Current Sleep Medicine Reports (2019) 5:128–134
https://doi.org/10.1007/s40675-019-00146-x

SLEEP AND TECHNOLOGY (J VAN DEN BULCK, SECTION EDITOR)

Media Use and Sleep in Teenagers: What Do We Know?

Lauren Hale[1] · Xian Li[1] · Lauren E. Hartstein[2] · Monique K. LeBourgeois[2]

Published online: 16 July 2019

Abstract

Purpose of Review The screen-based media landscape has changed markedly during the last decade, with 95% of American teens owning or having access to a smartphone. Coinciding with the rise in digital media devices, researchers have noted a high prevalence of insufficient sleep among youth. In this article, we review recent literature about adolescents' screen use behaviors and sleep health outcomes published between 2015 and 2019.

Recent Findings Overall, we found a high level of screen use and poor sleep health (i.e., short duration, poor quality, late timing) among adolescents. The great majority of recent observational studies demonstrated a robust inverse association between screen media device use and sleep outcomes among adolescents all over the world. Screen-based media use has also been linked to a series of adverse psychosocial and behavioral outcomes, partially if not fully mediated through impaired sleep health. Experimental data, however, offer mixed findings on the causal relationship between teen media use and sleep. In addition, there is uncertainty as to the relative roles of the proposed mechanisms underlying those relationships, whether driven by the light emitted by devices, time displacement, or the media content affecting psychological state (e.g., fear of missing out, anxiety).

Summary Current empirical research demonstrates that screen-based digital media use is closely associated with sleep duration and sleep quality among teens; however, limited data show a direct causal effect of screen-based media use on adolescent sleep health. With very few studies demonstrating easy-to-implement and effective interventions, we argue that more basic, translational, and clinical research is necessary.

Keywords Sleep · Screens · Video · Television · Smartphones · Social media · Adolescents · Teenagers · Digital media · Electronic media

This article is part of the Topical Collection on *Sleep and Technology*

✉ Lauren Hale
Lauren.hale@stonybrook.edu

Xian Li
Stellalixian@hotmail.com

Lauren E. Hartstein
Lauren.Hartstein@colorado.edu

Monique K. LeBourgeois
Monique.LeBourgeois@colorado.edu

[1] Department of Family, Population and Preventive Medicine, Program in Public Health, Renaissance School of Medicine at Stony Brook University, HSC Level 3, Room 071, Stony Brook, New York 11794-8338, USA

[2] Department of Integrative Physiology, University of Colorado Boulder, 354 UCB, Boulder, CO 80309, USA

Introduction

The pervasive use of screen-based digital media devices, during the day and evening hours, is accompanied by a high prevalence of insufficient sleep, affecting a majority of adolescents [1]. In this review article, we provide an updated overview of the current research on screens and sleep among adolescents. Due to space limitations and the changing nature and usage patterns of digital technology, we focus on articles published between 2015 and 2019. We begin by summarizing the high rates of both screen use and insufficient sleep among teenagers. Next, we review up-to-date evidence of the associations between screen use and sleep outcomes using observational studies. We follow with an appraisal of the more limited recent experimental studies on screens and sleep. We conclude with directions for future research, interventions, and policies.

High Levels of Screen Use and Poor Sleep Health Among Adolescents

During the last decade, the screen-based media landscape has changed markedly. According to the Pew 2018 report, 95% of American teens (aged 13–17) own or have access to a smartphone, which is a more than 20 percentage point increase from 73% in 2014–2015 [2]. As a result, 45% of teens reported being "almost constantly online." Data from a 2016 nationally representative study of over 2600 US youth indicated that 47% of tweens and 57% of teens have TVs in their bedrooms [3]. Additionally, parent-reported data from the 2014 *Sleep in America* (*SIA*) poll by the National Sleep Foundation revealed that 75% of youth keep at least one type of electronic screen-based device in their bedroom [4].

Coinciding with the rise in digital media devices, two recent studies using US population-based data on teens show that compared with 1991, 58% more adolescents reported insufficient sleep in 2015. The authors concluded that the decreased sleep duration was primarily driven by use of portable screen devices [5••, 6]. Others have also argued that the ubiquitous prevalence of screen-based media devices (e.g., smartphones and tablets) is associated with poorer adolescent sleep health [7]. For example, the *SIA* poll found that the 57% of teenagers who leave an electronic device on in their bedroom after bedtime obtained less total sleep and had lower sleep quality compared with those who did not have a device in their room [4]. In fact, a recent US-based study found that 87% of 553 teenagers self-reported high levels of screen activities as a barrier to good sleep [8].

