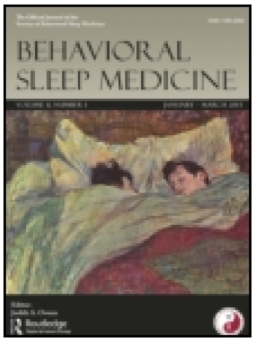

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ARTICLES

The Association Between Use of Electronic Media in Bed Before Going to Sleep and Insomnia Symptoms, Daytime Sleepiness, Morningness, and Chronotype

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This study investigated whether the use of a television, computer, gaming console, tablet, mobile phone, or audio player in bed before going to sleep was associated with insomnia, daytime sleepiness, morningness, or chronotype. 532 students aged 18–39 were recruited from lectures or via e-mail. Respondents reported the frequency and average duration of their in-bed media

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use, as well as insomnia symptoms, daytime sleepiness, morningness-eveningness preference and bedtime/rise time on days off. Mean time of media use per night was 46.6 minutes. The results showed that computer usage for playing/surfing/reading was positively associated with insomnia, and negatively associated with morningness. Mobile phone usage for playing/surfing/texting was positively associated with insomnia and chronotype, and negatively associated with morningness. None of the other media devices were related to either of these variables, and no type of media use was related to daytime sleepiness.

Sleep is regulated by an interaction between three main factors—a homeostatic factor, an endogenous circadian factor, and a behavioral factor (Bjorvatn & Pallesen, 2009; Borbély & Achermann, 1999; Dijk & Czeisler, 1995). The sleep homeostat reflects the average level of sleep depth, its activity depending on the duration of prior sleep, and wakefulness (Borbély & Achermann, 1999). The circadian factor mainly affects the timing and overall duration of sleep (Dijk & Czeisler, 1995), and is normally entrained by external zeitgebers to a 24-hr cycle (Aschoff, 1965), with the environmental light–dark cycle considered the primary synchronizer (Bjorvatn & Pallesen, 2009; Czeisler et al., 1986; Sack et al., 2007).

As behavioral factors can override both the homeostatic and circadian factors, it is important to gain knowledge about behaviors that affect sleep (Bjorvatn & Pallesen, 2009). Behaviors carried out close to sleep can potentially disturb sleep. For example, research has shown that increased arousal at bedtime and behaviors involving exposure to bright light are both associated with sleep disturbances (Gellis & Lichstein, 2009; Higuchi, Motohashi, Liu, & Maeda, 2005; Kubota et al., 2002).

In the past few decades, we have witnessed a sharp increase in the availability and use of electronic devices, such as mobile phones, video game consoles, DVD players, television, audio players, computers, tablets, and so forth (Brunborg et al., 2011; Suganuma et al., 2007). As electronic media become more lightweight and portable, people may conveniently use these devices even in bed. According to the National Sleep Foundation's *2011 Sleep in America Poll*, 95% of the respondents used electronic media, such as television, computer, video game, or cell phone, at least a few nights per week within the hour before bed, with young adults being major consumers of electronic media devices (National Sleep Foundation, 2011; Suganuma et al., 2007). Overall, this underlines the importance of investigating how in-bed media use may affect sleep.

Existing research on the association between electronic media use and sleep has mainly focused on children and adolescents. One study of adolescents found a negative correlation between hours of media use in the evening and hours of sleep during the following school day (Calamaro, Mason, & Ratcliffe, 2009). Another study related children's evening use of television, computer games, and the Internet to delayed bedtimes and less time spent in bed (Van den Bulck, 2004). Frequent use of a mobile phone after lights out has also been shown to predict tiredness 1 year later (Van den Bulck, 2007). Research on children's and adolescents' evening use of electronic media and its effect on sleep consistently shows that such use is associated with delayed bedtime and a reduction in total sleep time (Cain & Gradisar, 2010).

