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SCIENTIFIC INVESTIGATIONS

Binge Viewing, Sleep, and the Role of Pre-Sleep Arousal

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Study Objectives: To investigate the prevalence of binge viewing, its association with sleep and examine arousal as an underlying mechanism of this association.

Methods: Four hundred twenty-three adults (aged 18–25 years old, 61.9% female) completed an online survey assessing regular television viewing, binge viewing, sleep quality (Pittsburgh Sleep Quality Index), fatigue (Fatigue Assessment Scale), insomnia (Bergen Insomnia Scale), and pre-sleep arousal (Pre-Sleep Arousal Scale). Regression analyses were conducted. Mediation analysis was performed using PROCESS Macro.

Results: There were 80.6% who identified themselves as a binge viewer. Among those who binge viewed (n = 341), 20.2% had binge viewed at least a few times a week during the past month. Among poor sleepers (Pittsburgh Sleep Quality Index > 5), 32.6% had a poor sleep quality associated with being a binge viewer. Higher binge viewing frequency was associated with a poorer sleep quality, increased fatigue and more symptoms of insomnia, whereas regular television viewing was not. Cognitive pre-sleep arousal fully mediated these relationships.

Conclusions: New viewing styles such as binge viewing are increasingly prevalent and may pose a threat to sleep. Increased cognitive arousal functions as the mechanism explaining these effects. Measures of media exposure should take into account the user's level of engagement with media. Interventions aimed at (1) alerting viewers about excessive viewing duration and (2) reducing arousal before sleep may be useful ways to tackle sleep problems in binge viewers.

Keywords: arousal, binge viewing, fatigue, insomnia, PSQI, sleep quality

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INTRODUCTION

The way we watch television has dramatically changed over the past decades. New technologies such as digital recorders and streaming services have ended the era of appointment viewing: 63% of American households use a streaming service,[1] and the use of digital video recorders and the Internet increased the amount of viewing in college students.[2] The unprecedented access to television content has also introduced a new viewing style: binge viewing, defined as watching multiple episodes of the same series in one sitting.[3] Statistics indicate that binge viewing is on the rise: 3 out of 4 respondents in the study by Sung et al. self-identified as a binge viewer,[4] and research showed that 70% of television viewers between 13 and 49 years old binge viewed at least sometimes.[5] In general, viewers are increasingly watching television in larger doses at a time of their choosing.

The term binge viewing hints at an overindulgence or addiction regarding television viewing, and concerns have been raised over its harmful effects. Prior research has indicated that media bingeing was associated with more anxiety, depression, and fatigue.[6,7] Binge viewers also reported higher levels of loneliness and depression.[4] Although some researchers worry that binge viewing may lead to a reduction in social skills in the long term,[6,8] binge viewers also reported the behavior has a social value: the ability to participate in conversations about a show with friends creates a sense of belonging.[5,9,10]

Despite the growing popularity of binge viewing, the phenomenon has received little scholarly attention thus far. In sleep research, it is recognized that screen exposure negatively affects sleep. For television viewing, findings have been inconsistent: a review study indicated that 32 of 42 studies that examined television viewing and sleep outcomes found significant negative associations.[11] Conversely, Bartel and colleagues found television viewing not to be a significant risk factor for sleep.[12] Most of the research on this topic focuses on regular viewing volume. To our knowledge, this study is the first to investigate the association between binge viewing and sleep.

Dworak and colleagues posited that excessive media consumption would negatively affect sleep,[13] and research found that watching television for more than 2 hours per day increased sleep onset delay among children.[14] Considering that binge viewing signifies an intense or more extreme viewing

BRIEF SUMMARY

Current Knowledge/Study Rationale: Whether regular television viewing has much effect on sleep is debated. New viewing patterns, such as binge viewing, in which consumers watch an excessive amount of television in one sitting, have, however, not been studied. There is also a lack of understanding of the underlying mechanism of the association between technology use and sleep.

Study Impact: The current study shows binge viewing is prevalent among young adults and is the first to demonstrate a link with poorer sleep quality, more fatigue, and increased insomnia. Importantly, the mechanism explaining this relationship appears to be increased cognitive arousal, resulting from binge viewing. Although this has been explained by viewers' higher level of engagement with the television show, future research should verify this hypothesis.

habit, we expect that binge viewing will negatively affect sleep outcomes.