Screen Media Use and Sleep Outcomes in Observational Data

Several meta-analyses and reviews have documented a robust inverse association between screen-based media activities and adolescent sleep health outcomes [8–13]. Across a diverse range of socio-cultural backgrounds and levels of economic development, consistent empirical results have emerged from countries around the world, including the USA [6, 14], France [15], Mexico [16], Turkey [17], Brazil [18], and India [19]. Overall, these studies have shown that screen-based media device use is associated with a range of adverse sleep outcomes, including later bedtimes [20–23], later sleep midpoints [16, 24], longer sleep latencies [25, 26], insufficient sleep duration [27, 28], more insomnia symptoms [29••, 30], reduced sleep quality [31–33], lower sleep efficiency [34], and excessive daytime sleepiness [14, 35–38]. For example, one study using two US adolescent national datasets from 2010 to 2015 revealed a linear exposure-response association between screen devices use and increased odds of short sleep duration [5••]. Likewise, a Canadian study found a dose-response relationship between social media use and greater risk of short sleep duration, with much higher odds of insufficient sleep being observed among teens using social media for 5 or more hours per day compared with those using it for only 1 h per day [21]. In addition, parent-reported data from the 2016 National Survey of Children's health found that every hour of digital screen time was associated with 3–8 fewer minutes of sleep duration and more irregular bedtimes during the weeknights [39]. While 3 to 8 min per hour may not seem like a large association, given the many hours that children spend in front of screens per day, this can add up to 40 min or more of shorter sleep duration if the child uses screens for 5 h per day or 80 min less sleep if the child uses screens for 10 h per day.

One meta-analysis investigated the association between portable screen-based media devices and sleep outcomes [13]. Merging results from 20 studies and over 125,000 youth, the authors consistently found that bedtime media usage is associated with insufficient sleep duration (OR = 2.17, $p < 0.001$), poor sleep quality (OR = 1.46, $p < 0.01$), and excessive daytime sleepiness (OR = 2.72, $p < 0.01$). The results of this meta-analysis also indicated that the mere presence of a portable screen-based media device in the bedroom has adverse associations with several sleep outcomes. Other recent studies support the case that the presence (not the use) of screen devices in the bedroom is associated with increased sleep problems [13, 40–42]. One study compared three groups of teens and found that longtime owners of smart phones slept significantly less and had poorer sleep quality than non-owners and new owners at the baseline [40]. Further, access to a smartphone in a teenagers' bedroom is associated with shorter sleep duration [15], lower sleep quality, and less efficiency [43].

Although most of the aforementioned studies relied upon self-reported or parent-reported data, which are more prone to recall errors or bias, studies using objective measures of screen-based activities and assessing sleep via actigraphy [44, 45••, 46] found similar results. One recent study found that electronic media use accounted for 30% of all variance in adolescent sleep efficiency, as measured by actigraphy [45••]. Additionally, one Swiss study using data from mobile phone records revealed that teens who suffered from mobile phone related nocturnal awakenings had 3 to 5 times higher odds of restless sleep and insomnia symptoms [47].

Several longitudinal cross-lagged analyses have revealed a reciprocal relationship between screen media use and sleep problems. Results from 3 studies highlighted that more screen time at baseline was associated with shorter sleep duration, more sleep problems, and more daytime impairments in the follow-up wave, and baseline sleep problems were linked with higher consumption of screen time at follow-up 1 year later [47–49]. Adding evidence to support bidirectionality, adolescents report using media at bedtime to "help" them fall asleep [50]. Thus, there may be reverse causality in which the individuals who have trouble falling asleep turn to media devices as a strategy to either help them fall asleep or for entertainment.

Although the vast majority of recent observational studies find an inverse relationship between screen time and sleep health, several studies have failed to find an association. Studies examining screen time and sleep duration among both Korean high school boys [37] and Australian girls (8–16 years old) found that high-frequency social media interactions before bedtime were not significantly linked with reduced time in bed [51]. More research is needed to understand why these studies failed to find an association.

Does It Matter What Time of Day the Screen Is Used?

Although most studies examined total daily screen time as a predictor, data from studies assessing both daytime and pre-bedtime screen use indicate associations with poor sleep outcomes [32, 52]. However, the greatest effects on sleep come from studies assessing nighttime media use in the bedroom (i.e., in the 1–2 h before bedtime) [53, 54] or screen activities after lights-out [55] and the use of violent media at any time of the day [56, 57]. For example, one lab study found that video game use prior to bedtime leads to sleep loss and next day attention deficits among Australian adolescents [58]. Another experimental study revealed that prolonged violent gaming before bedtime caused decreases in objective sleep efficiency and total sleep time, as well as an increase in subjective sleep onset latency [59].

Are There Differences Across Types of Device?