So far, relatively few studies have investigated the association between electronic media use and sleep in adults. One such study found the use of computers and mobile telephones in the bedroom to be associated with delayed timing of sleep (Brunborg et al., 2011). Extensive use of electronic media before sleep has also been reported to increase levels of self-perceived insufficient sleep (Suganuma et al., 2007). In addition, one study found that frequent use of mobile phone and "high accessibility stress" at baseline were associated with reporting sleep disturbances at follow up 1 year later (Thomée, Härenstam, & Hagberg, 2011). In another study, Internet surfing increased the risk of developing sleep disturbances in the form of repeated awakenings for women (Thomée, Eklöf, Gustafsson, Nilsson, & Hagberg, 2007). For men, the number of mobile phone calls and text messages per day were associated with sleep disturbances in the form of difficulties falling asleep. Furthermore, the number of hours spent watching television has been shown as significantly related to delayed weekend bedtimes, with hours using the Internet significantly related to a delay in both bedtime and rise time during weekends (Custers & Van den Bulck, 2012). The same study, however, failed to show a relation between media use and total sleep time or level of tiredness. This is supported by a study that found no relation between hours spent watching television and total sleep time (Jones, Otten, Johnson, & Harvey-Berino, 2010). Another study found no difference between good and poor sleepers concerning the average number of days per week they watched television in bed (Gellis & Lichstein, 2009). An experimental study found that playing an exciting computer game on a bright light display was associated with significantly longer sleep latency and shorter total REM sleep compared to a control condition (Higuchi et al., 2005). Overall, the majority of research on the association between electronic media use and sleep in adults suggests that use of electronic media is associated with different types of sleep disturbances.

Most of the existing research has restricted the investigation to only one or two electronic devices (Higuchi et al., 2005; Li et al., 2007; Mesquita & Reimão, 2010; Munezawa et al., 2011; Thomée et al., 2011; Van den Bulck, 2007). Furthermore, the majority of previous studies have investigated the presence of and use of electronic media in the bedroom, with only three studies having, to our knowledge, explicitly addressed the use of such media in bed in the evening or during the night (Gellis & Lichstein, 2009; Munezawa et al., 2011; Van den Bulck, 2007). A further limitation is that most studies have assessed the frequency of electronic media use, rather than its duration, thus enabling only crude estimates of total media exposure. Also, previous studies have mainly consisted of participants of quite a young age. As the chronotype is normally delayed during the teenage years (Roenneberg et al., 2004), it is possible that the effects of using electronic media in bed before sleep may be different for pre-puberty individuals, compared with post-puberty individuals. In addition, adults often have different schedules than children and adolescents, and have the luxury to determine their own use of electronic media free of parent-imposed constraints. It is also possible that due to a tight schedule, media use is only applicable close to bedtime or in bed for some adults. These factors make it especially interesting to the study of the use of electronic media in young adults.

This led us to conduct a survey among young adult students, investigating whether exposure to different electronic media in bed before going to sleep was related to insomnia, daytime sleepiness, morningness (one end of the morningness–eveningness dimension), or chronotype (as operationalized as the clock time of the midpoint of sleep on weekends and days off).

Our design made it possible to examine whether the different media devices had varying effects on sleep. We explicitly asked for media use in bed because we assumed that activities carried out close to sleep onset could potentially have a greater effect on sleep than activities carried out earlier (Stepanski & Wyatt, 2003). Previous studies have shown that one person's behavior may significantly impact the sleep of another (Leonhard & Randler, 2009). We therefore asked if a possible partner used electronic media in bed. Overall, we expected use of electronic media in bed to be positively related to insomnia, daytime sleepiness, and (later) chronotype and negatively related to morningness. We especially selected these variables, as previous studies have shown that these parameters might be affected by electronic devices (Brunborg et al., 2011; Kauderer & Randler, 2012; Thomée et al., 2007; Van den Bulck, 2007).

METHOD

Sample and Procedure

For this study, 532 students between the ages of 18 and 39 were recruited during lectures (response rate about 90%) at different faculties at the University of Bergen, and by e-mail invitation sent to students at the university's Faculty of Psychology. The sample consisted of 74.1% women and 25.9% men, aged 22.8 years ($SD = 3.4$), on average. Anonymous self-report questionnaires were distributed to the sample by e-mail or paper. Respondents were informed that participation was voluntary. As the study did not contain any identifiable information about health, it was exempted from ethical approval according to the Regional Committee for Medical and Health Research Ethics of Western Norway.

Measures

Use of electronic media. To assess the exposure to different electronic media devices, we constructed and included in this study a total of 20 items concerning the frequency and duration of electronic media use in bed before going to sleep. Respondents were asked to indicate the number of days per week (0–7) they watched television or used a computer, gaming console, tablet (such as iPad® and Kindle), mobile phone, or audio player in bed before going to sleep. We distinguished between different types of use for some of the electronic media, such as the use of a mobile phone for playing, surfing, texting, or talking. This was done to investigate whether different types of use would reveal unique relations with the different sleep parameters. In addition, one question was asked pertaining to how many days per week any bedroom partner used electronic media of any kind in bed after the respondent him- or herself had gone to bed. Respondents were also asked to indicate, in minutes, their average daily in-bed electronic media use and exposure. This enabled assessment of the total exposure time (dose) contributed by each electronic device, calculated by multiplying the number of days by average exposure time for each media type.

