

Digital Media and Sleep in Childhood and Adolescence

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abstract Given the pervasive use of screen-based media and the high prevalence of insufficient sleep among American youth and teenagers, this brief report summarizes the literature on electronic media and sleep and provides research recommendations. Recent systematic reviews of the literature reveal that the vast majority of studies find an adverse association between screen-based media consumption and sleep health, primarily via delayed bedtimes and reduced total sleep duration. The underlying mechanisms of these associations likely include the following: (1) time displacement (ie, time spent on screens replaces time spent sleeping and other activities); (2) psychological stimulation based on media content; and (3) the effects of light emitted from devices on circadian timing, sleep physiology, and alertness. Much of our current understanding of these processes, however, is limited by cross-sectional, observational, and self-reported data. Further experimental and observational research is needed to elucidate how the digital revolution is altering sleep and circadian rhythms across development (infancy to adulthood) as pathways to poor health, learning, and safety outcomes (eg, obesity, depression, risk-taking).



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Data from US population-based studies show that ~30% of preschool-aged children and between 50% and 90% of school-aged children and adolescents do not get as much sleep as they may need.^{1,2} The pervasive use of screen-based media is a likely contributor to widespread sleep insufficiency. Screen-based media devices are present in the bedrooms of 75% of children,³ and ~60% of adolescents report viewing or interacting with screens in the hour before bedtime.⁴ In a recent systematic review of 67 studies of screen time and media use in school-aged youth and teenagers (1999–2014), 90% found that screen time was adversely associated with sleep health, primarily via delayed bedtimes and reduced sleep duration.⁵ Potential mechanisms underlying these observed associations include the following⁶: (1) time displacement (ie, time spent on screens replaces time spent doing other things, including sleeping)⁷; (2) psychological stimulation based on media content⁸; and (3) the effects of light emitted from devices on circadian timing, sleep physiology, and alertness.⁹ Healthy sleep patterns in childhood and adolescence are associated with lower obesity risk,^{10,11} better psychological well-being,¹² improved cognitive functioning,¹³ and lower risk-taking behaviors.¹⁴ We propose that sleep among children and adolescents should be a priority in family, school, and clinical contexts, as well as in future basic, observational, and translational research.

CURRENT STATE

We summarize the current state of knowledge regarding digital media use and sleep in school-aged children and adolescents.

Does Media Use Affect the Timing and Duration of Sleep Among Children and Adolescents?

A recent review highlights consistent associations between media and

sleep in children and adolescents 5 to 17 years of age from diverse geographic regions around the world.⁵ More than 5 dozen observational studies using cross-sectional or prospective approaches have examined associations between screen time (ie, television, computers, video games, mobile devices) and a variety of sleep parameters. In >90% of these studies, more screen time was associated with delayed bedtimes and shorter total sleep time among children and adolescents. Computer use was more consistently associated with poor sleep outcomes than television, perhaps because television watching may be less interactive than computer-based activities. Among studies of the associations between television use and sleep timing and/or quality, >75% found links between television use and insufficient sleep.

In addition to that review, data from other studies demonstrate adverse implications of screen time for sleep duration and timing in developing populations around the world. These studies include infants in Thailand,¹⁵ preschool-aged children in the Netherlands,¹⁶ school-aged children in Canada,¹⁷ and adolescents in Saudi Arabia¹⁸ and Norway.⁴ Further published works report an association between mobile devices and sleep duration, including studies among school-aged children in China¹⁹ and France.²⁰ In a recent cross-sectional study of a representative sample of children (6–17 years old) in the United States, whether technology (ie, phone, computer, or television) was left on overnight in the child's bedroom was a significant predictor of insufficient, age-appropriate sleep duration.³

How Do Observational Studies Inform Links Between Screen Time and Sleep Quality and Tiredness?