There are varying results regarding whether the type, size, or how interactive a teen is with screens affects sleep outcomes. Some studies have found that interactive screen media use (e.g., video games and mobile devices) may have a greater impact on sleep than passive use, such as watching television [20, 60–64]. For example, one study found no association between TV, game console or computer use, and sleep problems, and only cell phone and MP3 player use in the bedroom (which are less subject to parental control) predicted teens' sleep problems [32]. One meta-analysis found no association between television watching and sleep duration, while computer use was associated with shorter total sleep duration.

Experimental Data Provide Mixed Results

Although observational studies demonstrate direct associations between adolescents' electronic media use before bed and insufficient sleep, relevant experimental research is limited and offers mixed results. Results from studies among young adults report that, compared with reading printed material, reading from a light-emitting e-book or tablet before bed results in greater melatonin suppression, less self-reported sleepiness before bed, later bedtimes, and later sleep onset times as measured with polysomnography [65••, 66, 67]. Additionally, a recent review of experimental research on the effects of video game exposure on sleep in adolescents and adults concluded that playing video games, particularly in the evening, negatively impacts sleep duration, sleep onset latency, and sleep architecture [68]. One possible mechanism underlying the relationship between screen-based media use and insufficient sleep is the alerting effect of short-wavelength blue light commonly emitted by mobile devices. In one study, young adults using a computer for 2 h in the evening had greater melatonin suppression, disrupted sleep, and daytime sleepiness when the computer emitted more short wavelength light [69]. In another study, adolescents showed more sensitivity to short wavelength light than adults, demonstrating greater melatonin suppression after exposure to light containing more blue light, while adults showed no differences in suppression to the different lighting conditions [70]. In contrast, teens using a tablet to read or complete puzzles for 2 h prior to bedtime demonstrated no differences in sleep quality or sleep duration compared with performing the same activities on paper [71], suggesting participants were unaffected by the light of the device. Additionally, one study with adults demonstrated that exposure to bright light during the day eliminates the impacts of nighttime use of light-emitting devices on melatonin [72]. Further experimental research is needed, however, to examine whether interactive contents on mobile devices, such as video games or social media, have a greater impact on adolescents' sleep compared with more passive content, such as puzzles and reading. One recent study suggests the content of media use does play a role in whether sleep is disrupted [73]. Young adults assigned to using a smartphone in the evening to perform a breathing exercise through an application, compared with those browsing social media, reported improvements in subjective sleep quality.

From the sparse experimental findings currently available, it cannot be determined whether increased media use causes the observed sleep deficiencies reported in observational studies, or whether media use displaces poor sleepers' time spent awake. In fact, in one study among preadolescents, time in bed was decreased by 1.5 h per night, and as a result, children reported watching significantly more television [74], suggesting the relationship between media use and sleep is bi-directional.

A variety of experiments have explored ways to limit adolescent nighttime media use to reduce negative impacts on sleep. An intervention instructing high school athletes not to use any electronic media after 22:00 had no measured impact on sleep timing or efficiency [75]. This finding is perhaps due to the exclusive sample of high school athletes studied, who may have already followed more routine and efficient sleep

than non-athletes [76]. In addition, participants in the intervention group had an average weekday bedtime of 22:10, suggesting the intervention was too close to bedtime to be effective. Indeed, a different study demonstrated that adolescents who stopped using their mobile phones 1 h prior to average weekday bedtime turned off their lights earlier and slept longer [77••]; however, only 26% of students invited to participate contributed data, suggesting low motivation to restrict their phone use. Additionally, a recent focus group of adolescents and young adults reported that although subjects expressed willingness to change their behaviors to improve sleep, they find it difficult to disconnect from their devices at night, due in large part to social media use and fear of missing out (FOMO) [78, 79]. For example, a recent study had found that FOMO is one of the pathways that drive teens' late night social media use and poor sleep [26].

For teens reluctant to reduce their media use, wearing "blue-blocker" glasses to filter out short wavelength light mitigated melatonin suppression and alertness when using light-emitting devices at night, although no differences in polysomnography or self-reported sleep quality were observed [80••, 81]. In addition, using a tablet for 1 h before bedtime that emits light with short wavelengths filtered out, compared with dim or bright light, leads to no differences in sleep onset latency or architecture [82].

Several studies have explored the efficacy of using school-based interventions to provide students with information on the importance of sleep and good sleep hygiene habits. One such intervention leads to a significant decrease in nighttime electronic media use, but no impact on self-reported sleep duration or daytime tiredness [83]. In contrast, another study reported that their intervention resulted in improvements in objective sleep quantity and quality, but no differences in technology use before bedtime [84]. Yet, a follow-up study with the same intervention yielded no impact on self-reported media use before or during sleep or sleep hygiene [85]. Together, these studies highlight the need for further research to determine what information such interventions could provide to be most effective for adolescents.