Bergen Insomnia Scale (BIS). The BIS (Pallesen et al., 2008) is based on the formal and clinical diagnostic criteria for insomnia. The scale consists of six items measuring different symptoms of insomnia. Respondents indicate on an 8-point scale, ranging from 0 to 7, the number of days per week during the last month they experienced problems with various aspects of sleep. An example of an item is, "During the past month, how many days a week have you been so sleepy/tired that it has affected you at school/work or in your private life?" The scale has high test–retest reliability and has demonstrated high convergent validity (Pallesen et al., 2008). Internal consistency (Cronbach's alpha) for the BIS in this study was 0.80.

Diurnal Scale (DS). The DS (Torsvall & Åkerstedt, 1980) comprises seven items assessing the morningness–eveningness dimension. Each item requires the respondent to choose, out of four alternatives, the one best matching their preferred time for conducting certain activities (e.g., "When do you usually begin to feel the first signs of tiredness and need for sleep?"; Torsvall & Åkerstedt, 1980). Internal consistency (Cronbach's alpha) for the DS in this study was 0.75. We have previously shown that the DS has good reliability and validity (Thun et al., 2012).

Epworth Sleepiness Scale (ESS). The ESS (Johns, 1991) is a trait measure of daytime sleepiness. Respondents are instructed to indicate their general tendency to fall asleep or doze off in each of eight described situations (e.g. "when sitting and reading"), on a 4-point Likert scale ranging from 0 (*no chance*) to 3 (*high chance*) (Johns, 1991). The scale has acceptable reliability and validity (Pallesen et al., 2007). Internal consistency (Cronbach's alpha) for the ESS in this study was 0.66.

Munich Chronotype Questionnaire (MCTQ). Chronotype was measured by the MCTQ (Roenneberg, Wirz-Justice, & Merrow, 2003), which asks participants to report bedtime, time for lights out, sleep onset latency, and wake up time. These parameters are reported for both workdays and days off. The most commonly used index from the MCTQ is the time of the midpoint of sleep on weekends and days off, expressed in terms of clock time (Roenneberg et al., 2003). The scale has high convergent validity (Zavada, Gordijn, Beersma, Daan, & Roenneberg, 2005).

Statistics. Data were analyzed using the 19th version of the IBM® Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL). Respondents who were outliers according to Mahalanobis distances were excluded. Hierarchical multiple regression analyses were conducted, with the four dependent variables being the composite scores of the BIS, the DS, the ESS, and chronotype assessed by the MCTQ. In the first step, age and gender (1 = *female*, 2 = *male*) were entered for each dependent variable. In the second step, we added the total time of in-bed television watching, surfing, playing, reading, or watching television, movies, or TV series on both computers and tablets, mobile phone use for playing, surfing, or texting, as well as talking, and listening to music or radio. Preliminary analyses were performed to ensure the assumption of normality was not violated, as well as checking for multicollinearity, linearity, and homoscedasticity.

RESULTS

Figure 1 shows the percentage of respondents who reported using each of the electronic media devices in bed before going to sleep at least one evening per week. As shown by Figure 1, using a mobile phone for playing, surfing, and texting was the most frequent such activity, reported by 75.8% of respondents, with the least frequent activity being the use of a gaming console, reported by only 0.9%. Only 5.3% of the respondents reported never using or being exposed to electronic media in bed before going to sleep. Mean time of media use per night was 46.6 min ($SD = 61.3$).

