Bedtime Smartphone Use & Sleep Efficiency: Blue Light Filter as a Moderating Factor

Gini Choi Student # 38976149

University of British Columbia

Abstract

The past literature on sleep quality and smartphone use have primarily relied on self-reported data, which typically reports negative sleep outcomes with higher smartphone use (Lemola et al., 2015; Schweizer et al., 2017; Papaconstant et al., 2017). Moreover, the majority of these past studies have focused on the younger population, often completely disregarding older adults. To address these common gaps in the past research, the following correlational study has recruited a wide age range of participants from 14 years and older (N = 90, 32% male; 19-69 years) and asked them to download an Android smartphone app (i.e. BeTrack) to objectively track the duration and frequency of the participants' smartphone app use for 7 days. Participants were also asked to put on a movement activity tracking wristband (i.e. accelerometer) for 7 nights of sleep to collect objective day-to-day sleep efficiency data. Consistent with past research, we hypothesize that objective sleep efficiency score derived from the accelerometers will be negatively correlated with the duration of smartphone activity 1 hour before bedtime, with the use of blue light filter moderating the strength of this relationship.

Introduction

As technology continues to advance rapidly at an exponential speed, it constantly shapes the daily habits of individual technology users (Policy Horizons Canada, 2013). Prevalence of technology ownership has multiplied to the point of almost everyone in most industrialized countries to have mainstream technologies, such as the smartphone (Liadi, 2016). Amongst the current widespread use of modern technology around the globe, smartphones seem to be one of the most predominant. Perhaps partly due to the wide variety of useful functionalities that accompany smartphones, they have now become completely integrated into many of our daily lives (Liadi, 2016). The majority of smartphone users will use their smartphones multiple times per day, as well as report keeping their phone on overnight, with 75% of the respondents in an online survey indicating that they use their phone after lights out (Saling & Haire, 2016). This extensive use of smartphone technology being present even during bedtime raises concern over the possibility of interrupted sleep quality, and consequently overall well-being during waking hours.

Many studies on this topic seems to conclude that bedtime smartphone use is associated with more sleep disturbance, shorter sleeping duration, more daytime dysfunction, lower sleep quality and worse sleep efficiency in both adult and adolescent samples (Exelmans & Bulck, 2016; Christensen et al. 2016; Lemola et al., 2015; Schweizer, 2017). For instance, one study by Christensen et al. (2016) objectively measured participants' screen-time duration with a smartphone application and found that "longer average screen-time was associated with shorter sleeping duration and

worse [self-reported] sleep efficiency" (p.2). However, the majority of these past research studies on sleep solely relied on self-reported data, which do not have strong reliability and validity due to people's tendency to overestimate their sleep duration (Borghese, 2018). Furthermore, these studies often only recruit adolescents or university students, and completely disregard the older adults in their samples, leading to a non-representative sample. Due to the unique lack of attachment to smartphones that is typical amongst the elderly (Shin, Lee & Park, 2012), it could give important insight to look at more of a wide range of age in the participant sample.

To address these past research limitations, we will be conducting the first study using objective measures for examining both sleep quality and smartphone use, with a more inclusive sample of participants from ages 14 and older. Another research question of interest is whether digital media smartphone use before bed is particularly detrimental to sleep. One of the sleep variables commonly addressed in this line of research is sleep efficiency, operationally defined as the total sleep duration divided by the total time spent in bed (Lee & Suen, 2017). This sleep variable will be examined as the primary outcome variable for this correlational study. Specifically, we will be examining how the duration of smartphone activity in the one hour before sleep attempt relates to sleep efficiency scores objectively derived from the Actiwatch accelerometer. The rationale to focus our analysis on the 1 hour before bedtime came from results of a similar correlational study by Orzech et al. (2016). From their finding of negative correlations on sleep with digital media use before bedtime, the 1 hour before bedtime seems to have had the most significant associations with the effects on sleep.

Furthermore, light in the blue spectrum emitting from the LED screens of smartphones has shown to damage our retinas, as well as suppress the body's production of melatonin; this can lead to difficulty falling asleep, and the feeling of inadequate rest (Christensen et al., 2016). Consequently, blue light filter use will also be examined as a potential moderating factor. Consistent with past research, it will be hypothesized that objectively measured sleep efficiency scores derived from the Actiwatch will be negatively correlated with the duration of smartphone activity 1 hour before bedtime. Blue light filter use will also be hypothesized to moderate the degree of the relationship between sleep efficiency (both objective and subjective) and bedtime smartphone use.

Methods

Participants

So far, 90 Android users of ages 19 and older from Metro Vancouver (19-69 years; *M* = 27.25 years; *SD* = 10.88; 32% male) have participated in the research study advertised to investigate the relationship between smartphone use, sleep, and wellbeing. All participants were recruited through the study website, Facebook and Instagram advertisements, UBC Human Subject Pool, as well as posters around the city. People who were interested in participating in the study contacted research assistants to schedule the first initial session to get set up with the study materials and instructions. Community participants were compensated CAD $20.00 at the first session, and CAD $55.00 at the second 30-40 minute debriefing session after completing the week-duration of the study. University students recruited through the

UBC Human Subject Pool were compensated with either CAD $25.00 (i.e. $10.00 for each session and $5.00 for the Actiwatch portion) or course credits. The Behavioural Research Ethics Board gave their approval for the study procedures prior to running our first participants.

Measures

The primary predictor variables being examined in this study are the duration of daily smartphone app activity 1 hour before sleep, as well as the use of blue light filter as a moderating factor. The main outcome variable analyzed will be the day-to-day objective sleep efficiency score from the accelerometer. The participants are also given a "sleep diary" with a set of questions to determine any unexpected circumstances that may have influenced their nightly sleep. Duration and frequency of smartphone use is objectively measured with an Android smartphone app-tracking application, 'BeTrack'. Participants' use of blue light filter is obtained with a question in the self-report demographics survey during the second session. Sleep efficiency scores are obtained from the movement tracking wristband 'Actiwatch', and calculated as total duration of sleep divided by the total duration of time in bed on that same night.

Procedures

At the first 30-40 minute meeting with the researcher, research assistants verbally explained all the tasks involved during the 7-night participation of the study. After being fully informed of all aspects of the study, the researchers obtain verbal and electronic consent before setting up individual participants with all the study materials. Participants are then asked to download 'Betrack', an Android research app that tracks

the duration and frequency of each individual app usage on their smartphones. The participants are also provided with a movement tracking wristband ‘Actiwatch’ for 7 nights of sleep, as well as a sleep diary. With the Actiwatch, the participants are asked to set a time marker on the wristband by pressing a button when they attempt to go to sleep (i.e. bedtime onset), as well as when they finish attempting to sleep. An online demographics survey was administered at both the first and final meeting with the researcher.

Statistical Analysis

After data collection is complete, moderated multiple regression will be used to analyze whether the sleep efficiency score (i.e. interval outcome variable) objectively measured from the Actiwatch will be negatively correlated with the duration of smartphone activity 1 hour before sleep attempt (i.e. continuous predictor variable). Blue light filter will be examined as the dichotomous moderator variable for the regression data analysis.

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