Potential Impacts of Screen Time on Sleep

Screen-based media use has been linked to a range of adverse developmental outcomes among adolescents, including poor academic performance [86, 87], low school satisfaction [88], and physical, behavioral, and mental health problems [27, 28, 89]. For example, national survey data of US 8th and 10th graders revealed that watching TV on a weekday was negatively associated with academic outcomes, and students with lower grades used technology and interactive social media more often than their peers with higher grades [86]. Cross-sectional data from Chinese adolescents highlighted a positive correlation between problematic smartphone use and physical symptoms such as back/neck pain and daytime fatigue [90].

One of the primary pathways through which screen-based digital media may affect adolescent development is through impaired sleep health. Indeed, studies have identified the mediating role of sleep problems in the association between screen media use and a range of negative adolescent outcomes [27, 28, 90–93]. For example, data from a diverse sample of US urban birth cohorts found that sleep duration and insomnia symptoms mediated the association between screen activities and adolescent depressive symptoms, even after adjustment for childhood depressive symptoms [29••]. Similar results have also been noted in teens from Switzerland [28] and China [93]. Two longitudinal studies of Australian teens also confirmed that nighttime screen media use was associated with lower psychosocial well-being, primarily through poorer perceived sleep quality and increased sleep problems [91, 94••]. In contrast, another study found no significant mediating role of sleep duration or disturbance in the relationship between late media use and increased depression and suicidality [95].

Future Directions in Research, Interventions, and Policies

Current empirical research demonstrates that digital media is adversely associated with a range of sleep health outcomes among teens. Limited data, however, indicate a direct causal mechanism of this robust association. Further, very few studies demonstrate easy-to-implement and effective interventions to modify digital media use, especially in the evening, to improve sleep among teens. One novel but ineffective policy on adolescent screen use and sleep was implemented by the South Korean government when they started banning juvenile online gaming from 12 a.m. to 6 a.m. in 2011 [96]. Interestingly, results from this national shutdown initiative indicated no practical effects in altering problematic Internet use [97] among middle school students (age 13–18 years) and only increased youth's sleep duration by about 2 min [98].

Conclusions

Based upon this review of the literature, it is clear that more experimental research is needed to better understand the mechanisms underlying the widely observed association between screen time and a range of sleep health outcomes. Understanding the causal mechanisms will aid in the necessary development, implementation, and evaluation of sustainable interventions that minimize the potential adverse effects of evening screen use on sleep. Furthermore, more basic, translational, and clinical studies are necessary to investigate the effects of screen-based media on sleep and related health

consequences among adolescents. Such efforts are essential in order to educate and motivate parents, clinicians, teachers, and teens to develop healthier sleep habits.

Compliance with Ethical Standards

Conflict of Interest Authors on this paper declare support by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) of the National Institutes of Health under award numbers R01HD073352 (supporting Dr. Hale, Dr. Li), R01HD087707, and UG3/UH3OD023313 (supporting Dr. LeBourgeois and Dr. Hartstein). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. Outside of the current work, Dr. Hale receives an honorarium from the National Sleep Foundation for her role as Editor-in-Chief of the journal, *Sleep Health*.

Human and Animal Rights Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
•• Of major importance