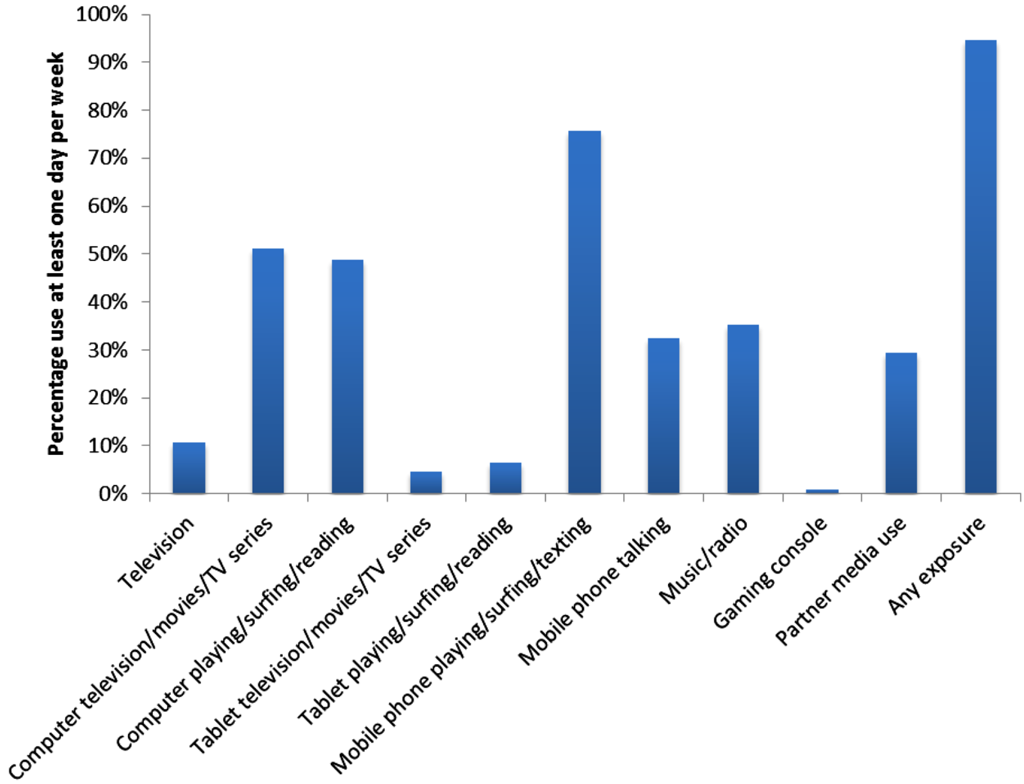

FIGURE 1 Percentage use of each media type in bed before going to sleep at least one day per week. (Color figure available online.)

There was no difference in gender distribution between those who answered the questionnaires during the lectures compared to those who answered the survey via the Internet, $\chi^2(1, N = 532) = 1.17$ (continuity correction), $p > .05$. However, those who answered during the lectures were significantly younger than those who answered via the Internet (22.3 years vs. 24.4 years), $t(530) = 6.80$, $p < .01$. Those who answered during the lectures reported a higher mean of daily electronic media use in bed than those who answered via the Internet (66.8 min vs. 32.5 min), $t(528) = 5.60$, $p < .01$. The correlation coefficient between age and mean of daily electronic media was −0.20 ($df = 531$, $p < .01$).

The bivariate intercorrelations between study variables showed that gender was negatively correlated with mobile phone use (1 = *female*, 2 = *male*). Age was correlated negatively with using a mobile phone and with using a computer. Table 1 shows an overview of means and standard deviations of the study's variables.

Table 2 shows the results of the regression analysis, with the score on the BIS as the dependent variable. In Step 1, the demographic variables (age and gender) were entered and explained 1.2% of the variance, $F(2, 499) = 2.90$, $p > .05$. In Step 2, respective total exposure time was entered for each media device, explaining a further 10.6% of the variance in insomnia

TABLE 1
Descriptive Study Variables

Variable	*n*	*M*	*SD*
Age	532	22.87	3.42
Television dose	532	14.52	64.35
Computer: television, movie, TV series dose	532	106.06	181.45
Computer: playing, surfing, reading dose	532	73.81	131.52
Tablet: television, movie, TV series dose	532	2.18	14.45
Tablet: playing, surfing, reading dose	532	2.70	14.17
Mobile phone: playing, surfing, texting dose	532	64.57	101.12
Mobile phone: talking dose	532	19.22	47.55
Music, radio dose	532	47.31	124.37
Gaming console dose	532	0.12	2.67
Partner's media use dose	532	25.04	64.98
Bergen Insomnia Scale total score	502	12.67	7.85
Epworth Sleepiness Scale total score	497	7.58	3.38
Morningness scale total score	492	15.95	3.90
Munich Chronotype Questionnaire total score	421	6:17	77.52

Note. Dose refers to minutes of media use in bed per week.

