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Adolescent Sleep and the Impact of Technology Use Before Sleep on Daytime Function

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Purpose Technology has become pervasive in our culture, particularly among adolescents. The purpose of this study is to examine associations between use of technology before sleep and daytime function in adolescents.
Design and Methods: This study is a secondary analysis of respondents aged 13 to 21 years (N = 259) from the 2011 National Sleep Foundation's Sleep in America Poll. The survey included questions on demographics, sleep habits, and use of technology in the hour before bedtime. Daytime sleepiness was assessed with the Epworth Sleepiness Scale (ESS). Student's *t*-tests, Mann–Whitney U, and Fischer's exact tests were performed to detect differences in demographics, sleep duration, and technology use in the total sample, and between respondents with "adequate" compared to "inadequate" sleep. Correlations were calculated between technology frequency and daytime function.
Results: Adolescents had mean sleep duration of 7.3 ± 1.3 h. Almost all respondents (97%) used some form of technology before sleep. Increased technology use and the frequency of being awoken in the night by a cell phone were significantly associated with waking too early, waking unrefreshed, and daytime sleepiness ($p < 0.05$). Adolescents who reported "inadequate" sleep had shorter sleep duration, greater frequency of technology use before bedtime, feeling unrefreshed on waking, and greater daytime sleepiness than those reporting "adequate" sleep (all p-values < 0.05).
Conclusion: Technology use before sleep by adolescents had negative consequences on nighttime sleep and on daytime function.
Practice Implications: Healthcare professionals who interact with adolescents should encourage technology to be curtailed before bedtime and for adolescents to value obtaining adequate sleep.

ADOLESCENTS REQUIRE APPROXIMATELY 8 to 10 h of sleep per night, but many studies suggest that they obtain much less (Arora, Broglia, Thomas, & Taheri, 2014; Eaton et al., 2010; McKnight-Eily et al., 2011; Wolfson & Johnson, 2014). In the past two decades, the number of adolescents reporting more than 7 h of sleep per night and the percentage reporting adequate sleep per night has steadily decreased (Iglowstein, Jenni, Molinari, & Largo, 2003; Keyes, Maslowsky, Hamilton, & Schulenberg, 2015). Studies comparing self-reported adolescent sleep duration with objectively measured sleep duration (i.e. actigraphy) suggest that self-reports frequently overestimate actual sleep duration. This suggests that sleep loss in adolescents may be even greater than many reports indicate (Fossum, Nordnes, Storemark, Bjorvatn, & Pallesen, 2014).

The decline in adolescent sleep quantity and quality is multifactorial, and is influenced by biological, environmental, societal, and behavioral factors (Bartel, Gradisar, & Williamson, 2015; Calamaro, Mason, & Ratcliffe, 2009; Pallesen et al., 2011). With the marked increase in technology during the 21st century, screen time has become an integral part of life for today's adolescent, who values the connectivity offered by technology and relies on digital interfaces to interact with the world. It is not surprising that technology devices such as computers, cell phones, video games, tablets, and e-readers are being used by adolescents prior to bedtime. In a study of adolescents recruited from a pediatric office (N = 100, ages

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12–18-years), the majority (66%) had a television in their bedroom, almost 30% had a computer, and 90% had a cell phone (Calamaro et al., 2009). In another, 76% of adolescents reported using a cell phone before sleep for playing games, surfing the Internet, and texting (Fossum et al., 2014). Adolescents have been found to simultaneously engage with an average of four technology devices after 9:00 pm. This usage was positively correlated with severity of insomnia symptoms (Pilcher, Ginter, & Sadowsky, 1997). Engaging in a higher number of technologies, such as computer games and television, at bedtime has been associated with less nighttime sleep and more daytime sleepiness (Eggermont & Van Den Bulck, 2006).