Addressing the call for more research into the underlying mechanisms explaining the relationship between media use and sleep,[15,16] this study will explore arousal as an explanatory factor (ie, mediator) of the aforementioned relationship. In addition to displacing sleep and affecting melatonin output, screen exposure is presumed to affect sleep through its effect on arousal.[15] The existing research has found that playing video games increased activity in the central and autonomic nervous system, which in turn prolonged sleep onset.[13,17,18] One recent study reported that cognitive pre-sleep arousal mediated the relationship between social media use and sleep onset latency.[19] Although it has been argued that these results can be extrapolated to other media platforms,[14,20] evidence of this hypothesis is scarce.

The limited literature on binge viewing provides some indications to propose arousal as a mediator of the relationship with sleep. Television shows that are binge viewed are characterized by a complex narrative structure and intense character development. Binge viewers become strongly immersed into the story, identify with the characters, and experience increased difficulty to stop viewing.[10,21,22] In other words, because of the higher emotional and cognitive involvement during binge viewing, we expect that binge viewing will affect sleep through its effect on arousal. In summary, we formulate two research questions:

- RQ1: Does binge viewing affect sleep (ie, sleep quality, fatigue, insomnia)?
- RQ2: Is arousal a significant mediator of the relationship between binge viewing and sleep?

METHODS

Sample and Procedure

Arnett identified "emerging adults," the group of 18- to 25-year-olds between adolescence and adulthood, as a group particularly sensitive to risk behaviors.[23] As young adults are also often considered to be the most avid binge viewers,[5] 18- to 25-year-olds were invited to participate in an online survey in February 2016. A call for participation was disseminated via Facebook postings that highlighted the topic of the research project and the voluntary nature of participation. The study was presented as a study on young people's leisure time and well-being to blind the relationships we were studying. Anonymous participation was guaranteed. The study was conducted in accordance with the ethics requirements of the Social and Societal Ethics Committee of the KU Leuven, and informed consent was obtained from all respondents.

A total of 463 questionnaires were completed. Respondents who reported that they had a clinical history of sleep problems (ie, who indicated they had consulted a doctor regarding sleep difficulties, n = 40) were dropped from the analyses, resulting in a final sample of 423 respondents. There was a higher proportion of women (61.9%), and 74.2% of respondents were students, 23.0% was working, and 2.8% were unemployed. Respondents' average age was 22.17 years (standard deviation [SD] = 1.86).

Measures

Sleep Quality

The Pittsburgh Sleep Quality Index (PSQI)[24] is a 19-item self-report measure that assesses sleep quality over the past month. The index consists of 7 component scores (sleep duration, subjective sleep quality, sleep efficiency, sleep latency, sleep disturbances, daytime dysfunction, use of sleep medication) ranging between 0 and 3, with a higher score indicating more problems in that component. An overall sleep quality score is computed, and respondents scoring higher than 5 are categorized as poor sleepers. The index showed acceptable internal consistency ($\alpha = .60$).

Insomnia

The Bergen Insomnia Scale (BIS)[25] is composed of 6 items measuring how frequently respondents experienced different symptoms of insomnia during the past month (0 = 0 days per week over the last month, 7 = every day over the last month). A total score was computed, ranging between 0 and 42. Cronbach alpha (α) for the BIS was .76.

Fatigue

We used the Fatigue Assessment Scale (FAS),[26] consisting of 10 items that describe symptoms of daytime fatigue experienced during the past month, rated on a 5-point scale (1 = never, 5 = always). The total scores ranges between 0 and 50 and the scale showed good internal consistency ($\alpha = .87$).

Pre-Sleep Arousal

We assessed pre-sleep arousal using the Pre-Sleep Arousal Scale.[27] The scale taps into somatic (eg, heart racing, pounding, or beating irregularly) and cognitive (eg, being mentally alert, active) manifestations of arousal experienced when trying to fall asleep, with 8 items in each subscale. Respondents rated on a 5-point scale (1 = not at all, 5 = extremely) how intensely they experienced each element during the past month as they attempted to fall asleep. The scale has been broadly used and shows satisfactory internal consistency and test-retest reliability.[27–30] Validity has been demonstrated for populations with insomnia versus good sleeper controls.[27] Both subscales ($\alpha_{som} = .73$; $\alpha_{cog} = .88$) showed good internal consistency in our sample.