Lack of sleep and poor sleep quality are associated with daytime tiredness,⁵ which in turn is linked to

a large number of negative outcomes, including poor school performance and a host of psychological problems.^{12,13} Although the most current systematic review found that the majority of studies observed a relationship between tiredness and television viewing, computer use, video-game play, or mobile phone use in children and adolescents,⁵ the influence of media exposure on tiredness may be age dependent. For example, media use in adults is associated with sleep onset latency but not with tiredness because adults who spend substantial time engaging with media may have the opportunity to compensate by sleeping longer.²¹ Such a compensatory mechanism is largely impossible for children and adolescents because their wake times are primarily determined by parents, school hours, and/or extracurricular activities.²² Taken together, this suggests that future research should address links between digital media use and sleep between weekdays and weekends, as well as between the school term and holidays.^{3,23}

New technologies, digital platforms, intrusive and/or engaging software, and media-related behaviors are rapidly changing and exceed our understanding of their impact on sleep and health. Hand-held mobile screens, including smartphones and tablets, complicate research on the relationships between media and sleep in developing individuals. Data from a cross-sectional study of 454 adolescents revealed that >60% kept their mobile phones with them when they went to bed and >45% used their phones as an alarm, a reflection of the high prevalence of digital media in the sleep spaces of adolescents.²⁴ Furthermore, a recent study of ~2000 fourth- and seventh-graders indicated that sleeping near what was defined as “a small screen” was associated with increased tiredness.¹³ Among US children and adolescents, poorer sleep quality is also associated with

leaving technology on overnight in the bedroom.³

What Is the Influence of Light on Circadian Physiology and Sleep Health Among Children and Adolescents? Is the Medium Itself a Factor?

Although the media-related impact on sleep may be caused by the alerting nature of the content of media use,^{25,26} the light emitted by electronic devices could also be a strong contributor to hyperarousal and decreased sleepiness at bedtime. For example, data from a recent study of young adults showed that reading on a light-emitting device before bedtime increased sleep onset latency and reduced the duration of rapid eye movement sleep.⁹ This exposure to light-emitting screens also resulted in the suppression of melatonin, the sleep-promoting hormone that typically increases in the evening hours before bedtime, and a delay in the circadian phase of the melatonin rhythm.

Along with an increase in the prevalence of mobile media use in children²⁷ is a heightened interest from the scientific community regarding sleep and the properties of light emitted from such electronic devices (eg, smartphones and tablets). The spectral composition of light produced by many electronic devices is enriched for short wavelengths (~450 nm) in the blue light range.⁹ Short-wavelength light is generally more effective than longer-wavelength light for suppressing melatonin levels, phase shifting the circadian clock, acutely increasing alertness, and altering subsequent sleep.²⁸ Children are more sensitive to light than mature adults on the basis of age-related changes in ophthalmologic features, including larger pupil size and increased light transmission rate of the crystal lens.²⁹ Furthermore, the enhanced transmission rate in young

individuals is especially prominent in the short wavelength of light, which is emitted from light-emitting-diode electronic devices, such as all computers and smartphones currently on the market.

To date, understanding of the effects of artificial light on sleep and circadian rhythms in childhood and adolescence is based on only a handful of well-controlled studies. Only 1 published study has quantified the amount of melatonin suppressed in response to evening light exposure in a sample of primary-school children.²² The magnitude of melatonin suppression by a light stimulus of 580 lux (typical indoor light levels) in children was almost twice that of adults. Furthermore, pupil diameter in both dim and bright light conditions was significantly larger in children than adults. These results suggest that children are more sensitive to the effects of light (ie, melatonin suppression and pupillary light response). Additionally, recent findings indicate that prepubertal children, in comparison with postpubertal adolescents, have greater melatonin suppression to low (15 lux), moderate (150 lux), and bright (5000 lux) light exposure in the evening hours before bedtime.³⁰

What Are the Limitations of the Current Research?

Although there is general agreement about the associations between screen time and adverse sleep outcomes, most studies on media use and sleep among children and adolescents are observational; therefore, it is impossible to ascertain the causal dynamic between them. Specific mechanisms cannot be determined without well-designed experimental research. Although this issue is a common limitation of most observational studies, it is a particularly relevant question in the case of media use: does media time

displace and affect sleep, or are bad sleepers more likely to fill wake time with media use? One recent study showed bidirectional relationships between screen time and poor sleep health among Australian children across ages 4, 6, and 8 years.³¹

Another concern is that because of primarily self-reported data, both the screen time and sleep assessments suffer from measurement error, which generally attenuates the magnitude of findings. Thus, the true associations between screen time and sleep may be stronger than reported in most studies. A critical priority and challenge for researchers is the limited high-quality surveillance data on digital media and sleep, especially using more generalizable population-based approaches. Furthermore, studies examining screen time are unable to adequately measure the nuances of digital-media use, due to the rapid advances in technologies and platforms, in a way that remains relevant for more than a few years. For example, it is difficult to define and capture exposures involving behaviors such as multitasking and interactivity across screen experiences (eg, Internet to smartphones to virtual reality) and characteristics of content (eg, violence, emotional stimulation), especially with a rapidly changing technological landscape and increasing intrusiveness of “always on” software, games, and social media.

