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Adolescent Sleep and Cellular Phone Use: Recent Trends and Implications for Research

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ABSTRACT: Adolescent sleep needs range from 8.5–10 hours per night, with older adolescents requiring less sleep than younger adolescents. On average, however, American adolescents receive between 7.5–8.5 hours of sleep per night, with many sleeping fewer than 6.5 hours on school nights. Cellular phone use is emerging as an important factor that interferes with both sleep quality and quantity, particularly as smartphones become more widely available to teens. This review paper has three objectives. First, we will describe adolescent sleep patterns and the effects of sleep deprivation on adolescent physical and mental health. Second, we will describe current trends in technology use among adolescents, making associations to how technology impacts sleep. Lastly, we will discuss some of the methodological barriers of conducting sleep and technology research with adolescents and young adults and offer suggestions for overcoming those barriers. We will also discuss implications for healthcare providers.

KEYWORDS: Adolescent, sleep, technology, cellular phone, mobile, methodology

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Introduction

Healthy People 2020 recently identified the importance of sleep in the health and well-being of Americans.[1] One objective set forth in this initiative is to increase the proportion of adolescents and adults who get sufficient sleep. Although sleep deprivation among adolescents is not a new phenomenon, in recent years sleep has garnered more mainstream, clinical, and academic attention. This comes at a time when there are increased demands on adolescents[a] that conflict with getting a full night's sleep, which can negatively impact physical, social, and psychological health.

The correlations between sleep deprivation and health outcomes have been well documented. Physically, sleep deprivation can disrupt circadian rhythms resulting in dysregulated sleep patterns, as well as dysregulated metabolic, endocrine, and immune responses.[2,3] Examples include weight gain, insulin resistance, increased cortisol levels, systemic inflammation, hypertension, and decreased immune response.[2,4–6] Sleep deprivation is also correlated with behaviors that can have negative effects on the body, including increased alcohol and drug use, increased sexual behavior, and the overuse of prescribed and/or non-prescribed stimulants to counteract drowsiness.[7,8] Excessive daytime sleepiness can also make individuals particularly vulnerable to injury and death resulting from driving while sleep deprived, as sleep deprivation is associated with lapses in attention, delayed response time, and daytime drowsiness.[7,9–12] Psychologically, inadequate sleep can affect cognitive functioning and has been linked to reduced short-term memory, decreased learning ability, poor productivity, and decreased motor performance. Mood is also significantly affected, with sleep deprivation associated with negative mood states, depressive

[a]This review utilizes a developmental perspective of adolescence, which includes two stages (i.e., early and late) and spans from age 12 to age 24.[45] This definition departs from a purely biological interpretation that emphasizes the pubertal process and sexual maturation, and instead considers both psychosocial and biophysiological factors. The rationale for a developmental definition lies in the similarities among 12- to 24-year-olds regarding both challenges to healthy sleep and patterns of technology use.

symptoms, decreased stress management, family and peer conflict, impulsivity, and the loss of other forms of behavioral control.[7,13–15]

Sleep Needs During Adolescence

According to guidelines recommended by the Centers for Disease Control (2012), the average adolescent requires 8.5–9.25 hours of sleep per night, with thirteen year olds requiring approximately 10 hours and 19 year olds requiring approximately 8.5 hours per night.[16,44] However, these are mere guidelines, with some individuals requiring more sleep and some requiring less sleep than the averages. Despite these recommendations, researchers have consistently demonstrated that most adolescents do not get enough sleep, with most sleeping between 7.5 and 8.5 hours per night (e.g.,[7,17]). In a seminal article by Wolfson & Carskadon (1998), the researchers reported that 26% of adolescents in their sample received 6.5 hours of sleep or less on school nights.[17] One explanation for these sleep patterns is that during this developmental stage, circadian rhythms shift causing teenagers to stay up later, which directly impacts sleep quantity.[18] Biological shift, however, is not the sole issue. A combination of endogenous and exogenous factors contributes to sleep deprivation in adolescents.

Modern society is not designed to allow adolescents the sleep they need during this developmental transition. While their bodies are commanding them to stay up later, high school start times are increasingly earlier and incongruent with this biological shift. "Sleep hygiene" factors also play an important role in sleep deprivation. Napping for more than 45 minutes (e.g., after school) or too close to bedtime and sleeping in on weekends to "catch up" on sleep, rather than establishing set sleep and wake times, disrupts the sleep cycle.[7,19] An abundance of academic demands, employment, or extracurricular activities may also contribute to doing homework at night rather than earlier in the day, and studying late into the night can interfere with the ability to get a sufficient amount of sleep.[11] Socially, a fear of missing out, the transition to and through high school and college, and constant contact with peers often get in the way of going to bed at a healthy time.[20] Another contributing factor in adolescent sleep problems is technology use.