Binge Viewing

Appendix 1 in the supplemental material shows our operationalization of binge viewing, which is based on previous research.[4] The first question was a screening question to identify binge viewers in the sample. Because there is considerable inconsistency in the number of episodes that are required before the literature defines a session as a "binge,"[31] we provided a definition of binge viewing as "watching multiple consecutive episodes of the same television show in one sitting on a screen, be it a television, laptop, computer or tablet computer screen." Those who identified themselves as a binge viewer continued to answer questions about their frequency of binge viewing during the last month (1 = once during the past month, 5 = (almost) every day), the duration of an average binge viewing

Table 1—Descriptive statistics and correlations for variables of interest.

1. Binge viewing frequency	–							
2. Binge viewing duration	−.144**	–						
3. TV viewing (h/week)	.166**	.084	–					
4. PSQI	.148 **	.061	−.003	–				
5. FAS	.144**	.011	−.028	.532***	–			
6. BIS	.154**	−.003	.007	.700***	.557***	–		
7. PSAcog	.150**	.021	.028	.563***	.479***	.590***	–	
8. PSAsom	.091	−.010	.007	.509***	.491***	.515***	.591***	–
Mean	2.190	3.137	7.578	5.039	12.219	10.802	19.710	12.884
Standard deviation	1.276	1.629	3.466	2.353	6.238	7.101	6.959	4.464

* = $P < .05$. ** = $P < .01$. *** = $P < .001$. BIS = Bergen Insomnia Scale, FAS = Fatigue Assessment Scale, PSAcog = cognitive pre-sleep arousal, PSAsom = somatic pre-sleep arousal, PSQI = Pittsburgh Sleep Quality Index, TV = television.

session (hours and minutes), and the number of episodes they usually watched (2, 3–4, 5–6, more than 6).

Control Variables

We incorporated sex (0 = male, 1 = female), age, status (1 = students living on campus, 2 = students living at home, 3 = full time employment, 4 = part-time employment, 5 = unemployed), shiftwork (0 = no, 1 = yes), perceived physical health ("In general, would you say your health is: 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent"),[32] exercise level ("how many hours per week do your exercise to the extent of becoming out of breath?"), and bedtime television viewing volume as control variables. For bedtime television viewing volume, respondents reported how much (hours and minutes) television they usually watched during the final 2 hours before bedtime on an average weekday and an average weekend day. Weekly bedtime television viewing volume was computed by multiplying weekday volume by 5 and adding it to the weekend day volume multiplied by 2.[33]

Analyses

SPSS for Windows (Version 22.0, Chicago, Illinois, United States) was used to execute all analyses. Descriptive statistics and zero-order correlations were computed, and regression analyses (hierarchical and logistic) were conducted. Hayes' PROCESS computational tool with 5,000 bootstrap samples was used to test the proposed mediation hypothesis.[34,35] The results are represented as bias-corrected confidence intervals: 95% confidence intervals that do not contain zero indicate a significant indirect or mediating effect.

RESULTS

Descriptive statistics and correlations are reported in **Table 1**. Most of the sample (80.6%) reported that they had binge viewed. Among those who binge viewed (n = 341), 39.6% did this once during the month preceding the study, 28.4% a few times, 11.7% once a week, 13.5% a few times a week, and 6.7% had binge viewed almost every day during the preceding month. They spent 3 hours and 8 minutes on a binge viewing session on average (mean = 3.14, SD = 1.63). Men (mean = 1.01, SD = 1.38) binge viewed less frequently than women (mean = 1.46, SD = 1.91) ($t(314.43) = -2.469$, $P < .05$), but binge viewing sessions lasted longer among men (mean = 3.50, SD = 1.68) compared to women (mean = 2.93, SD = 1.57) ($t(235.361) = 3.077$, $P < .01$). Binge viewing frequency and duration were negatively related ($r = -.144$, $P < .01$): the more frequently one had binge viewed during the past month, the less time they spent on a binge viewing session. Finally, one in four (25.6%) watched on average of 2 episodes per binge viewing session, one in two (52.4%) watched 3 to 4 episodes in one sitting, 16.2% watched 5 to 6 episodes, and 5.9% watched more than 6 episodes in one sitting.