Finally, we do not know the extent to which the effects of digital media on sleep affect and/or amplify other aspects of child health and development. Sleep has not been fully incorporated into studies in which researchers investigated the effects of media on other outcomes. In particular, little is known about developmentally based susceptibilities to digital media

and associated exposure to bright screens.

FUTURE RESEARCH

Our working group has agreed on the following overarching goal for future research on digital media and sleep: To better understand how the digital revolution is altering sleep and circadian rhythms across development (infancy to adulthood) as pathways to poor health, learning, and safety outcomes (eg, obesity, depression, risk-taking, etc).

We also identified the following 4 research areas that align with this overarching goal:

1. Population-based longitudinal studies using validated (not just self-reported) measures of media use, sleep, and health and safety outcomes are essential. Such studies will increase understanding of the magnitude of the influence of digital media (eg, device types, duration, timing, and content) on sleep health in the real world, while also considering context and developmental stage.
2. Well-controlled experimental protocols are needed to test the effects of light (eg, intensity, spectral composition) and media content on sleep, circadian rhythms, and arousal across childhood and adolescence. Rigorous approaches will improve understanding of mechanisms underlying links between digital media and insufficient sleep and other health outcomes.
3. Measures of sleep health should be added as a key health outcome in future studies performed by the digital media research community.
4. Evaluation of existing and new digital media interventions is essential to translate basic science and population-based research into improvements in sleep, health, and well-being.

RECOMMENDATIONS FOR CLINICIANS AND EDUCATORS

We extend the recent American Academy of Pediatrics policy statement about media use in children adolescents^{32,33} with the following sleep-related recommendations:

- Make sleep a priority: Talk with families about the importance of sleep and healthy sleep expectations.
- Encourage a bedtime routine that includes calming activities and avoids electronic media use.
- Encourage families to remove all electronic media from their children or teenagers' bedrooms, including televisions, video games, computers, tablets, and cell phones.
- Talk with families about the negative consequences of bright light in the evening on sleep.
- If the child or adolescent in your care is exhibiting mood or behavioral problems, consider insufficient sleep as a contributing factor.

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REFERENCES

1. National Sleep Foundation. Sleep in America poll: teens and sleep. 2004. Available at: https://sleepfoundation.org/sites/default/files/FINAL_SOF_2004.pdf. Accessed August 1, 2017
2. National Sleep Foundation. Sleep in America poll: teens and sleep. 2006. Available at: https://sleepfoundation.org/sites/default/files/2006_summary_of_findings.pdf. Accessed August 1, 2017
3. Buxton OM, Chang AM, 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

4. Hysing M, Pallesen S, Stormark KM, Jakobsen R, Lundervold AJ, Sivertsen B. Sleep and use of electronic devices in adolescence: results from a large population-based study. *BMJ Open*. 2015;5(1):e006748
5. Hale L, Guan S. Screen time and sleep among school-aged children and adolescents: a systematic literature review. *Sleep Med Rev*. 2015;21:50–58
6. Council on Communications and Media. Media and young minds. *Pediatrics*. 2016;138(5): e20162591
7. Gregory AM, Sadeh A. Annual research review: sleep problems in childhood psychiatric disorders—a review of the latest science. *J Child Psychol Psychiatry*. 2016;57(3):296–317
8. Cain N, Gradisar M. Electronic media use and sleep in school-aged children and adolescents: a review. *Sleep Med*. 2010;11(8):735–742
9. Chang AM, Aeschbach D, Duffy JF, Czeisler CA. Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness. *Proc Natl Acad Sci USA*. 2015;112(4):1232–1237
10. Arora T, Hussain S, Hubert Lam KB, Lily Yao G, Neil Thomas G, Taheri S. 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):1254–1260
11. Cappuccio FP, Taggart FM, Kandala NB, et al. Meta-analysis of short sleep duration and obesity in children and adults. *Sleep*. 2008;31(5):619–626
12. Beebe DW. Cognitive, behavioral, and functional consequences of inadequate sleep in children and adolescents. *Pediatr Clin North Am*. 2011;58(3):649–665
13. Falbe J, Davison KK, Franckle RL, et al. Sleep duration, restfulness, and screens in the sleep environment. *Pediatrics*. 2015;135(2). Available at: www.pediatrics.org/cgi/content/full/135/2/e367
14. Exelmans L, Van den Bulck J. Sleep quality is negatively related to video gaming volume in adults. *J Sleep Res*. 2015;24(2):189–196
15. Vijakhana N, Wilaisakditipakorn T, Ruedeechajorn K, Pruksananonda C,