Trends in Cellular Phone Use Among Adolescents

Adolescent technological trends change at a rapid pace. In the last decade, rates of cell phone ownership among adolescents have risen dramatically. In 2004, the Pew Research Center found that 45% of youth age 12 to 17 owned a cell phone.[21] In a 2012 follow-up study, this number had risen to 78%.[22] Correspondingly, texting via these devices has quickly become the primary mode of communication for this group, with adolescents sending a modal average of 100 texts per day.[23] While the ubiquity of cell phone ownership has changed the way youth communicate, rapidly rising ownership of the "smartphone," which allows users to connect to the internet via their mobile device, is changing the way adolescents interact with online media. In 2012, 37% of adolescents surveyed by the Pew Research Center owned a smartphone, an increase of 14% from the previous year.[22] A study of college students placed smartphone ownership among this cohort even higher, at 62%.[24] In addition, one in four adolescents reports using the cell phone as their primary mode of online connection.[22] Accordingly, today's youth have the potential to be "connected" at any location, twenty-four hours a day, which has clear implications for sleep.

Many teens are using technology within the hour before trying to fall asleep or using cell phones in bed, which interferes with the ability to fall asleep and stay asleep throughout the night.[6] Functionally, cellular phone use shortly before bed has been linked to a number of negative outcomes. Van den Bulck (2007) found that use of cell phones after "lights out" was related to increased tiredness, and Munezawa and colleagues (2011) found a positive association between device use after lights out and four types of sleep disturbance.[25,26] This trend is also evident among college students, a group already at high risk for sleep difficulties.[27] Adams and Kisler found that college students who used cell phone technology after sleep onset reported being awake an extra 46 minutes per week.[28] Forty-seven percent of students awoke after sleep onset to answer text messages and 40% to answer cell phone calls. Importantly, greater levels of tech use during sleep time predicted lower sleep quality, and lower sleep quality increased depressive/anxious symptomology. Similarly, Jenaro and colleagues (2007) concluded that pathological Internet use and cellular phone use were associated with insomnia and sleep disturbance, particularly in female college students.[29] Interestingly, White and colleagues (2011) reported that college students may have a "hyper vigilant" attitude towards their phone, and may immediately awaken to the sound of their phone in the same way a mother awakens upon hearing her baby cry. College students that engaged in increased mobile phone use, pathological texting, and problem texting also experienced increased sleep disturbance and decreased sleep quality.[30] Emerging research points to the prevalence of patterns of problematic phone use among adolescents that are akin to behavioral addiction. This is a significant barrier when attempting to alter patterns of adolescent technology use by encouraging adolescents to place boundaries on their technology use.[31–34]

Those adolescents who are able to disconnect from their phones may have difficulty settling down to sleep. Emerging research points to a connection between the backlit display common to many portable tech devices and disruption of circadian physiology and melatonin expression.[35,36] Many computers, televisions, and smartphones emit short-wavelength light. Artificial, short-wavelength light exposure during evening hours—a time when many adolescents are using technology—can disrupt circadian rhythms, impacting sleep

and neurobehavioral operation. Chronic, ill-timed exposure to short-wavelength light can cause a misalignment of the circadian timing system, resulting in sleep issues and depressive symptomology.[35]

Methodological Issues in Conducting Sleep and Technology Research

Although several studies have identified the negative impact of other forms of technology (e.g., video games, television viewing and computers) on adolescent sleep, the need for well-designed studies examining mobile phone use and sleep remains an area of future study.[37] Several barriers exist in conducting research in this area, ranging from difficulty utilizing objective measurements of technology use after sleep onset, measuring the specific feature of mobile technology that impacts sleep (e.g., does actively texting with a peer lead to poorer outcomes when compared to passively listening to music),[37] and/or the timeliness of publication. Researchers should consider the following issues when planning research in this area.