The sample scored on average 5.04 (SD = 2.35) on the PSQI, which borders on the cutoff point for having poor sleep quality. More than one in three respondents (37.4%) were categorized as a poor sleeper. Respondents went to bed at 11:32 PM (SD = 1:04) and got up at 8:11 AM (SD = 1:28). On average, they slept 7 hours, 37 minutes (SD = 1:02). Sleep quality was positively related to all other sleep indicators: a poorer sleep quality was thus associated with more symptoms of fatigue, insomnia, and pre-sleep arousal (**Table 1**).

Those who identified as a binge viewer reported more fatigue ($mean_{binge} = 12.58$, $SD_{binge} = 6.30$; $mean_{non\text{-}binge} = 10.73$, $SD_{non\text{-}binge} = 5.76$; $t(130.633) = -2.549$, $P < .05$) and poorer sleep quality ($mean_{binge} = 5.14$, $SD_{binge} = 2.35$; $mean_{non\text{-}binge} = 4.60$, $SD_{non\text{-}binge} = 2.32$; $t(117.592) = -1.845$, $P = .068$) compared to those who had never binge viewed. Logistic regression analyses showed that those who identified as a binge viewer had a 98% higher likelihood of having poor sleep quality compared to those who did not identify as a binge viewer ($Exp(B) = 1.981$, $P < .05$). Attributable risk, which is an epidemiological indicator reflecting the difference in prevalence of a phenomenon between the exposed and the nonexposed group,[36] was 32.6%. A PSQI score higher than 5 could thus be attributed to binge viewing in almost one in three cases.

Binge viewing frequency was positively associated with all sleep indicators, whereas binge viewing duration did not have a significant relationship with our sleep variables. Binge viewing frequency was also positively associated with cognitive pre-sleep arousal, but there was no relationship with somatic

Table 2—Hierarchical regression analyses predicting sleep quality, fatigue, and insomnia.

		PSQI (n = 326)		FAS (n = 331)		BIS (n = 336)	
		β	SE	β	SE	β	SE
Step 1	R^2	.065*		.100***		.039	
Step 2	Sex	−.037	.288	.004	.748	.017	.847
	Age	−.049	.081	.005	.214	−.045	.242
	S1	.068	.859	.045	2.251	−.024	2.570
	S2	.115	.860	.068	2.252	.070	2.571
	S3	.007	1.218	−.082	3.189	.065	3.642
	S4	.125	.879	−.107	2.297	.068	2.621
	Shiftwork	−.057	.788	.041	1.903	−.077	2.170
	General health	−.224***	.167	−.267***	.435	−.143*	.493
	Exercise (h/week)	.108	.090	−.002	.234	.076	.266
	TV viewing (h/week)	−.035	.039	−.082	.101	−.061	.114
	Binge viewing frequency	.145**	.101	.131*	.265	.161**	.300
	$R^2/\Delta R^2$	.085/.020**		.116/.016*		.064/.025**	

* = $P < .05$. ** = $P < .01$. *** = $P < .001$. BIS = Bergen Insomnia Scale, FAS = Fatigue Assessment Scale, PSQI = Pittsburgh Sleep Quality Index, SE = standard error, TV = television. S1: (0 = students on campus, 1 = students at home), S2: (0 = students on campus, 1 = full time employment), S3: (0 = students on campus, 1 = part-time employment), S4: (0 = students on campus, 1 = unemployed).

pre-sleep arousal (**Table 1**). In hierarchical regression analyses (**Table 2**) control variables were added in Step 1, and binge viewing frequency was added in Step 2. Results show that those who binge viewed more frequently reported a poorer sleep quality (β = .145, $P < .01$), more daytime fatigue (β = .131, $P < .05$), and more symptoms of insomnia (β = .161, $P < .01$). Bedtime television viewing volume was not a significant predictor of these sleep indicators.