TABLE 2
Hierarchical Regression Analysis With the Bergen Insomnia Scale Total Score as the Dependent Variable

Predictor	*B*	*SE B*	*β*	*t*
Step 1				
Age	−0.07	0.102	−.03	−0.72
Gender (1 = *female*, 2 = *male*)	−1.80	0.799	−.10	−2.25*
Step 2				
Age	0.08	0.102	.04	0.80
Gender (1 = *female*, 2 = *male*)	−1.25	0.781	−.07	−1.60
Television dose	0.00	0.005	.02	0.55
Computer: playing, surfing, reading dose	0.00	0.003	.03	0.51
Computer: television, movie, TV series dose	0.01	0.002	.14	2.58*
Tablet: playing, surfing, reading dose	0.02	0.036	.03	0.48
Tablet: television, movies, TV series dose	0.05	0.036	.09	1.37
Mobile phone: playing, surfing, texting dose	0.02	0.004	.19	4.01**
Mobile phone: talking dose	0.01	0.007	.07	1.45
Music, radio dose	0.00	0.003	.06	1.31
Gaming console dose	0.15	0.128	.05	1.14
Partner's dose	−0.01	0.005	−.06	−1.35

Note. $N = 502$. For Step 1: $R^2 = .012$, $\Delta R^2 = .012$; for Step 2: $R^2 = .117$, $\Delta R^2 = .106^{**}$. Dose refers to minutes of media use in bed per week.

$^{*}p < .05$. $^{**}p < .001$.

symptoms, $F(10, 489) = 5.89$, $p < .001$. The model as a whole explained 11.7% of the variance. Results from Step 2 showed that using a computer for watching television, movies, and TV series in bed was significantly and positively related to symptoms of insomnia ($\beta = 0.14$, $p < .05$), as was using a mobile phone for playing, surfing, and texting in bed ($\beta = 0.19$, $p < .001$).

Table 3 shows the results of the regression analysis, with the score on the ESS as the dependent variable. Step-1 variables (age and gender) were found to explain 2.6% of the variance in daytime sleepiness. Entering media exposure times in Step 2 explained an additional 3.6% of the variance, $F(10, 484) = 1.87$, $p < .05$. The model as a whole explained 6.3% of the variance. After the addition of Step-2 variables, only gender remained significantly and negatively related to daytime sleepiness ($\beta = -0.15$, $p < .01$), with men reporting less sleepiness than women.

Table 4 presents the results of the regression analysis, with the score on the morningness scale as the dependent variable. Age and gender (Step 1) were found to explain 2.5% of the variance, $F(2, 489) = 6.32$, $p < .05$. Media exposure in bed (Step 2) explained 7.9% of the variance in the morningness–eveningness dimension, $F(10, 479) = 4.23$, $p < .001$. Thus, the model as a whole explained 10.4% of the variance. In this final model, morningness was significantly and negatively associated with gender ($\beta = -0.17$, $p < .001$). Morningness was also negatively associated with the use of a computer for watching television, movies, and TV series in bed ($\beta = -0.14$, $p < .05$), as well as with the use of a mobile phone for playing, surfing, and texting in bed ($\beta = -0.17$, $p < .05$).

TABLE 3
Hierarchical Regression Analysis With the Epworth Sleepiness Scale Total Score as the Dependent Variable

Predictor	*B*	*SE B*	β	*t*
Step 1				
Age	−0.02	0.044	−.02	−0.40
Gender (1 = *female*, 2 = *male*)	−1.24	0.343	−.16	−3.60***
Step 2				
Age	0.02	0.046	.02	0.52
Gender (1 = *female*, 2 = *male*)	−1.16	0.349	−.15	−3.31**
Television dose	0.00	0.002	.08	1.79
Computer: playing, surfing, reading dose	0.00	0.001	.04	0.77
Computer: television, movie, TV series dose	0.00	0.001	.09	1.66
Tablet: playing, surfing, reading dose	0.03	0.016	.11	1.58
Tablet: television, movies, TV series dose	−0.02	0.016	−.07	−0.95
Mobile phone: playing, surfing, texting dose	0.00	0.002	.01	0.26
Mobile phone: talking dose	0.01	0.003	.07	1.56
Music, radio dose	0.00	0.001	−.01	−0.13
Gaming console dose	−0.05	0.057	−.04	−0.81
Partner's dose	0.00	0.002	.00	−0.09

Note. $N = 497$. For Step 1: $R^2 = .026$, $\Delta R^2 = .026$**; for Step 2: $R^2 = .063$, $\Delta R^2 = .036$*. Dose refers to minutes of media use in bed per week.

*$p < .05$. **$p < .01$. ***$p < .001$.