Measures of technology use and sleep. Multiple devices to measure sleep habits and patterns exist, including apps such as Sleep Cycle and Somnometer, tracking devices such as a FitBit® and Zeo®, and actigraphy devices such as Sleeptracker®.[38] Devices to track technology use, however, are more limited. In previous studies, researchers have relied on self-report frequencies of cellular phone use or self-reported amount of hours using social networking sites (e.g.,[28,39]). These methods are not able to assess for the complexity of technology use and are vulnerable to the reliability of self-report.[39,40] One strategy to collect data usage after sleep onset is to ask participants to review telephone logs and report the data on a daily basis. This method is limited by participant engagement in the research protocol. Researchers could also review monthly telephone logs from the cellular phone carrier; however, many adolescents are on their parent's cellular plans, which would create an additional barrier, and issues of confidentiality of information arise. There are many apps on the market that track cell phone and text messaging use; however, most of these apps only produce a daily report of usage, which limits the ability to examine data usage trends during the nighttime hours. After an extensive search, it was determined that one app (Mobile Monitor®) could effectively collect the necessary data. One caveat is that this app makes the content of the user's text messages and emails available to researchers, increasing concerns about the privacy of participants' personal communications. Lastly, researchers could collect accelerometer data from smartphones to assess if a phone was picked up during the night and for how long; however, this would only be feasible with the development of a new app.

Another important consideration in sleep and technology research is the need for validation of apps for sleep tracking. Given the lack of studies to validate the use of sleep tracking apps in research, it is unclear if these apps accurately and consistently measure constructs of interest. Traditional sleep research has relied on "gold standard" techniques, including actigraphy, as well as self-report measures of sleep disturbance and mobile phone use.[30,41] Researchers have yet to determine the most valid methodology for measuring technology use before or after sleep onset. For instance, using an actigraph combined with a self-report diary is an effective strategy to detect sleep disturbance; and perhaps combining actigraphy data, a review of the phone log, and the use of self-report questionnaires (such as *The Mobile Phone Use Questionnaire*[30]) would provide valid data about usage throughout the night. Additional barriers to consider include: 1) the cost of app development for both iphone® and Android® platforms; 2) the assumption that all participants would all have access to smartphones; 3) the assumption that all participants are accessing technology using a phone rather than a tablet or other portable electronic device; and 4) the cost of actigraphs for use in research. We also believe that future research would be strengthened by the development of clear theoretical models that attempt to explain the role of technology on sleep. One example is the model presented by Cain and Gradisar (2010) which combines social, familial, developmental, and biological factors to explain how media affects sleep.[37]

Dissemination of research findings. Another methodological barrier to conducting sleep and technology research in adolescents is the rapid evolution of preferred technological platforms.[42,43] Therefore, it is imperative for sleep and technology researchers to maintain regular contact with adolescents to assess their patterns of use. Researchers should conduct semi-annual focus groups with adolescents and/or informally discuss current technological trends. Moreover, in terms of the process of executing research (i.e., initial conceptualization, IRB approval, data collection, write up, and publication of findings), researchers must have time dedicated to focusing on expedient research. Soon after data is collected it, must be promptly analyzed and written up for publication. Researchers should also carefully choose peer-reviewed journals that have an expedited review time (i.e., 3 months or less). Since technological trends change so quickly, the time from write-up to publication can be a major factor in the relevance of the study at the time of publication. Lastly, researchers should consider disseminating their results directly to mainstream or clinical venues, such as community newsletters, service presentations at local health centers or schools, or annual conferences. The impact of technology on sleep is a topic of vast interest in popular press and should be made available to the public in a judicious manner to give individuals timely access to current trends.

Conclusion and Clinical Implications

Given that poor and disrupted sleep can cause problems with physical and psychological functioning, adolescents may present to pediatricians or mental health clinicians with depressive symptoms or increased illness presentation

that are exacerbated by poor sleep. Few healthcare providers, however, have received in-depth training in sleep and may not inquire about sleep as a contributor to larger health issues in their patients. Therefore, we encourage practitioners to consider the following recommendations: 1) Practitioners should regularly assess both the amount of sleep that adolescents receive as well as disruption caused by modifiable environmental factors (e.g., technology use); 2) Parents should be provided with information about how to foster healthy sleep habits in adolescents, which include setting very clear boundaries around technology use in the home (e.g., all phones "turned in" to a centralized location at night); and 3) Practitioners should remain attentive to the evolving technological platforms that adolescents are using and overtly ask their patients about the impact of technology on sleep. These inquiries could include questions such as "Do you go to bed later than you should because you get caught up on social media or texting," or "Do you wake up after falling asleep to answer texts?" Adolescents are typically very candid about disclosing these behaviors, thus opening the door for practitioners to provide psychoeducation about the importance of sleep and technological boundaries. Given the importance of sleep on growing minds and bodies, any efforts to improve adolescent sleep quantity and quality should be considered a worthwhile investment.