Mediation analyses were performed using PROCESS macro. Cognitive pre-sleep arousal was used as a mediator, and all of the control variables were taken into account (**Table 3**). Results showed that binge viewing frequency was significantly related to cognitive pre-sleep arousal (Model PSQI: β = .133, $P < .05$; Model FAS: β = .122, $P < .05$; Model BIS: β = .135, $P < .05$) and that cognitive pre-sleep arousal was strongly related to each sleep indicator (Model PSQI: β = .589, $P < .001$; Model FAS: β = .462, $P < .001$; Model BIS: β = .565, $P < .001$). Cognitive pre-sleep arousal fully mediated the relationship between binge viewing and sleep quality (effect size = .078; *Boot SE* = .033; 95% CI [.014; .145]), daytime fatigue (effect size = .056; *Boot SE* = .027; 95% CI [.008; .110]), and insomnia (effect size .077; *Boot SE* = .032; 95% CI [.014; .137]). In other words, the more frequently respondents binge viewed, the more cognitive pre-sleep arousal they reported, which in turn affected their sleep quality, daytime fatigue, and insomnia symptoms.

DISCUSSION

Consuming television content in larger bursts instead of, or in addition to, regular daily viewing is an increasingly common practice. Although extensive research has been carried out on the effects of television viewing on sleep, no earlier study exists that explicitly investigates the association between binge viewing and sleep. Moreover, there is little understanding of how media exposure affects sleep. The current study, therefore, examined the relationship between binge viewing and sleep outcomes (sleep quality, fatigue, insomnia) and explored the role of arousal as an underlying mechanism.

Approximately 80% of our participants considered themselves to be a binge viewer, and one in five respondents (20.2%) had binge viewed at least a few times a week in the month preceding the study. This prevalence of binge viewing is congruent with that found by Sung and colleagues, who researched a similar American age group.[4] Additionally, the results showed that (1) a higher frequency of binge viewing was related to poorer sleep quality, more fatigue, and insomnia, and (2) cognitive pre-sleep arousal fully mediated these relationships. Cognitive pre-sleep arousal thus appeared to be the explanatory mechanism for the effects of binge viewing on sleep. These results are consistent with those of Harbard and colleagues who found that cognitive pre-sleep arousal mediated the relationship between social media use and sleep.[19]

Only cognitive pre-sleep arousal was a significant mediator, whereas somatic arousal was not. A possible explanation might be that binge viewing leads to a stronger sense of involvement into the narrative and identification with its characters than does regular viewing. This would also explain why regular bedtime television viewing was not related to our sleep indicators or arousal measure. The narrative structure that characterizes "bingeable" television shows involves (1) a larger number of (2) more diverse storylines that (3) extend beyond one episode, and that often (4) intersect during a season or (5) turn out to be connected with each other in the end.[37,38] As such, the narrative complexity in these shows leaves viewers thinking about episodes and their sequel after viewing them. This prolongs sleep onset or, in other words, requires a longer period to "cool down" before going to sleep, thus affecting sleep overall.

Table 3—Results of the mediation analyses using PROCESS.