TABLE 4
Hierarchical Regression Analysis With the Morningness Scale Total Score as the Dependent Variable

Predictor	*B*	*SE B*	*β*	*t*
Step 1				
Age	0.08	0.051	.07	1.61
Gender (1 = *female*, 2 = *male*)	−1.30	0.398	−.15	−3.26**
Step 2				
Age	0.01	0.052	.01	0.14
Gender (1 = *female*, 2 = *male*)	−1.51	0.395	−.17	−3.81***
Television dose	0.00	0.003	−.04	−1.01
Computer: playing, surfing, reading dose	0.00	0.002	−.03	−0.62
Computer: television, movie, TV series dose	0.00	0.001	−.14	−2.48*
Tablet: playing, surfing, reading dose	−0.01	0.018	−.05	−0.78
Tablet: television, movies, TV series dose	0.02	0.018	.05	0.80
Mobile phone: playing, surfing, texting dose	−0.01	0.002	−.17	−3.41**
Mobile phone: talking dose	0.00	0.004	.02	0.45
Music, radio dose	0.00	0.001	−.05	−1.15
Gaming console dose	−0.06	0.065	−.04	−0.92
Partner's dose	0.00	0.003	−.01	−0.27

Note. $N = 492$. For Step 1: $R^2 = .025$, $\Delta R^2 = .025^{**}$; for Step 2: $R^2 = .104$, $\Delta R^2 = .079^{***}$. Dose refers to minutes of media use in bed per week.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 5 shows the results of the regression analysis, with the scores on the MCTQ (midpoint of sleep on weekends and days off) as the dependent variable. In Step 1, age and gender explained 2.9% of the variance, $F(2, 418) = 6.17$, $p < .01$. In Step 2, the addition of media exposure in bed explained an additional 10.2% of the variance, $F(10, 408) = 4.79$, $p < .001$. The model as a whole explained 13.1% of the variance. Step-2 results showed that chronotype was positively associated with gender ($\beta = 0.17$, $p < .05$), with men showing a later chronotype than women. Chronotype was also positively associated with the use of a mobile phone for playing, surfing, and texting in bed ($\beta = 0.19$, $p < .001$).

DISCUSSION

This study aimed to estimate the association between in-bed media usage and relevant sleep variables. After controlling for the effects of age and gender, hierarchical multiple regression analyses showed that electronic media use in bed explained approximately 4% to 11% of the variance in insomnia, morningness, daytime sleepiness, and chronotype.

The use of computer for watching television, movies, and TV series in bed was found to be positively related to the severity of insomnia symptoms. This is in line with previous studies showing that use of electronic media for a prolonged period just before sleep is related to self-perceived insufficient sleep (Suganuma et al., 2007). However, our findings are inconsistent with those of one study that found no association between bedroom use of a computer and symptoms of insomnia (Brunborg et al., 2011).

TABLE 5
Hierarchical Regression Analysis With the Chronotype Questionnaire Total Score as the Dependent Variable

Predictor	*B*	*SE B*	*β*	*t*
Step 1				
Age	−2.60	1.096	−.11	−2.37
Gender (1 = *female*, 2 = *male*)	23.40	8.549	.13	2.74*
Step 2				
Age	−0.95	1.096	−.04	−0.87
Gender (1 = *female*, 2 = *male*)	29.35	8.39	.17	3.50*
Television dose	0.10	0.056	.08	1.70
Computer: playing, surfing, reading dose	0.03	0.035	.05	0.83
Computer: television, movie, TV series dose	0.05	0.025	.11	1.92
Tablet: playing, surfing, reading dose	0.27	0.383	.05	0.70
Tablet: television, movies, TV series dose	−0.55	0.391	−.10	−1.41
Mobile phone: playing, surfing, texting dose	0.14	0.04	.19	3.60**
Mobile phone: talking dose	−0.03	0.079	−.02	−0.42
Music, radio dose	0.05	0.031	.08	1.62
Gaming console dose	−0.78	1.378	−.03	−0.57
Partner's dose	0.03	0.058	.02	0.48

Note. $N = 504$. For Step 1: $R^2 = .029$, $\Delta R^2 = .029^*$; for Step 2: $R^2 = .131$, $\Delta R^2 = .102^{**}$. Dose refers to minutes of media use in bed per week.
$^*p < .01$. $^{**}p < .001$.