1. Sleep in America poll: teens and sleep. National Sleep Foundation Retrieved from: https://www.sleepfoundationorg/sites/default/files/2006_summary_of_findingspdf. 2006.
2. Anderson M, Jiang J. Teens, social media and technology. Washington, DC: Pew Internet and American Life Project; 2018.
3. The common sense census: media use by tweens and teens. Common Sense Media Inc; 2015.
4. Buxton OM, Chang A-M, Spilsbury JC, Bos T, Emsellem H, Knutson KL. Sleep in the modern family: protective family routines for child and adolescent sleep. Sleep Health. 2015;1(1):15–27.
5. •• Twenge JM, Hisler GC, Krizan Z. Associations between screen time and sleep duration are primarily driven by portable electronic devices: evidence from a population-based study of U.S. children ages 0–17. Sleep Med. 2019;56:211–8. **National survey data revealed that US children and teens spent more time on screen devices slept fewer hours, and short sleep duration was more strongly associated with changes in portable electronic device use compared with stationary device use.**
6. Twenge JM, Krizan Z, Hisler G. Decreases in self-reported sleep duration among U.S. adolescents 2009–2015 and association with new media screen time. Sleep Med. 2017;39:47–53.
7. Tarokh L, Saletin JM, Carskadon MA. Sleep in adolescence: physiology, cognition and mental health. Neurosci Biobehav Rev. 2016;70:182–8.
8. Hoyt LT, Maslowsky J, Olson JS, et al. Adolescent sleep barriers: profiles within a diverse sample of urban youth. J Youth Adolesc. 2018;47(10):2169–80.
9. Hale L, Guan S. Screen time and sleep among school-aged children and adolescents: a systematic literature review. Sleep Med Rev. 2015;21:50–8.
10. Mei X, Zhou Q, Li X, et al. Sleep problems in excessive technology use among adolescent: a systemic review and meta-analysis. Sleep Sci Pract. 2018;2(1):9.
11. LeBourgeois MK, Hale L, Chang AM, et al. Digital media and sleep in childhood and adolescence. Pediatrics. 2017;140(Suppl 2):S92–6.
12. Bartel KA, Gradisar M, Williamson P. Protective and risk factors for adolescent sleep: a meta-analytic review. Sleep Med Rev. 2015;21:72–85.
13. Carter B, Rees P, Hale L, et al. Association between portable screen-based media device access or use and sleep outcomes: a systematic review and meta-analysis. JAMA Pediatr. 2016;170(12):1202–8.
14. Johansson AE, Petrisko MA, Chasens ER. Adolescent sleep and the impact of technology use before sleep on daytime function. J Pediatr Nurs. 2016;31(5):498–504.
15. Royant-Parola S, Londe V, Tréhout S, et al. The use of social media modifies teenagers' sleep-related behavior. L'Encephale. 2018;44(4):321–8.
16. Arrona-Palacios A. High and low use of electronic media during nighttime before going to sleep: a comparative study between adolescents attending a morning or afternoon school shift. J Adolesc. 2017;61:152–63.
17. Akcay D, Akcay BD. The influence of media on the sleep quality in adolescents. Turk J Pediatr. 2018;60(3):255–63.
18. da Silva AO, de Oliveira LMFT, dos Santos MAM, et al. Tempo De Tela, PercepÇÃo Da Qualidade De Sono E EpisÓdios De Parassonia Em Adolescentes. Rev Bras Med Esporte. 2017;23(5):375–9.
19. Bansal S, Mahajan RC. Impact of mobile use amongst children in rural area of Marathwada region of Maharashtra, India. Int J Contemp Pediatr. 2017;5(1):50.
20. Oka Y, Suzuki S, Inoue Y. Bedtime activities, sleep environment, and sleep/wake patterns of Japanese elementary school children. Behav Sleep Med. 2008;6(4):220–33.
21. Sampasa-Kanyinga H, Hamilton HA, Chaput JP. Use of social media is associated with short sleep duration in a dose–response manner in students aged 11 to 20 years. Acta Paediatr. 2018;107(4):694–700.
22. King DLD, Delfabbro PH, Zwaans T, Kaptsis D. Sleep interference effects of pathological electronic media use during adolescence. Int J Ment Health. 2014;1:21–35.
23. Nuutinen T, Ray C, Roos E. Do computer use, TV viewing, and the presence of the media in the bedroom predict school-aged children's sleep habits in a longitudinal study? BMC Public Health. 2013;13:684.
24. Mireku MO, Barker MM, Mutz J, et al. Night-time screen-based media device use and adolescents' sleep and health-related quality of life. Environ Int. 2019;124:66–78.
25. Alexandru G, Michikazu S, Shimako H, Xiaoli C, Hitomi K, Takashi Y, et al. Epidemiological aspects of self-reported sleep onset latency in Japanese junior high school children. J Sleep Res. 2006;15(3):266–75.
26. Scott H, Woods HC. Fear of missing out and sleep: cognitive behavioural factors in adolescents' nighttime social media use. J Adolesc. 2018;68:61–5.
27. Kelly Y, Zilanawala A, Booker C, et al. Social media use and adolescent mental health: findings from the UK Millennium Cohort Study. EClinicalMedicine. 2018;6:59–68.
28. Lemola S, Perkinson-Gloor N, Brand S, et al. Adolescents' electronic media use at night, sleep disturbance, and depressive symptoms in the smartphone age. J Youth Adolesc. 2015;44(2):405–18.
29. •• Li X, Buxton OM, Lee S, et al. Sleep mediates the association between adolescent screen time and depressive symptoms. Sleep Med. 2019;57:51–60. **Four types of screen-based activities were associated with more sleep problems and shorter sleep duration, which further link with more adolescent depressive symptoms.**