	PSQI (n = 324)			FAS (n = 329)			BIS (n = 334)		
	B	β	SE (β)	B	β	SE (β)	B	β	SE (β)
Outcome (PSAcog)									
Binge viewing frequency	.724	.133*	.348	.666	.122*	.055	.739	.135*	.054
Sex	1.558	.224	.054	1.482	.213	.122	1.569	.225	.120
Age	.048	.013	.120	.042	.011	.065	.014	.004	.064
S1	−1.555	−.224	.064	−1.398	−.201	.365	−1.555	−.224	.363
S2	−1.139	−.164	.359	−.983	−.141	.365	−1.088	−.156	.363
S3	−1.310	−.188	.508	−1.326	−.191	.517	−1.327	−.191	.515
S4	−3.751	−.539	.368	−3.804	−.547	.373	−3.604	−.518	.371
Shiftwork	−1.541	−.222	.330	−.567	−.082	.309	−.755	−.109	.308
General health	−1.358	−.152**	.059	−1.185	−.133*	.055	−1.121	−.126*	.054
Exercise (h/week)	.279	.062	.055	.199	.044	.059	.169	.038	.059
TV viewing (h/week)	.051	.026	.056	.115	.005	.057	.013	.007	.056
Outcome (dependents)									
PSAcog	.199	.589***	.047	.414	.462***	.049	.576	.565***	.046
Binge viewing frequency	.115	.063	.045	.365	.075	.049	.440	.079	.045
Sex	−.459	−.195	.100	−.521	−.084	.107	−.556	−.078	.099
Age	−.089	−.070	.053	−.020	−.006	.057	−.224	−.059	.053
S1	.607	.258	.297	1.130	.181	.321	.500	.071	.298
S2	.798	.339	.297	1.315	.211	.321	1.675	.236	.298
S3	.342	.145	.421	−3.053	−.489	.454	3.900	.549	.422
S4	1.430	.608*	.306	−.026	−.004	.329	3.319	.467	.305
Shiftwork	−.414	−.176	.253	1.537	.246	.272	−2.498	−.352	.252
General health	−.403	−.134	.049	−1.638	−.205***	.049	−.629	−.069	.048
Exercise (h/week)	.095	.063**	.046	−.115	−.029	.052	−.191	.042	.045
TV viewing (h/week)	−.040	−.059	.046	−.163	−.090	.050	−.148	−.072	.046
Unstand. indirect effect	.144; *Boot SE* = .059; 95% CI (.032; .264)			.276; *Boot SE* = .131; 95% CI (.030; .542)			.426; *Boot SE* = .175; 95% CI (.091, .767)		
Stand. indirect effect	.078; *Boot SE* = .033; 95% CI (.014; .145)			.056; *Boot SE* = .027; 95% CI (.008; .110)			.077; *Boot SE* = .032; 95% CI (.014; .137)		

* = *P* < .05. ** = *P* < .01. *** = *P* < .001. BIS = Bergen Insomnia Scale, Boot SE = bootstrap estimate of the standard error, FAS = Fatigue Assessment Scale, PSAcog = cognitive pre-sleep arousal, PSQI = Pittsburgh Sleep Quality Index, SE = standard error, TV = television. S1: (0 = students on campus, 1 = students at home), S2: (0 = students on campus, 1 = full time employment), S3: (0 = students on campus, 1 = part-time employment), S4: (0 = students on campus, 1 = unemployed). Analyses are based on 5,000 bootstrap samples.

Whether the increase in cognitive pre-sleep arousal can be attributed to the higher degree of involvement with the content is an interesting avenue for future research.

Our results may shed new light on the fact that the findings on the effects of television viewing on sleep have been somewhat inconsistent,[11] and a recent meta-analysis by Bartel et al. concluded that in comparison with other media such as video games and computer use, television viewing is not a significant risk factor for sleep.[12] Different types of television content and different types of television viewing behavior are likely to have different effects on sleep. Our study suggests that intense exposure leads to cognitive arousal. It would be interesting to study whether, for instance, relaxing media content does the opposite.

In a broader sense, we think this study signals a need to move beyond a focus on "how much" people are using media and incorporate measures on usage styles and experience. It is interesting to note that although television viewing has undergone a remarkable transformation, the ways of measuring television viewing have not. One recommendation could be to incorporate people's media habits: the definition of "watching a lot" can vary strongly between individuals. Wagner found that among respondents who regularly watch only a little television, binge watching ignited more guilt compared to those who watch a lot of television habitually.[31] What qualifies as a "binge" can thus vary strongly between individuals. Accounting for the length of shows or identifying concrete cutoff scores for binge viewing that take into account viewing history are challenges for future research. In addition, repeated exposure to arousing media content can also lead to habituation of physiological and emotional reactions, which is often associated with so-called "desensitization." These differences in how people react to media content may explain the differences in effects on sleep. For instance, King et al. hypothesized that violent video games

may elicit only minimal effect on sleep parameters among older adolescents and adults because they have grown accustomed to these stimuli by more frequent exposure.[39]

Relevance and Guidelines

Our exploratory, cross-sectional design and the modest size of the beta coefficients mean that recommendations based on our conclusions have to be cautious and tentative. However, our study signals that binge viewing is prevalent in young adults and that it may be harmful to their sleep. Research has also shown that binge viewing signifies an overall passive or sedentary lifestyle,[8] which in turn has been associated with increased health risk and sleep problems.[40,41] Curiously, binge viewing appears to be unintentional: reports indicate that 71% of binge viewing happens by accident, when people wound up watching more than they wanted to.[42] De Feijter and colleagues argued that the first step to avoid viewing too much television is to become aware of short- and long-term viewing behavior. They suggested implementing a system—such as an app—that allows viewers to determine their optimal viewing duration, such that the viewer can engage with the content, without leading to a disconnect between the intended and actual viewing time. According to their research, optimal viewing time is generally passed after 5 episodes.[8] Some online streaming services already alert viewers when a number of consecutive episodes have been watched.

