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Sleep Interference Effects of Pathological Electronic Media Use during Adolescence

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Abstract Adolescents increasingly use electronic media as a night-time activity, amid concerns about the potential negative impact on sleep and daytime functioning. The present study examined electronic media use and pathological media use in relation to sleep activity in a normative sample of Australian adolescents. A total of 1,287 high school students aged 12–18 years (50 % female) were recruited from seven secondary schools in South Australia. Adolescents completed a questionnaire assessing electronic media use, pathological media use, and sleep factors. Adolescents reported non-optimal sleep duration on weekday (71 %) and weekend nights (53 %). One in five adolescents reported nightly bedtime delay as a consequence of electronic media use. Adolescent pathological media users reported significantly more sleep problems than their non-pathological peers. These data contribute to current knowledge of how electronic media use may negatively affect adolescent sleep patterns, particularly in regard to sleep displacement and sleep-onset latency effects. Further research is needed in light of the increasing accessibility and uptake of portable electronic media devices, as well as the growing use of media as a sleeping aid, among young people.

Keywords Adolescent · Sleep · Media · Video-gaming · Internet

Epidemiological data suggest that the average Australian adolescent spends 5 h per day engaged in a range of electronic media activities (Australian Communications and Media Authority 2008). This figure is consistent with those presented by studies conducted in other Western countries (Rideout et al. 2010; Strasberger et al. 2010). Media activities are therefore a formative environmental influence on adolescent development, with the potential to enhance and/or interfere with multiple domains of functioning (Allison et al. 2006; Andraessen et al. 2011; Hussain and Griffiths 2009; Mentzoni et al. 2011; Smyth 2007). Although there are several documented benefits of electronic media for adolescents, including opportunities for learning and socialisation (Subrahmanyam et al. 2001) and improved coping and well-being (Durkin and Barber 2002), research studies suggest that electronic media may impact negatively on adolescents' sleep patterns and quality of sleep (Dworak et al. 2007; King et al. 2013b; Punamaki et al. 2007). Although several survey studies have been conducted internationally

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(Brunborg et al. 2011; Choi et al. 2009) there are limited data on adolescents in the Australian context (Short et al. 2013) and few investigations with a specific focus on pathological media use (Cheung and Wong 2011). Therefore, the aim of this study was to examine pathological electronic media use in relation to sleep factors in a normative sample of Australian adolescents.

Electronic media use has been theorised to interfere with sleep in three main ways (Cain and Gradisar 2010). First, electronic media may cause direct displacement of sleep. Sleep displacement may occur more readily and/or frequently when electronic media devices are located in the bedroom (Gaina et al. 2005). Second, pre-sleep electronic media use may increase cognitive, emotional, and physiological arousal at bedtime, thereby increasing sleep-onset latency and reducing total sleep time (Ivarsson et al. 2009). Third, the bright light display of electronic devices may have a disruptive effect on circadian rhythm, with associated sleep consequences, such as needing to sleep later than intended to reduce sleep debt or taking naps during the day (Li et al. 2007).

Several large survey studies have been conducted in response to the increasing uptake and use of digital technology among youth (Gentile 2009; Rehbein et al. 2010). A consistent finding in the sleep literature is that those adolescents who have electronic media devices in the bedroom report later bed times, shorter sleep duration, longer sleep-onset latency, and worse daytime functioning (e.g., worse memory or concentration), as compared to those without devices in their bedroom (BaHammam et al. 2006; Li et al. 2007; Oka et al. 2008; Punamaki et al. 2007; Schochat et al. 2010; Suganuma et al. 2007; Van den Bulck 2004). Eggermont and Van den Bulck (2006) surveyed 2,546 schoolchildren about their media habits and sleep. They found that over a third of adolescents reported watching television to help them fall asleep. Similarly, about 1 in 4 adolescents played video-games directly before bedtime. Using electronic media as a sleep aid was related to later time to bed, decreased total sleep time, and increased daytime tiredness. Comparable findings have been reported in other large survey studies by Brunborg et al. (2011) and Choi et al. (2009). Research evidence suggests, therefore, that electronic media use is a prevalent pre-sleep activity among adolescents, and is often associated with poor sleep-related outcomes.