Author Contributions

Conceived and designed the experiments: SKA. Analyzed the data: SKA. Wrote the first draft of the manuscript: SKA, JFD, DNW. Contributed to the writing of the manuscript: SKA, JFD, DNW. Agree with manuscript results and conclusions: SKA, JFD, DNW. Jointly developed the structure and arguments for the paper: SKA, JFD, DNW. Made critical revisions and approved final version: SKA, JFD, DNW. All authors reviewed and approved of the final manuscript.

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As a requirement of publication the authors have provided signed confirmation of their compliance with ethical and legal obligations including but not limited to compliance with ICMJE authorship and competing interests guidelines, that the article is neither under consideration for publication nor published elsewhere, of their compliance with legal and ethical guidelines concerning human and animal research participants (if applicable), and that permission has been obtained for reproduction of any copyrighted material. This article was subject to blind, independent, expert peer review. The reviewers reported no competing interests. Provenance: the authors were invited to submit this paper.

REFERENCES

1. Healthy People 2020. In: Services United States Department of Health and Human Services. Washington, DC; 2010.
2. AlDabal L, BaHammam AS. Metabolic, endocrine, and immune consequences of sleep deprivation. *The Open Respiratory Medicine Journal*. 5:31–43.
3. Laposky AD, Bass J, Kohsaka A, Turek FW. Sleep and circadian rhythms: key components in the regulation of energy metabolism. *Federation of European Biochemical Societies Letters*. 2008;582(1):142–151.
4. Carskadon MA. Patterns of sleep and sleepiness in adolescents. *Pediatrician*. 1990;17(1):5–12.
5. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. *Obesity*. 2008;16(3):643–653.
6. Irwin M, McClintick J, Costlow C, Fortner M, White J, Gillin JC. Partial night sleep deprivation reduces natural killer and cellular immune responses in humans. *The Journal of the Federation of American Societies for Experimental Biology*. 1996;10(5):643–653.
7. Moore M, Meltzer LJ. The sleepy adolescent: causes and consequences of sleepiness in teens. *Paediatric Respiratory Reviews*. 2008;9(2):114–121.
8. Lund HG, Reider BD, Whiting AB, Prichard JR. Sleep patterns and predictors of disturbed sleep in a large population of college students. *Journal of Adolescent Health*. 2010;46(2):124–132.
9. National Institute of Health, National Center on Sleep Disorders Research and Office of Prevention Education, and Control, National Heart Lung, and Blood Institute. Working group report on problem sleepiness 1997.
10. Pack AI, Pack AM, Rodgman E, Cucchiara A, Dinges DF, Schwab CW. Characteristics of crashes attributed to the driver having fallen asleep. *Accident Analysis & Prevention*. 1995;27(6):769–775.
11. Williamson AM, Feyer A-M. Moderate sleep deprivation produces impairments in cognitive and motor performance equivalent to legally prescribed levels of alcohol intoxication. *Occupational and Environmental Medicine*. 2000;57(10):649–655.
12. Goel N, Rao H, Durmer JS, Dinges DF. Neurocognitive consequences of sleep deprivation. *Seminars in Neurology*. 2009;29(4):320–339.
13. Adolescent sleep needs and patterns: Research report and resource guide. The National Sleep Foundation., 2000. http://www.sleepfoundation.org/sites/default/files/sleep_and_teens_report1.pdf.
14. Curcio G, Ferrara M, De Gennaro L. Sleep loss, learning capacity and academic performance. *Sleep Medicine Reviews*. 2006;10(5):323–338.
15. Smaldone A, Honig JC, Byrne MW. Sleepless in America: inadequate sleep and relationships to health and well-being of our nation's children. *Pediatrics*. 2007;119(Supplement 1):S29.
16. National Science Foundation. Teens and Sleep. 2011; http://www.sleepfoundation.org/article/sleep-topics/teens-and-sleep. Accessed May 8, 2013.
17. Wolfson AR, Carskadon MA. Sleep schedules and daytime functioning in adolescents. *Child Development*. 1998;69(4):875–887.
18. Carskadon MA, Acebo C, Jenni OG. Regulation of adolescent sleep: implications for behavior. *Annals of the New York Academy of Sciences*. 2004;1021(1):276–291.
19. Carskadon MA, Wolfson AR, Acebo C, Tzischinsky O, Seifer R. Adolescent sleep patterns, circadian timing, and sleepiness at a transition to early school days. SLEEP-NEW YORK. 1998;21:871–881.
20. Dahl RE, Lewin DS. Pathways to adolescent health sleep regulation and behavior. *Journal of Adolescent Health*. 2002;31(6):175–184.
21. Lenhart A, Maddenn M, Hitlin P. Teens and technology: Youth are leading the transition to a fully wired and mobile nation 2005.
22. Madden M, Lenhart A, Duggan M, Cortesi S, Gasser U. Teens and technology 2013. Pew Internet & American Life Project 2013.
23. Lenhart A. Teens, smartphones & texting. Pew Internet & American Life Project 2012.
24. Dahlstrom E. ECAR Study of Undergraduate Students and Information Technology, 2012. *EDUCAUSE Center for Applied Research*. 7–8.
25. Van den Bulck J. Adolescent use of mobile phones for calling and sending text messages after lights out: Results from a prospective cohort study with a one-year follow up. *Sleep*. 2007;30(9):1220–1223.
26. 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):1013–1020.
27. Buboltz W, Jenkins SM, Soper B, Woller K, Johnson P, Faes T. Sleep habits and patterns of college students: an expanded study. *Journal of College Counseling*. 2009;12(2):113–124.
28. Adams SK, Kisler TS. Sleep Quality as a Mediator Between Technology-Related Sleep Quality, Depression, and Anxiety. *Cyberpsychology, Behavior, and Social Networking*. 16(1):25–30.
29. Jenaro C, Flores N, Gómez-Vela M, González-Gil F, Caballo C. Problematic internet and cell-phone use: Psychological, behavioral, and health correlates. *Addiction Research & Theory*. 2007;15(3):309–320.
30. White AG, Buboltz W, Igou F. Mobile phone use and sleep quality and length in college students. *International Journal of Humanities and Social Science*. 2011;1(18):51–58.
31. Healthcare A. Maintaining boundaries in the use of technology. http://www.washington.edu/admin/hr/benefits/publications/carelink/tipsheets/tech-maintain-boundaries.pdf. Accessed May 8, 2013.
32. Media CS. Parent tip sheet: common sense tips for a healthy media diet. http://www.commonsensemedia.org/sites/default/files/healthymediadiet-tip.pdf. Accessed May 8, 2013.
33. Martinotti G, Villella C, Di Thiene D, et al. Problematic mobile phone use in adolescence: a cross-sectional study. *Journal of Public Health*. 2011;19(6):545–551.