Also, because the relationship between binge viewing and sleep was fully mediated by pre-sleep arousal, interventions and treatments aimed at reducing arousal before sleep (such as relaxation techniques and mindfulness)[43] can be valuable approaches to target sleep problems associated with media use.

Strengths and Limitations

As is the case with all cross-sectional studies, we cannot determine causality, thus making the reversed hypothesis (ie, that poor sleep leads to increased binge viewing) also possible. However, the observation that binge viewing appears to be unintentional behavior,[8] and the support found for the temporal order of the mediation model (in which sleep outcomes were preceded by arousal, which was predicted by binge viewing) strengthens the hypothesized direction of the effects.

We conducted this research in a sample of younger Facebook users. Even though we did not explicitly state the focus of the study, recruitment through Facebook may have introduced self-selection bias. This caveat, and the restricted age group of this study, hinders the generalizability of the results. Although an online survey via social networks ensures the privacy of our respondents, we had no control over the respondents participating and increased the odds of tapping into groups of people with similar interests. Nonetheless, social media has been found to be a useful tool for exploratory studies on a new topic, aimed to investigate young people, an age group known to be active on social media.[44] A study on personality factors compared data gathered through Facebook with (1) online data from a large-scale web survey and (2) data from an online study among university students, and concluded that Facebook data are unlikely to exhibit systematic biases. In all, our sample may thus be non-representative but appears to represent those young adults who consume a lot of television (ie, a "risk group.")[45]

Although we used clinically validated sleep measures and constructed a binge viewing measure with a clear definition of the concept and multiple indicators of the behavior, this study relied on self-report measures that could have biased our results. Objective measures of sleep and arousal are already available, but future research would benefit from objectively measuring binge viewing, too. Experience sampling studies or partnering with streaming services are possible approaches in this regard.

Finally, there has been much inconsistency in the definition and operationalization of binge viewing. Binge viewing is a relatively new concept and the paucity of literature is still evolving. We composed a measure for binge viewing based on the study of Sung and colleagues.[4] Our measure focuses on global frequency and time estimates, which are among the most common forms of measurement in media research.[46] However, Robinson and Godbey posited that these estimates can be complex for respondents and require significant cognitive effort to answer correctly. Probing media use within delineated time slots or aiding recall with the use of graphic formats such as timelines are suggestions for improvement.[47] In addition, because we used a formative measurement model—and the scores on the items are thus not the result of an underlying latent construct—we cannot report reliability or validity estimates. Assessment of internal validity and reliability is only possible for reflective measurement models,[48] because covariance between the items can be zero, positive, or negative in formative models.[49] The design of a reflective measurement model for binge viewing is therefore recommended in future research.

CONCLUSIONS

Convergence between traditional and new media has diversified television's technology, distribution, and use. This study provides initial evidence that modern viewing styles such as binge viewing may negatively affect overall sleep quality, and identified cognitive pre-sleep arousal as the explanatory mechanism. Despite television's status as a form of "old media," the rise of binge viewing shows that viewers are more engaged than ever with television content. Although sleep research is increasingly devoted to uncovering the effects of media on sleep, continued efforts are essential to monitor the dynamic relationship between leisure time and sleep. As quoted by Mikos: "Television will not disappear: it will only become available on all existing screens—and so become more present and more important."[10]

ABBREVIATIONS

BIS, Bergen Insomnia Scale
Boot SE = bootstrap estimate of standard error
FAS, Fatigue Assessment Scale
PSAcog, cognitive pre-sleep arousal
PSAsom, somatic pre-sleep arousal
PSQI, Pittsburgh Sleep Quality Index

SD, standard deviation
SE, standard error

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