30. Lange K, Cohrs S, Skarupke C, et al. Electronic media use and insomnia complaints in German adolescents: gender differences in use patterns and sleep problems. J Neural Transm (Vienna). 2017;124(Suppl 1):79–87.
31. Ivarsson M, Anderson M, Akerstedt T, et al. The effect of violent and nonviolent video games on heart rate variability, sleep, and emotions in adolescents with different violent gaming habits. Psychosom Med. 2013;75(4):390–6.
32. Munezawa T, Kaneita Y, Osaki Y, et al. The association between use of mobile phones after lights out and sleep disturbances among Japanese adolescents: a nationwide cross-sectional survey. Sleep. 2011;34(8):1013–20.
33. Woods HC, Scott H. #Sleepyteens: social media use in adolescence is associated with poor sleep quality, anxiety, depression and low self-esteem. J Adolesc. 2016;51:41–9.
34. Galland BC, Gray AR, Penno J, et al. Gender differences in sleep hygiene practices and sleep quality in New Zealand adolescents aged 15 to 17 years. Sleep Health. 2017;3(2):77–83.
35. Wallenius M, Punamäki RL, Rimpela A. Digital game playing and direct and indirect aggression in early adolescence: the roles of age, social intelligence, and parent-child communication. J Youth Adolesc. 2007;36(3):325–36.
36. Lemola S, Brand S, Vogler N, Perkinson-Gloor N, Allemand M, Grob A. Habitual computer game playing at night is related to depressive symptoms. Pers Individ Differ. 2011;51(2):117–22.
37. Jun N, Lee A, Baik I. Associations of caffeinated beverage consumption and screen time with excessive daytime sleepiness in Korean high school students. Clin Nutr Res. 2017;6(1):55–60.
38. Brunetti VC, O'Loughlin EK, O'Loughlin J, et al. Screen and nonscreen sedentary behavior and sleep in adolescents. Sleep Health. 2016;2(4):335–40.
39. Przybylski AK. Digital screen time and pediatric sleep: evidence from a preregistered cohort study. J Pediatr. 2019;205:218–23 e1.
40. Schweizer A, Berchtold A, Barrense-Dias Y, et al. Adolescents with a smartphone sleep less than their peers. Eur J Pediatr. 2017;176(1):131–6.
41. Continente X, Pérez A, Espelt A, et al. Media devices, family relationships and sleep patterns among adolescents in an urban area. Sleep Med. 2017;32:28–35.
42. Bruni O, Sette S, Fontanesi L, et al. Technology use and sleep quality in preadolescence and adolescence. J Clin Sleep Med. 2015;11(12):1433–41.
43. Dube N, Khan K, Loehr S, et al. The use of entertainment and communication technologies before sleep could affect sleep and weight status: a population-based study among children. Int J Behav Nutr Phys Act. 2017;14(1):97.
44. Cabre-Riera A, Torrent M, Donaire-Gonzalez D, et al. Telecommunication devices use, screen time and sleep in adolescents. Environ Res. 2019;171:341–7.
45.•• Fobian AD, Avis K, Schwebel DC. Impact of media use on adolescent sleep efficiency. J Dev Behav Pediatr. 2016;37(1):9–14. **Actigraphy data indicated that sleep efficiency was negatively correlated to daily and bedtime media use, as well as nighttime awakenings by mobile phones.**
46. Troxel WM, Hunter G, Scharf D. Say "GDNT": frequency of adolescent texting at night. Sleep Health. 2015;1(4):300–3.
47. Foerster M, Henneke A, Chetty-Mhlanga S, et al. Impact of adolescents' screen time and nocturnal mobile phone-related awakenings on sleep and general health symptoms: a prospective cohort study. Int J Environ Res Public Health. 2019;16(3):518.
48. Mazzer K, Bauducco S, Linton SJ, et al. Longitudinal associations between time spent using technology and sleep duration among adolescents. J Adolesc. 2018;66:112–9.
49. Poulain T, Vogel M, Buzek T, et al. Reciprocal longitudinal associations between adolescents' media consumption and sleep. Behav Sleep Med. 2018;24:1–15.