- Chonchaiya W. Evening media exposure reduces night-time sleep. *Acta Paediatr.* 2015;104(3):306–312
16. Sijtsma A, Koller M, Sauer PJ, Corpeleijn E. Television, sleep, outdoor play and BMI in young children: the GECKO Drenthe cohort. *Eur J Pediatr.* 2015;174(5):631–639
 17. Chaput JP, Leduc G, Boyer C, et al. Electronic screens in children's bedrooms and adiposity, physical activity and sleep: do the number and type of electronic devices matter? *Can J Public Health.* 2014;105(4):e273–e279
 18. Al-Hazzaa HM, Al-Sobayel HI, Abahussain NA, Qahwaji DM, Alahmadi MA, Musaiger AO. Association of dietary habits with levels of physical activity and screen time among adolescents living in Saudi Arabia. *J Hum Nutr Diet.* 2014;27(suppl 2):204–213
 19. Jiang X, Hardy LL, Baur LA, Ding D, Wang L, Shi H. Sleep duration, schedule and quality among urban Chinese children and adolescents: associations with routine after-school activities. *PLoS One.* 2015;10(1):e0115326
 20. Kubiszewski V, Fontaine R, Potard C, Gimenes G. Bullying, sleep/wake patterns and subjective sleep disorders: findings from a cross-sectional survey. *Chronobiol Int.* 2014;31(4):542–553
 21. Basner M, Spaeth AM, Dinges DF. Sociodemographic characteristics and waking activities and their role in the timing and duration of sleep. *Sleep.* 2014;37(12):1889–1906
 22. Higuchi S, Nagafuchi Y, Lee SI, Harada T. Influence of light at night on melatonin suppression in children. *J Clin Endocrinol Metab.* 2014;99(9):3298–3303
 23. Warner S, Murray G, Meyer D. Holiday and school-term sleep patterns of Australian adolescents. *J Adolesc.* 2008;31(5):595–608
 24. Adachi-Mejia AM, Edwards PM, Gilbert-Diamond D, Greenough GP, Olson AL. TXT me I'm only sleeping: adolescents with mobile phones in their bedroom. *Fam Community Health.* 2014;37(4):252–257
 25. Garrison MM, Liekweg K, Christakis DA. Media use and child sleep: the impact of content, timing, and environment. *Pediatrics.* 2011;128(1):29–35
 26. Weaver E, Gradisar M, Dohnt H, Lovato N, Douglas P. The effect of presleep video-game playing on adolescent sleep. *J Clin Sleep Med.* 2010;6(2):184–189
 27. Radesky JS, Schumacher J, Zuckerman B. Mobile and interactive media use by young children: the good, the bad, and the unknown. *Pediatrics.* 2015;135(1):1–3
 28. Cho Y, Ryu SH, Lee BR, Kim KH, Lee E, Choi J. Effects of artificial light at night on human health: a literature review of observational and experimental studies applied to exposure assessment. *Chronobiol Int.* 2015;32(9):1294–1310
 29. Turner PL, Mainster MA. Circadian photoreception: ageing and the eye's important role in systemic health. *Br J Ophthalmol.* 2008;92(11):1439–1444
 30. Crowley SJ, Cain SW, Burns AC, Acebo C, Carskadon MA. Increased sensitivity of the circadian system to light in early/mid-puberty. *J Clin Endocrinol Metab.* 2015;100(11):4067–4073
 31. Magee CA, Lee JK, Vella SA. Bidirectional relationships between sleep duration and screen time in early childhood. *JAMA Pediatr.* 2014;168(5):465–470
 32. Council on Communications and Media. Media use in school-aged children and adolescents. *Pediatrics.* 2016;138(5):e20162592
 33. Reid Chassiakos YL, Radesky J, Christakis D, Moreno MA, Cross C; Council on Communications and Media. Children and adolescents and digital Media. *Pediatrics.* 2016;138(5):e20162593