



# The impact of Sleep Time-Related Information and Communication Technology (STRICT) on sleep patterns and daytime functioning in American adolescents



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## ARTICLE INFO

### Article history:

Available online 21 August 2015

### Keywords:

Smartphones  
Mobile phones  
Adolescents  
Sleep  
Texting  
STRICT

## ABSTRACT

This cross-sectional study explored the extent and impact of mobile device-based Sleep Time-Related Information and Communication Technology (STRICT) use among American adolescents ( $N = 3139$ , 49.3% female, mean age = 13.3 years). Nearly 62% used STRICT after bedtime, 56.7% texted/tweeted/messaged in bed, and 20.8% awoke to texts. STRICT use was associated with insomnia, daytime sleepiness, eveningness, academic underperformance, later bedtimes and shorter sleep duration. Moderation analysis demonstrated that the association between STRICT use and insomnia increased with age, the association between STRICT use and daytime sleepiness decreased with age, and the association between STRICT use and shorter sleep duration decreased with age and was stronger in girls. Insomnia and daytime sleepiness partially mediated the relationship between STRICT use and academic underperformance. Our results illustrate the adverse interactions between adolescent STRICT use and sleep, with deleterious effects on daytime functioning. These worrisome findings suggest that placing reasonable limitations on adolescent STRICT use may be appropriate.

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## Introduction

### Scope of the problem

Mobile phone ownership among American adolescents is increasing rapidly. Data from the Pew Research Institute suggest that over three-quarters of Americans between the ages of 12 and 17 years of age now own a mobile phone, almost half of which are smartphones (Madden, Lenhart, Duggan, Cortesi, & Gasser, 2013). Adolescent smartphone ownership rose by 14% between 2011 and 2013, mirroring trends in several European and Asian countries (Byun et al., 2013; Mezei, Benyi, & Muller,

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2007; Munezawa et al., 2011; Söderqvist, Hardell, Carlberg, & Hansson Mild, 2007). Nearly 65% of American teenagers text daily, making it the most popular means of communication in this age group (Lenhart, 2012). The prevalence of adolescent texting increases with age, and girls consistently text more frequently than boys across all age groups. American teenagers who text send and receive an average of 1500 messages per month, the vast majority of which are simply to “say hello and chat”; texting thus appears to have essentially become a social activity (Lenhart, Ling, Campbell, & Purcell, 2010). Adolescents also use mobile devices as the primary means to access the internet (Lenhart, Purcell, Smith & Zickurh, 2010) and electronic social media (ESM) including online gaming, social media sites such as Facebook, and microblogging sites such as Twitter (Madden, Lenhart, Cortesi, et al., 2013). However, data regarding the long-term consequences of such easy accessibility to ESM are sparse.

The ubiquity of smartphones presents unique challenges for parents and teachers. While computers are often shared with other family members (Madden, Lenhart, Duggan et al., 2013), mobile devices are generally in the exclusive, unsupervised control of the adolescent. Apart from safety concerns such as cyberbullying (Nixon, 2014) and “sexting” (the sending and receiving of sexually explicit messages and photographs through electronic media; Katzman, 2010), one area that has recently been receiving attention is the impact of unregulated mobile device-based ESM use, especially at night, on sleep patterns in the youth. The term “Sleep Time-Related Information and Communication Technology” (STRICT) has been proposed to describe ESM use just before bedtime and after lights-out, times of the day when its impact on sleep would be expected to be greatest (Polos et al., 2010).