50. Eggermont S, Van den Bulck J. Nodding off or switching off? The use of popular media as a sleep aid in secondary-school children. J Paediatr Child Health. 2006;42(7–8):428–33.
51. Reynolds AC, Meltzer LJ, Dorrian J, et al. Impact of high-frequency email and instant messaging (E/IM) interactions during the hour before bed on self-reported sleep duration and sufficiency in female Australian children and adolescents. Sleep Health. 2019;5(1):64–7.
52. Hysing M, Pallesen S, Stormark KM, et al. Sleep and use of electronic devices in adolescence: results from a large population-based study. BMJ Open. 2015;5(1):e006748.
53. Owens J, Maxim R, McGuinn M, et al. Television-viewing habits and sleep disturbance in school children. Pediatrics. 1999;104(3):e27.
54. Van den Bulck J. Television viewing, computer game playing, and Internet use and self-reported time to bed and time out of bed in secondary-school children. Sleep. 2004;27(1):101–4.
55. Kubiszewski V, Fontaine R, Rusch E, et al. Association between electronic media use and sleep habits: an eight-day follow-up study. Int J Adolesc Youth. 2014;19(3):395–407.
56. Garrison MM, Liekweg K, Christakis DA. Media use and child sleep: the impact of content, timing, and environment. Pediatrics. 2011;128(1):29–35.
57. Mazurek MO, Engelhardt CR, Hilgard J, et al. Bedtime electronic media use and sleep in children with autism spectrum disorder. J Dev Behav Pediatr. 2016;37(7):525–31.
58. Wolfe J, Kar K, Perry A, et al. Single night video-game use leads to sleep loss and attention deficits in older adolescents. J Adolesc. 2014;37(7):1003–9.
59. King DL, Gradisar M, Drummond A, et al. The impact of prolonged violent video-gaming on adolescent sleep: an experimental study. J Sleep Res. 2013;22(2):137–43.
60. Arora T, Broglia E, Thomas GN, et al. Associations between specific technologies and adolescent sleep quantity, sleep quality, and parasomnias. Sleep Med. 2014;15(2):240–7.
61. Arora T, Hussain S, Hubert Lam KB, et al. Exploring the complex pathways among specific types of technology, self-reported sleep duration and body mass index in UK adolescents. Int J Obes. 2013;37(9):1254–60.
62. Weaver E, Gradisar M, Dohnt H, et al. The effect of presleep video-game playing on adolescent sleep. J Clin Sleep Med. 2010;6(2):184–9.
63. Falbe J, Davison KK, Franckle RL, et al. Sleep duration, restfulness, and screens in the sleep environment. Pediatrics. 2015;135(2):e367–75.
64. Chahal H, Fung C, Kuhle S, et al. Availability and night-time use of electronic entertainment and communication devices are associated with short sleep duration and obesity among Canadian children. Pediatr Obes. 2013;8(1):42–51.
65.•• Chang AM, Aeschbach D, Duffy JF, et al. Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness. Proc Natl Acad Sci U S A. 2015;112(4):1232–7. **Data from young adults revealed that reading on an e-book for 4 hours before bedtime leads to melatonin suppression, longer sleep latency, and less sleepiness before bed compared with reading from a printed book.**
66. Chinoy ED, Duffy JF, Czeisler CA. Unrestricted evening use of light-emitting tablet computers delays self-selected bedtime and disrupts circadian timing and alertness. Phys Rep. 2018;6(10):e13692.
67. Gronli J, Byrkjedal IK, Bjorvatn B, et al. Reading from an iPad or from a book in bed: the impact on human sleep. A randomized controlled crossover trial. Sleep Med. 2016;21:86–92.
68. Peracchia S, Curcio G. Exposure to video games: effects on sleep and on post-sleep cognitive abilities. A systematic review of experimental evidences. Sleep Sci. 2018;11(4):302–14.