This study also found a positive relation between the use of a mobile phone for playing, surfing, and texting in bed and severity of insomnia symptoms. These findings are consistent with previous studies suggesting an association between texting on a mobile phone after lights out and a range of sleep disorders, including insomnia (Munezawa et al., 2011; Thomée et al., 2007; Thomée et al., 2011). However, Brunborg et al. (2011) found no association between use of a mobile phone in the bedroom (not necessarily in bed) and symptoms of insomnia.

We also found the use of a mobile phone for playing, surfing, and texting in bed to be associated with a relatively late chronotype. This makes sense in light of previous findings indicating that excessive use of a mobile phone in the bedroom may cause sleep phase delay (Brunborg et al., 2011). Similarly, our analysis demonstrated that individuals who use a computer for watching television, movies, and TV series or a mobile phone for playing, surfing, and texting in bed before going to sleep scored lower on morningness than did individuals making more limited use of such devices. This may indicate that excessive use of mobile phones in bed causes a phase delay of the circadian rhythm, as suggested by Brunborg et al. However, an alternative explanation could be that late chronotype or evening-typed individuals use media devices because they have a preference for staying up late, thus feeling more awake in bed in the evening, as compared to their early chronotype or morning-typed counterparts (Cain & Gradisar, 2010). This could also be the case for the relation between insomnia symptoms and media use, as electronic media use may be an epiphenomenon of sleeplessness.

Apart from computers and mobile phones used for these specific purposes, no other media devices used in bed were significantly related to insomnia, chronotype, or morningness. These nonsignificant findings may be related to the low prevalence of such media use in this study, and do not necessarily imply that increased use of these devices in bed has no effect on sleep. Previous findings are inconsistent regarding the association between various sleep variables and television viewing, talking on a mobile phone, and playing, surfing, or reading on a computer (Custers & Van den Bulck, 2012; Gellis & Lichstein, 2009; Higuchi et al., 2005; Munezawa et al., 2011; Thomée, Dellve, Härenstam, & Hagberg, 2010). This study found no significant association between either of the media devices and daytime sleepiness, which is in line with an earlier study finding no relation between media use and tiredness levels (Custers & Van den Bulck, 2012). However, these results are inconsistent with a study of adolescents which showed that excessive use of a mobile phone after lights out predicted tiredness 1 year later (Van den Bulck, 2007). In sum, computer and mobile phone use in bed before going to sleep was positively related to insomnia and late chronotype, as well as inversely related to morningness.

Inconsistent findings in this field may be related to methodological differences across previous studies, such as number of participants (ranging from 100 [Calamaro et al., 2009] to 94,777 [Munezawa et al., 2011], yielding highly variable statistical power), the number of media devices assessed (from 1 device [Munezawa et al., 2011; Thomée et al., 2011; Van den Bulck, 2007] to 6 [Brunborg et al., 2011]), and the time frame of measured media use in relation to the sleep period. In addition, media exposure is sometimes operationalized in terms of frequency (Brunborg et al., 2011; Li et al., 2007), whereas others report exposure time (Calamaro et al., 2009; Suganuma et al., 2007). A lack of standardized questionnaires for measuring media use complicates direct comparison of findings, as does the use of different outcome measures across studies. Thus, this field of research would benefit from increased consensus on how to operationalize and assess the impact of electronic media on sleep parameters. This study provides one example of how dosage and exposure to electronic media can be operationalized, and also suggests that assessment of electronic media use in relation to sleep should be context specific (e.g., in bed).

Possible Mechanisms

Media use may reduce sleep length and cause sleep deprivation by, for example, causing difficulties falling asleep (Custers & Van den Bulck, 2012), resulting in longer sleep latencies (Higuchi et al., 2005) delaying bedtimes and shortening total time spent in bed (Van den Bulck, 2004). Media use in bed may act as a direct displacement of sleep, and may also replace activities that promote good sleep (Stepanski & Wyatt, 2003). Further, prolonged use of media can cause physical discomfort, such as muscular pain and headache, which can negatively affect sleep (Thomée et al., 2010). Repeated use can cause the bed and the bedroom to lose their power as sleep-inducing stimuli by becoming associated with electronic media (Hauri & Fisher, 1986). Another potential mechanism may be related to exposure to the bright light emitted by many electronic devices (Cain & Gradisar, 2010). Evening bright light, especially with short wavelengths, can cause phase delays, typically postponing sleep onset (Bjorvatn & Pallesen, 2009; Khalsa, Jewett, Cajochen, & Czeisler, 2003; Zeitzer, Dijk, Kronauer, Brown, & Czeisler, 2000). In addition, using electronic media devices may be associated with cognitive, emotional or physiological arousal, which may, in turn, impair sleep (Cain & Gradisar, 2010; Gellis & Lichstein, 2009; Higuchi et al., 2005). Light may also have an immediate, although temporary, activating effect, which can counteract sleep (Cajochen et al., 2011; Campbell et al., 1995).