Relatively fewer studies of adolescent sleep have assessed pathological media use, as distinct from normal and/or high patterns of electronic media use, as a potential risk factor for poorer sleep outcomes (Choi et al. 2009). Pathological electronic media use refers to a persistent and maladaptive use of electronic media, resulting in psychological and/or physical problems. In particular, online video-gaming is increasingly recognised as a potential significant psychological and health problem among adolescents (Bakken et al. 2009; Tejeiro et al. 2012; Wolniczak et al. 2013). For example, since May 2013 "Internet Gaming Disorder", which refers to a persistent pattern of maladaptive Internet video-gaming, has been included in the appendix of the DSM-5 as a mental health disorder in need of further study (King and Delfabbro 2013). Notably, however, this classification does not recognise problematic use of other electronic media activities, such as television-viewing, Internet use, or smartphone use, despite evidence that such activities may also be associated with symptomatology similar to Internet gaming (Strasberger et al. 2010) and may impact sleep (Van den Bulck 2004). Empirical data suggests that pathological media use is a highly prevalent problem in Australia as well as other Western contexts (Ferguson et al. 2011). For example, Porter et al. (2010) study of adolescents (N= 1,042) reported that 9 % met criteria for pathological video-gaming. Similarly, Thomas and Martin (2010) surveyed 1,326 school students (51 % male) and reported that 4–5 % of youth were problem users of video games or the Internet.

A defining characteristic of pathological media use is a pattern of media use that is not regulated or limited by the user, thereby producing conflict or interference with other daily activities and commitments (Choo et al. 2010; King et al. 2013c; Van Rooij et al. 2010).

Therefore, it may be expected that individuals who report a pathological relationship with electronic media activities will be at greater risk of sleep-related problems than their non-pathological counterparts. A growing body of research on adolescent and adult pathological media users supports this assertion. In Yen, Ko, Yen, and Cheng's (2008) study of 8,004 Taiwanese adolescents, problematic electronic media use was significantly related to short nocturnal sleep duration and insomnia. A study conducted in China reported that 51 % of high school students with Internet addiction met the diagnosis for insomnia (Cheung and Wong 2011). Similarly, in a large representative study conducted in Norway, the prevalence of sleep disorders was 38.6 % among adults who met the criteria for Internet addiction (Bakken et al. 2009). Such findings highlight the need for further examination of sleep problems among those who use electronic media at high levels. To date, the prevalence of sleep problems specifically related to pathological electronic media use has not been investigated in an Australian sample of adolescents. Therefore, this research was designed to serve two broad aims: (1) to examine the relationship between electronic media use and sleep factors in a normative sample of Australian adolescents, and (2) to further evaluate pathological media use as a potential risk factor for maladaptive sleep behaviors and poorer sleep outcomes among adolescents.

Method

Participants

A total of 1,287 high school students aged 12–18 years were recruited. The sex distribution was 49.6 % male and 50.4 % female. The mean age was 14.9 years ($SD = 1.5$). Participants identified as Caucasian Australian (85.5 %), Asian (6.8 %), European (5.1 %), Aboriginal (1.6 %), or Other (.9 %). English was the primary language spoken at home by 95 % of participants. Rates of ownership and/or home accessibility for various electronic media device were as follows: mobile phone or smartphone (91 %), portable music player (89 %), laptop (86 %), video-gaming console (78 %), personal computer (71 %), and tablet devices (37 %). Participants reported that they had first used the Internet at the age of 8.2 years ($SD = 2.3$), video-games at 9.2 years ($SD = 3.7$), and a mobile phone at 10.9 years ($SD = 2.1$).

Measures

A survey battery obtained basic demographic information and details of electronic media use (i.e., media ownership and accessibility, frequency of use of each device, function and social context of media use, and age at which devices were first used). All questions on frequency of electronic media referred to a typical week in the previous 3-month period. Additional psychometric instruments, as detailed below, assessed problematic media use, and various sleep factors.

