hypothesis, with adult participants also reporting that the more they enjoyed the media content the more likely they were to watch longer, push back bedtime, and have worse sleep outcomes. While there was stronger support for the media recovery hypothesis in this sample when it was assessed alone, once it was added to the combined model in competition with sleep displacement processes the media recovery associations became non-significant.

General Discussion

The results of these two studies indicate bedtime media use had more negative than positive associations with sleep. They provide stronger support for the sleep displacement hypothesis in both undergraduates and general population adults. However, the media recovery hypothesis did have some support when assessed in isolation. There are contexts in which positive sleep outcomes might yet occur because of (or in spite of) bedtime media use, and more research is needed to understand what those contexts are. Overall, though, the results are indicative of a more problematic relationship between bedtime media use and sleep. Previous research has focused on either the sleep displacement hypothesis (Exelmans & Van den Bulck, 2017) or the media recovery hypothesis (Reinecke & Rieger, 2020; Sonnentag et al., 2008) separately, but the present study is the first to our knowledge that has situated them as competing pathways. While we supported both areas of research with our separate models for each hypothesis, when they were allowed to compete in the same model the results suggested that the sleep displacement effect is more robust or otherwise statistically washes out the recovery effect.

According to these results, enjoyment may be an important predictor of how media use impacts sleep and next day outcomes. Enjoyment appears to be harmful to sleep when greater enjoyment is associated with increased likelihood of bedtime delay and thus sleep displacement. This may be because media enjoyment is rewarding for the user in the moment, whereas consequences for sleep displacement are not experienced until the following day or even multiple days later as sleep debt accumulates. This delayed negative effect may increase the appeal of media for users, who are willing to trade off distal consequences for immediate rewards. This type of time-distortion is typical among chronic procrastinators and has been associated with bedtime procrastination in particular (Chung et al., 2020). While the current study did not measure procrastination motives, there is some evidence suggesting delayed sleep onset can be due to “revenge” procrastination, whereby users knowingly defer sleep in order to establish a sense of control over their time use, particularly after a taxing day (Kamphorst et al., 2018), and entertaining media may be particularly appealing in these context.

Of course, enjoyment also has many positive associations outside of sleep outcomes, such as coping, the emotion and mood benefits of stress recovery, and behavioral engagement, among others (Nabi et al., 2021, Nabi et al., 2017, Tsay-Vogel & Nabi, 2015). Thus, we want to caution against “throwing the baby out with the bathwater” in terms of maligning media enjoyment as a bad thing – as with most media uses and effects, effects of enjoyment are context and outcome dependent. Certainly, future studies might examine the temporal dimensions of these relationships in more detail than the current cross-sectional design allows. For example, testing if in-the-moment enjoyment during sleep displacing media use is associated with next-day guilt, regret, stress, coping, and mood might help disentangle these relationships further.

In addition, there can often be a tendency to equate any negative outcomes of media with “problematic use.” However, problematic use of media at a clinical level is rare – for example, less than 3% of Americans fit the definition for problematic gaming or gaming disorder (Mentzoni et al., 2011; Wittek et al., 2016). Problematic use can be looked at as more of a continuum, in which some people may experience problematic use aspects at least some of the time. While this is important, it does not mean that all media use should be pathologized. Often, media use that goes beyond the norm into overconsumption is not a pattern of use for that individual but a one-off occurrence, in which they stay up late binge watching or scrolling social media and it affects their sleep negatively, but the next night they may compensate for that, and the effects are a wash over time. Research suggests that small variations in sleep debt can be made up for with later sleep (Faraut et al., 2017; Oh et al., 2019), meaning that poor sleep one night due to media use could be compensated for later. That said, large levels of sleep debt cannot be compensated for with napping and/or weekend sleeping in (Leger et al., 2020), so the overall patterns of behavior are important to consider. The present studies did not ask for next night sleep, nor do most of the other studies on this topic. Future research should consider the longitudinal implications of sleep compensation, and distinguish between moderate media consumption that sometimes ends up as overconsumption, versus chronic overconsumption of media – and importantly, how these variable instances of media use may be in response to fluctuating daily stressors and other contextual factors.