Adolescent sleep quantity is also greatly influenced by biological processes. The two-process model of sleep regulation describes sleep propensity (the likelihood of falling asleep) as the interaction between a homeostatic process (sleep need) and a circadian process (sleep-wake rhythm or "biological clock"). The homeostatic process increases sleep propensity while awake, and decreases it during sleep; while the circadian process is independent of sleep/wake state. The intersection between homeostatic and circadian processes determines wake-time (Borbély, Daan, Wirz-Justice, & Deboer, 2016). The rate at which homeostatic sleep propensity accumulates varies between prepubertal and postpubertal stages, and is correlated with secondary sex development (Carskadon et al., 1979). There is evidence to suggest that older adolescents accumulate sleep propensity more slowly, resulting in a later bedtime and a later preferred wake-time (Jenni, Achermann, & Carskadon, 2005; Wolfson & Carskadon, 1998). This presents a challenge on weekdays, when early school times prevent adolescents from obtaining the sleep that they need. Other elements of the contemporary adolescent lifestyle, such as stress, anxiety, social pursuits, and caffeine use may interact with biological processes to further exacerbate sleep irregularities within this age group (Astill, Van der Heijden, Van Ijzendoorn, & Van Someren, 2012; Calamaro, Yang, Ratcliffe, & Chasens, 2012).

Insufficient sleep in adolescence has been linked to negative physiological consequences, including an increased risk of obesity and metabolic dysfunction; and psychological and behavioral consequences, such as an increased risk of anxiety, depression, mood disturbances, suicidal ideation, and drug and alcohol use (Chen, Beydoun, & Wang, 2008; Gupta, Mueller, Chan, & Meininger, 2002; Lowry et al., 2012). Adolescents with poor sleep quality and decreased sleep duration report a lower sense of well-being and a decreased quality of life (Pilcher et al., 1997). Chronic sleep loss in adolescents has also been linked to poor judgment, lack of motivation, and inattention (Gradisar, Terrill, Johnston, & Douglas, 2008; Owens, 2014; Wolfson & Carskadon, 1998), and consequently with an increase in risk-taking behaviors, such as drinking and driving, smoking, and delinquency (Catrett & Gaultney, 2009; O'Brien & Mindell, 2005). Driving while drowsy is a frequent complaint among older adolescents, and daytime sleepiness in this demographic has been associated with an increased rate of motor vehicle accidents (Martiniuk et al., 2013; Owens, 2014; Pizza et al., 2010).

It remains unclear if technology use before bed affects daytime function (wake-time, refreshment, and daytime sleepiness). Previous studies of adolescent sleep and technology use have used small sample sizes and narrow age ranges within adolescence. The purpose of this study is to describe sleep in adolescents, examine associations between use of technology in the hour before sleep and daytime function, and to compare technology use in adolescents who report adequate sleep with those who report inadequate sleep.

Methods

Parent Study and Sampling Methodology

The National Sleep Foundation's 2011 Sleep in America Poll (National Sleep Foundation, 2011) was a cross-sectional survey of a nationally-representative, random sample of 1,508 Americans aged 13–64 years. The survey, which was developed by a panel of sleep experts, examined the use of a range of technologies in the bedroom.

Data were collected using telephone (n = 750) and Internet (n = 758) surveys. Telephone surveys were performed by random digit dialing (SDR Consulting Inc., Atlanta, USA) based on population sampling quotas by United States region. The telephone survey took approximately 18 min to complete. Internet surveys were distributed to members of an e-rewards panel. Maximum sampling error was ± 2.5 percentage points (95% CI) for the total sample. Incentives were not offered by the National Sleep Foundation (NSF) for completion of the survey.

De-identified data and details about study methodology were acquired from the NSF. The subsample studied was composed of 255 adolescents, aged 13–21 years from across the United States. Because one of the aims of this study is to describe sleep through adolescence, the subsample was divided into younger adolescents (13–17-years, n = 140) and older adolescents (18–-21-years, n = 118). Maximum sampling error for the subsample was ± 7.5 percentage points (95% CI). The institutional review board at the University of Pittsburgh approved this secondary analysis of the NSF data.

Survey Instrument

The survey instrument was designed by content experts in sleep across the life-span. Questions fit into four categories: demographics, sleep habits, sleep quality, and technology use in the hour before bed and during the night. Demographic items included age, gender, race, ethnicity, and school and/or employment status. Sleep habits included bedtime, wake-time, sleep duration, and naps on week days and weekend days. Bedtimes were recoded as "early" (7:00–8:59pm), "standard" (9:00–10:59pm), "late" (11:00pm-1:59am), and "very late "(2:00–5:00am). Rise times were recoded as "early" (before 6:00am), "standard" (6:00–8:59am), "late" (9:00–11:59am), and "very late" (after 12:00pm). Subjective sleep quality and daytime function for a two-week period were assessed using a 4-item Likert-type scale—1 (never) to 4 (every night or almost every night)—reporting how often in the last two weeks the