The Pathological Technology Use (PTU) checklist is a 10-item self-report questionnaire used to assess persistent and recurrent maladaptive use of computers, video-games, the Internet and other digital technologies (Gentile 2009; Sim et al. 2012). All questionnaire items were administered using a generic wording (i.e., "this activity"), with two adjacent columns containing response categories that referred to Internet and video game play, in order to assess Pathological Internet Use (PIU) and Pathological Video-Gaming (PVG) as separate concepts (see King and Delfabbro 2013). The PTU Checklist was developed using DSM-IV criteria for pathological gambling, and it has been shown to have good psychometric properties, including high

convergent and predictive validity (King et al. 2013c). PTU Checklist items converge with criteria for the proposed DSM-5 Internet Gaming Disorder category. Scores that include five or more affirmative ('yes') responses indicate pathological technology use (Sim et al. 2012).

The Sleep Activity and Media Questionnaire (SAMQ) is a 9-item measure designed for the purpose of this study. Its items were descriptive and based on standard screening questions used in sleep laboratory studies (e.g., Ivarsson et al. 2009) and surveys (e.g., Li et al. 2007). The SAMQ assesses sleep activity on typical "weekday" (Sun-Thurs) and "weekend" nights (Fri-Sat) in the last month, as recommended by Short et al. (2013). Items assess sleep-onset latency (min), bed time, and waking time. Total sleep duration is calculated based on reported values. Three items assess electronic media-related sleep disruption including: *bed time delay* (i.e., "Does electronic media use ever make you stay up later than intended?"), *extended SOL* (i.e., "Do you find it more difficult to fall asleep after using electronic media?", and *sleep interruption* (i.e., "Do you ever get woken up in the night by a media device?"). These questions are scored on a 4-point Likert scale (i.e., 1 = never, 2 = sometimes, 3 = often, and 4 = always).

Procedure

The present research was part of a larger study on adolescents and electronic use, as detailed in King et al. (2013a, 2014). Fifty secondary schools in the metropolitan region of Adelaide, South Australia, were randomly selected from a comprehensive list of public and private schools. Catholic schools were excluded due to barriers in obtaining ethical clearance. Each school principal was sent a letter and 1-week follow-up email invitation to participate. The study was promoted as an investigation of "electronic media use and mental health in young people". Each participating school was provided with an individualised summary report of findings, which included an indication of the number of adolescents at-risk of mental health problems. Informed consent was obtained from the school principal, the participant, and a parent or guardian.

The study was conducted at each secondary school during class hours. A school co-ordinator or teacher administered the questionnaire to each student in the classroom. An online version of the questionnaire was available via Survey Monkey for those schools with the requisite IT infrastructure. There were 379 online responses in total. No systematic differences in main study variables according to response format were identified. Survey responses were compiled and analysed using SPSS for Windows (v18.0). A total of 73 responses were excluded due to erroneous responses or missing data. This study was approved by the Human Research Ethics Subcommittee at the University of Adelaide, and the Department for Education and Child Development.

Statistical Analyses

A descriptive analysis of all main study variables across sex and age groups was first conducted. The yielded sample had a 50/50 gender ratio and age was distributed evenly across age groups of 13, 14, 15, 16 and 17 years. Two-way (2×5) ANOVAs were employed to assess main effects of sex and/or age on all study variables. Mann–Whitney U tests were employed to assess differences in sleep activity according to status of pathological electronic media use (i.e., normal versus pathological users). Pearson's correlations assessed the relationship between all electronic media use and sleep activity factors. A multiple regression analysis assessed the relative strength of electronic media variables as predictors of total sleep time after controlling for age and sex.

Results

Normative Electronic Media Use

Tables 1 and 2 present a summary of the descriptive results of adolescents' electronic media use. Males reported spending 218 min/day on screen-based electronic media during weekdays (Mon-Thurs) and 280 min/day during weekend days (Fri-Sun), as compared to females who spent 190 min/day and 223 min/day, respectively. Although the amount of electronic media use increased from age 13 years to 17 years, these differences were not statistically significant. The most time-consuming electronic media activity was Internet use (i.e., online social networking, information browsing, and online shopping). Males and females did not differ significantly in their Internet usage; both sexes spent, on average, between 101 and 115 min/day on the Internet during weekdays and weekends. Males spent 48 min/day playing video-games on weekdays as compared to females who spent 5 min ($t(1)=13.6$, $p<.05$, Cohen's $d=.81$), and males spent 81 min/day playing video-games on weekend days as compared to females who spent 13 min ($t(1)=15.6$, $p<.05$, Cohen's $d=.89$).