Strengths and Limitations

There are some limitations to this study that require consideration. First of all, the sample, comprising exclusively college and university students, is not representative of the general population. The gender distribution was also skewed with a female preponderance. However, the sample was rather large ($n = 532$), and there is no reason to believe that the association between media use in bed and sleep in this sample differs from the general population, as the potential mechanisms reflecting the findings are thought to be basic and largely biologically conveyed. Also, previous studies based on samples from the general population have shown similar results (Brunborg et al., 2011). There were some differences between the participants recruited at lectures and those recruited by mail, where the former group had a higher daily average media use. This difference seems to be related to the age difference between the two groups, as we found a negative relation between electronic media use and age.

Second, the study relied entirely on self-report, with all questions being retrospective. Thus, data may have been influenced by recall bias (Brewer, Hallman, Fiedler, & Kipen, 2004; Thomée et al., 2007; Van den Bulck, 2007), as well as by common method bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Social desirability may also have affected responses (Huang, Liao, & Chang, 1998). Future studies may benefit from more continuous observation methods (e.g., a sleep diary and daily media use measures). Another potential methodological problem with this study was that the use of different electronic media varied greatly, with the ability to show significant relations with the sleep parameters varying accordingly across media. It appears that the significant effects were evident where the use was greatest, implying that it is unlikely to find significant effects where the use is low. With an increased use of these media devices, it may be more likely to detect their potential effect on sleep in future studies.

Extensive use of electronic media outside bed may also influence sleep; however, we did not include questions about that in this study. It may be useful for future research to include measures of media use close to bedtime in addition to use in bed. The media data questions were constructed for the purpose of this study; thus, we have no data concerning the psychometric properties of this measure.

Along with the majority of previous studies, this study was based on a cross-sectional design, and causal relations can, therefore, not be determined. Future experimental studies should be conducted to reveal possible causal relations between these variables. This could be done by instructing one group of participants to stop the use of electronic devices in bed in comparison with a no-change control group, for example. There is also a need for longitudinal studies of the association between the use of electronic media devices and sleep disturbances, which may help elucidate this relation further. Future research could benefit from including more covariates known to affect sleep, such as stress, napping, and caffeine intake in the evening. Questions about whether respondents use technology at night while waiting to feel sleepy should also be included.

Despite its limitations, this study adds to the field in several ways. First of all, the use of a young adult sample is an asset. Second, this is (to our knowledge) the first study to investigate the use of tablets, alongside several other media devices. Future research should continue to assess new media devices, as their use is currently on the rise.

Another contribution of our study is that it is the first (to our knowledge) to present a measure of the total exposure time per week to each electronic device, including exposure to a partner's media use in bed. We also regard it as an asset of this study that it explicitly investigated media use in bed. A further asset is that we distinguished between different types of use for some of the electronic media devices. Future research may benefit from elaborating this distinction—for example, by distinguishing between active and passive media use. This distinction would enable an investigation of whether active and passive media use affect sleep differently, as found in some studies (Weaver, Gradisar, Dohnt, Lovato, & Douglas, 2010). It may also be beneficial for future research to examine whether differences in the content of, for example, television programs, movies, video games, and phone calls affect sleep differently.

As activities involving exposure to bright light close to sleep have been shown to have a disturbing effect (Khalsa et al., 2003), future studies should include the objective assessment of light exposure from electronic devices, aiming to investigate how these parameters are associated with both sleep variables and measures of circadian rhythm.

Also, trends in media convergence, such as the 24-hr news cycle and globalization of news, may exacerbate the use of screens late at night. Future studies should, thus, focus on this issue. Further knowledge about how and why media use affects sleep is important, as several studies have shown associations between electronic devices and unhealthy sleep patterns and sleep disturbances, including insomnia. As individuals with sleep problems are more likely to report a range of different health problems, public health prevention strategies should aim to inform and give advice about the importance of sleep and recovery, including advice about limits for the use of electronic media devices close to and after bedtime (Thomée et al., 2011).

In conclusion, our results suggest that the use of a computer for watching television, movies, and TV series and a mobile phone for playing, surfing, and texting in bed before going to sleep is positively associated with insomnia and delayed chronotype and negatively related to morningness.

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