34. Yen C-F, Tang T-C, Yen J-Y, et al. Symptoms of problematic cellular phone use, functional impairment and its association with depression among adolescents in Southern Taiwan. *Journal of Adolescence.* 2009;32(4):863–873.
35. Cajochen C, Frey S, Anders D, et al. Evening exposure to a light-emitting diodes (LED)-backlit computer screen affects circadian physiology and cognitive performance. *Journal of Applied Physiology.* 2011;110(5):1432–1438.
36. Wood B, Rea MS, Plitnick B, Figueiro MG. Light level and duration of exposure determine the impact of self-luminous tablets on melatonin suppression. *Applied Ergonomics.* 2013;44:237–240.
37. Cain N, Gradisar M. Electronic media use and sleep in school-aged children and adolescents: A review. *Sleep Medicine.* 2010;11:735–742.
38. Shirazi AS, Clawson J, Hassanpour Y, et al. Already Up? Using Mobile Phones to Track & Share Sleep Behavior. *International Journal of Human-Computer Studies.*
39. Strayhorn TL. Exploring the Impact of Facebook and Myspace Use on First-Year Students' Sense of Belonging and Persistence Decisions. *Journal of College Student Development.* 2012;53(6):783–796.
40. Monk TH, Buysse DJ, Kennedy KS, Potts JM, DeGrazia JM, Miewald JM. Measuring sleep habits without using a diary: the sleep timing questionnaire (STQ). *Sleep.* 2003;26:208–212.
41. Werner H, Molinari L, Guyer C, Jenni OG. Agreement rates between actigraphy, diary, and questionnaire for children's sleep patterns. *Archives of Pediatrics & Adolescent Medicine.* 2008;162(4):350–358.
42. Elliott A-M. Pheed: the next social craze for teens? March 10, 2013; http://mashable.com/2013/03/10/pheed-walkthrough/. Accessed May 8, 2013.
43. Crook J. Facebook still reigns supreme with teens, but social media interest dwindling. April 10, 2013; http://techcrunch.com/2013/04/10/facebook-still-reigns-supreme-with-teens-but-social-media-interest-dwindling/. Accessed May 8, 2013.
44. How Much Sleep Do I Need? Sleep and Sleep Disorders. Centers for Disease Control and Prevention, 09 May 2012. Web. 2013. http://www.cdc.gov/sleep/about_sleep/how_much_sleep.htm.
45. Newman BM, Newman PR. Development through life: A psychosocial approach. 11 ed. Belmont, CA: Wadsworth/Cengage Learning; 2012.