Limitations and Future Research

The present studies rely on cross-sectional survey data, meaning causality cannot be established. Experimental manipulations of bedtime media use, and/or longitudinal studies that follow participants across time, would be useful in this context to better provide causal evidence. In addition, the studies asked about retrospective and subject media use and sleep, which comes with the foibles of memory. The fact that the majority of participants in both samples were reporting on media use and sleep from the night before they completed the study, and next-day outcomes (alertness, mood, etc.) were therefore current mitigates this to some degree. As retrospective reports go, this was an ideal situation. However, some participants reported on events from a few days ago or longer, meaning their memories may have been compromised. Additionally, the sleep measures, while validated as a sleep diary and used in hundreds of studies (Monk et al., 1994), is still subjective and is therefore not likely as valid as objective sleep measurement (e.g., from EEG). Future research may wish to include objective measures of sleep to replicate these effects without the influence of participant memory or subjectivity.

Another limitation is that we did not consider content effects in the present study. Previous research on the media recovery hypothesis has stressed the importance of message content features, such as overexcitement or horror's effect on nightmares (Van den Bulck, 2004; Van den Bulck et al., 2016). But, there are many other kinds of content that are likely to have differential effects, as suggested by a recent study on cliffhangers and suspense (Baselgia et al., 2023). We did measure device type and medium, which was highly variable and also differed slightly in the two samples. Thus, we conclude that device and medium may to some extent be less important for sleep than amount of use, given that these patterns were found despite the high variability in these constructs potentially causing noise in the model. However, future research should look to the actual content (e.g., genre, format) for further detail on these relationships. Additionally, recent work has found that the intentionality can matter, such that outcomes are improved when the length of a session is preplanned and the plan is enacted without variation (Ulusoy et al., 2022). This should also be accounted for in future research.

Finally, it should be noted that the effect sizes found in our studies were quite small. While we believe that small statistical effects should not be over-interpreted or unreasonably applied, we would disagree that very small effects are unimportant or without theoretical value. Rather, small effects must be considered in context and examined for their predictive utility and significance from a broader range of criteria than just a numeric threshold alone (Abelson, 1985; Götz et al., 2022; Lang & Ewoldsen, 2010). In our particular case, cross-sectional studies were designed to interrogate a small number of media events relative to real-world use. A tiny (but meaningful and robust) effect might be multiplied over the number of bedtime media use events in a lifetime in the prediction of sleep debt over time. The predictive utility of these relationships, while individually small, may be cumulatively of substantial value to understanding the reality of bedtime media use and its effects. Our data naturally cannot investigate this premise, but reporting and publishing small effect sizes encourages the scholarly community to examine them further, for example in longitudinal modeling and other formats designed to examine compounding and cumulative effects over time. Thus, our small effects should be interpreted with due caution, but also should not be completely discounted.

Conclusion

The question of whether bedtime media use is positive, negative, or neutral for sleep outcomes is not clearly answered in the literature. Two studies provide evidence largely in favor of the sleep displacement hypothesis and a negative relationship between bedtime media use and sleep. However, there were also complexities limiting the conclusion that bedtime media use is always bad for sleep or that sleep displacement is the only process at play. Thus, while on the whole the evidence suggests forgoing bedtime media use in favor of sleep, the jury is still out on whether it should be universally condemned.

Notes

1. Participants reported on more than one event due to the possibility that it was an earlier event in the evening, not the proximate event to sleep, that led to pushing back bedtime and/or to the most recovery. For example, one might push back bedtime to continue binge watching a show on Netflix, but then spend a few minutes on social media right before falling asleep. If only the final media event before sleep is reported it would miss the information about what truly led to the later sleep time. However, because there were not specific hypotheses related to the different events, the analyses collapsed across events within an evening by averaging the variables that were measured on the event level within participant.
2. Bias-corrected bootstrapped samples adjust the endpoints of the confidence interval in either direction based on the proportion of values of *ab* that are smaller than the point estimate of *ab* in the original sample. Bias-corrected bootstrapping has been demonstrated to have higher statistical power and can correct for small samples (which this study has) and imperfect distributions (e.g., some of our key variables are ordinal in nature), but they also may have an inflated type I error rate (Chen & Fritz, 2021). Percentile-based confidence intervals have been demonstrated to have the lowest power, but also the lowest Type I error rate. In cases where the bias-corrected version and the percentile-based version of a confidence interval differ in interpretation (e.g., bias-corrected is significant but percentile is not) the results should be interpreted with caution and replication should be a goal.
3. OSF link: https://osf.io/fnps4/?view_only=dc8efa65bebc4c4eac49ef23afbd5018.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

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