69. Green A, Cohen-Zion M, Haim A, et al. Evening light exposure to computer screens disrupts human sleep, biological rhythms, and attention abilities. Chronobiol Int. 2017;34(7):855–65.
70. Nagare R, Plitnick B, Figueiro MG. Effect of exposure duration and light spectra on nighttime melatonin suppression in adolescents and adults. Light Res Technol. 2018;0:1–14.
71. Jones MJ, Peeling P, Dawson B, et al. Evening electronic device use: the effects on alertness, sleep and next-day physical performance in athletes. J Sports Sci. 2018;36(2):162–70.
72. Rangtell FH, Ekstrand E, Rapp L, et al. Two hours of evening reading on a self-luminous tablet vs. reading a physical book does not alter sleep after daytime bright light exposure. Sleep Med. 2016;23:111–8.
73. Laborde S, Hosang T, Mosley E, et al. Influence of a 30-day slow-paced breathing intervention compared to social media use on subjective sleep quality and cardiac vagal activity. J Clin Med. 2019;8(2):193.
74. Hart CN, Hawley N, Davey A, et al. Effect of experimental change in children's sleep duration on television viewing and physical activity. Pediatr Obes. 2017;12(6):462–7.
75. Harris A, Gundersen H, Mork-Andreassen P, et al. Restricted use of electronic media, sleep, performance, and mood in high school athletes–a randomized trial. Sleep Health. 2015;1(4):314–21.
76. Brand S, Gerber M, Beck J, et al. High exercise levels are related to favorable sleep patterns and psychological functioning in adolescents: a comparison of athletes and controls. J Adolesc Health. 2010;46(2):133–41.
77.•• Bartel K, Scheeren R, Gradisar M. Altering adolescents' pre-bedtime phone use to achieve better sleep health. Health Commun. 2019;34(4):456–62. **When asked to stop mobile phone use 1 hour prior to bedtime, adolescents turned off their lights earlier and slept longer.**
78. Paterson JL, Reynolds AC, Duncan M, et al. Barriers and enablers to modifying sleep behavior in adolescents and young adults: a qualitative investigation. Behav Sleep Med. 2017;17(1):1–11.
79. Milyavskaya M, Saffran M, Hope N, et al. Fear of missing out: prevalence, dynamics, and consequences of experiencing FOMO. Motiv Emot. 2018;42(5):725–37.
80.•• van der Lely S, Frey S, Garbazza C, et al. Blue blocker glasses as a countermeasure for alerting effects of evening light-emitting diode screen exposure in male teenagers. J Adolesc Health. 2015;56(1):113–9. **Wearing blue blocker glasses reduced the negative effects of blue light at night in adolescents.**
81. Figueiro M, Overington D. Self-luminous devices and melatonin suppression in adolescents. Light Res Technol. 2015;0:1–10.
82. Heath M, Sutherland C, Bartel K, et al. Does one hour of bright or short-wavelength filtered tablet screenlight have a meaningful effect on adolescents' pre-bedtime alertness, sleep, and daytime functioning? Chronobiol Int. 2014;31(4):496–505.
83. Das-Friebel A, Perkinson-Gloor N, Brand S, et al. A pilot cluster-randomised study to increase sleep duration by decreasing electronic media use at night and caffeine consumption in adolescents. Sleep Med. 2019;60:109–15.
84. Barber LK, Cucalon MS. Modifying the sleep treatment education program for students to include technology use (STEPS-TECH): intervention effects on objective and subjective sleep outcomes. Stress Health. 2017;33(5):684–90.
85. Rogers AP, Barber LK. Addressing FoMO and telepressure among university students: could a technology intervention help with social media use and sleep disruption? Comput Hum Behav. 2019;93:192–9.
86. Tang S, Patrick ME. Technology and interactive social media use among 8th and 10th graders in the U.S. and associations with homework and school grades. Comput Hum Behav. 2018;86:34–44.
87. Dimitriou D, Le Cornu Knight F, Milton P. The role of environmental factors on sleep patterns and school performance in adolescents. Front Psychol. 2015;6:1717.
88. Vernon L, Barber BL, Modecki KL. Adolescent problematic social networking and school experiences: the mediating effects of sleep disruptions and sleep quality. Cyberpsychol Behav Soc Netw. 2015;18(7):386–92.
89. Parent J, Sanders W, Forehand R. Youth screen time and behavioral health problems: the role of sleep duration and disturbances. J Dev Behav Pediatr. 2016;37(4):277–84.
90. Xie X, Dong Y, Wang J. Sleep quality as a mediator of problematic smartphone use and clinical health symptoms. J Behav Addict. 2018;7(2):466–72.
91. Vernon L, Modecki KL, Barber BL. Tracking effects of problematic social networking on adolescent psychopathology: the mediating role of sleep disruptions. J Clin Child Adolesc Psychol. 2017;46(2):269–83.
92. Zhao J, Zhang Y, Jiang F, et al. Excessive screen time and psychosocial well-being: the mediating role of body mass index, sleep duration, and parent-child interaction. J Pediatr. 2018;202:157–62 e1.
93. Mei X, Hu Z, Zhou D, et al. Sleep patterns, mobile phone use and psychological symptoms among adolescents in coastal developed city of China: an exploratory cross-sectional study. Sleep Biol Rhythms. 2019;17(2):233–41.
94.•• Vernon L, Modecki KL, Barber BL. Mobile phones in the bedroom: trajectories of sleep habits and subsequent adolescent psychosocial development. Child Dev. 2018;89(1):66–77. **Longitudinal data over 4 years shown that decreased sleep quality mediated the relationship between increased nighttime mobile phone use behaviors and decreased adolescent psychosocial well-being.**
95. Seo JH, Kim JH, Yang KI, et al. Late use of electronic media and its association with sleep, depression, and suicidality among Korean adolescents. Sleep Med. 2017;29:76–80.
96. Kiraly O, Griffiths MD, King DL, et al. Policy responses to problematic video game use: a systematic review of current measures and future possibilities. J Behav Addict. 2018;7(3):503–17.
97. Choi J, Cho H, Lee S, et al. Effect of the online game shutdown policy on Internet use, Internet addiction, and sleeping hours in Korean adolescents. J Adolesc Health. 2018;62(5):548–55.
98. Lee C, Kim H, Hong A. Ex-post evaluation of illegalizing juvenile online game after midnight: a case of shutdown policy in South Korea. Telematics Inform. 2017;34(8):1597–606.