Sleep is critically important in adolescence for emotional, mental and physical well-being, learning, memory and mood. Insufficient sleep is linked to decreased physical activity, poor nutrition, obesity (Stamatakis & Brownson, 2008), insulin resistance (Donga & Romijn, 2014), immunological vulnerability (Rogers, Szuba, Staab, Evans, & Dinges, 2001), increased risk of drowsy driving-related motor vehicle accidents (Owens, 2014) and decreased overall health-related quality of life (Paiva, Gaspar, & Matos, 2015). Poor and inadequate sleep is related to poor school attendance (Hysing, Haugland, Stormark, Bøe, & Sivertsen, 2015), academic underachievement and a decreased positive attitude towards life (Dewald, Meijer, Oort, Kerkhof, & Bogels, 2010; Lee, Park, Kim, Cho & Kim, 2015; Perkinson-Gloor, Lemola, & Grob, 2013; Titova et al., 2015). Sleep difficulties are also related to mood dysfunction and increased suicide risk (Baum et al., 2014; Lee, Cho, Cho & Kim, 2012; Lin & Yi, 2015; Roberts & Duong, 2014). Unfortunately, chronic sleep restriction is the norm for a majority of adolescents throughout the world (Hysing, Pallesen, Stormark, Lundervold, & Sivertsen, 2013; John, 2014; Mak et al., 2014; Mercer, Merritt, & Cowell, 1998; Ming et al., 2011; Yang, Kim, Patel, & Lee, 2005), as exemplified by concerning recent reports of a decline in self-reported adolescent sleep in the United States over the past 20 years (Keyes, Maslowsky, Hamilton, & Schulenberg, 2015). This “great sleep recession” appears to be due to a combination of the natural circadian phase delay in this age group (Sivertsen et al., 2013) and early school start times resulting in decreased time in bed on school nights (often made up for by longer hours of sleep on the weekends, so-called “catch-up sleep”). This has led to an advocacy in the United States for later high school start times (Boergers, Gable, & Owens, 2014). However, behavioral factors and sleep hygiene clearly have a contributory role, and unregulated STRICT use may be a major component.

Teenagers and their smartphones are becoming inseparable. Nearly 85% of adolescents in the United States sleep with their phone in or near their bed (Lenhart, Ling, et al., 2010). Texting after lights-out and awakenings from sleep due to incoming texts are very common (Adachi-Mejia, Edwards, Gilbert-Diamond, Greenough, & Olson, 2014; Munezawa et al., 2011). There seems to be a compulsive element to this behavior, as teenagers in focus groups have expressed concern that their friends would be upset if they did not immediately respond to texts, even texts arriving in the middle of the night, disrupting sleep. Some authors have argued that problematic mobile phone use constitutes a form of addiction (Smetaniuk, 2014). Despite these concerns, parental restriction of adolescent mobile phone use is limited (Lenhart, Ling, et al., 2010).

Prior studies have demonstrated decreased time in bed and daytime tiredness associated with the presence of television sets, video game consoles or internet-enabled computers in the bedroom (Nuutinen, Ray, & Roos, 2013; Shochat, Flint-Bretler, & Tzischinsky, 2010; Van den Bulck, 2004), and a negative impact on sleep–wake parameters when such media are used in the critical period just before bedtime or in bed (Chahal, Fung, Kuhle, & Veugelaers, 2013; Foley et al., 2013; Gamble et al., 2014; Hysing, Pallesen, et al., 2015; Oka, Suzuki, & Inoue, 2008). However, there have been few reports specifically exploring the relationship between mobile phone use and sleep. Recent investigations among Asian adolescents revealed that the total duration of daily mobile phone use predicted daytime sleepiness, decreased sleep duration and evening chronotype (Harada, Morikuni, Yoshii, Yamashita, & Takeuchi, 2002; Mak et al., 2014), and early studies from various countries evaluating in-bed texting after lights-out in particular have demonstrated a deleterious effect on sleep, mood and daytime alertness (Grover et al., 2015; Lemola, Perkinson-Gloor, Brand, Dewald-Kaufmann, & Grob, 2015; Munezawa et al., 2011; Van den Bulck, 2003; Van den Bulck, 2007).

Clearly, despite important previously published work in the area, the full impact of STRICT use on sleep and daytime functioning remains to be fully elucidated. In particular, there is a paucity of studies focusing specifically on mobile phone and smartphone-related STRICT use, which constitutes the bulk of adolescent electronic media exposure today, and its effect on sleep and daytime functioning. Additionally, several authors have reported that ESM use has a negative impact on academic performance (Jacobsen & Forste, 2011; Kirschner & Karpinski, 2010), but there has been limited research into the extent to which STRICT use-related sleep difficulties impact this relationship. Finally, while studies with similar objectives have been conducted in Europe and Asia, few large-scale evaluations in the adolescent population have been carried out in the United States, where cultural, familial and socioeconomic factors may result in a different student profile and degree of parental and school oversight. We therefore carried out this study to address these gaps in the literature.

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