Table 1 The main effect of sex on main study variables

	Total ($N=1,287$)		Male ($N=602$)		Female ($N=612$)		Gender effect	Effect size
	M	*SD*	*M*	*SD*	*M*	*SD*	$F(df=1)$	η^b
Electronic media use[a]								
WD: daily media use	204.1	147.1	218.3	157.8	190.3	134.4	11.0*	.01
WE: daily media use	251.8	179.1	280.9	193.9	223.3	158.5	31.6*	.03
Problem media use[b]								
Internet use	1.6	1.9	1.5	1.9	1.6	1.9	1.5	<.01
Video-gaming	1.0	1.7	1.4	1.9	.6	1.3	60.7*	.05
Sleep activity								
WD: bedtime	22:30	1:11	22:33	1:14	22:26	1:07	4.4	<.01
WD: wake time	7:03	0:38	7:05	0:40	7:01	0:35	3.5	<.01
WD: SOL (min)	29.6	25.8	28.0	25.1	30.9	26.5	3.5	<.01
WD: sleep duration (hrs)	8.2	1.5	8.2	1.6	8.2	1.5	.5	<.01
WE: bedtime	23:52	1:36	0:00	1:41	23:44	1:30	9.7*	<.01
WE: wake time	9:05	1:34	9:07	1:43	9:04	1:24	.9	<.01
WE: SOL (min)	25.9	26.3	24.6	26.3	27.1	26.2	2.6	<.01
WE: sleep duration (hrs)	8.8	1.7	8.7	1.8	8.9	1.7	2.7	<.01
Sleep disruption								
Bedtime delay	2.6	1.0	2.6	1.0	2.7	.9	3.1	<.01
Extended SOL	1.8	.9	1.7	.9	1.8	.9	5.4	<.01
Sleep interference	1.7	.9	1.6	.8	1.8	.9	13.4*	.01

WD weekday (Mon-Thurs). *WE* weekend (Fri-Sun)

*$p<.01$

[a] Screen-based media only (Internet, television and video-games)

[b] Number of endorsed criteria on the PTU checklist

Table 2 The main effect of age on main study variables

	13 years (N=195) M (SD)	14 years (N=247) M (SD)	15 years (N=276) M (SD)	16 years (N=234) M (SD)	17 years (N=183) M (SD)	Age effect F (df=4)	ES η^2	Post-hoc[a]
Electronic media use								
WD: daily media use	195 (137)	194 (140)	198 (134)	224 (153)	231 (178)	3.37*	.012	–
WE: daily media use	239 (152)	241 (169)	248 (167)	274 (189)	279 (224)	2.73*	.010	–
Problem media use								
Internet use	1.2 (1.7)	1.4 (1.7)	1.6 (2.0)	1.9 (1.9)	1.8 (1.5)	4.00*	.014	4>1
Video-gaming	1.1 (1.7)	1.0 (1.7)	1.1 (1.8)	1.1 (1.6)	.9 (1.5)	.63	.002	–
Sleep activity								
WD: bedtime	22:04 (1:08)	22:21 (1:04)	22:24 (1:01)	22:54 (1:01)	22:52 (1:07)	20.04*	.071	4,5>1,2,3
WD: wake time	7:02 (0:31)	6:59 (0:40)	7:05 (0:36)	7:06 (0:34)	7:08 (0:45)	1.80	.007	–
WD: SOL (min)	30 (26)	29 (26)	27 (23)	30 (33)	26 (24)	2.18	.008	–
WD: sleep duration (hrs)	8.7 (1.4)	8.3 (1.6)	8.3 (1.3)	7.7 (1.7)	7.8 (1.3)	12.88*	.047	4,5>1,2,3
WE: bedtime	23:26 (1:38)	23:38 (1:34)	23:51 (1:31)	0:15 (1:37)	0:25 (1:31)	13.44*	.048	4,5>1,2,3
WE: wake time	8:55 (1:32)	8:57 (1:40)	9:10 (1:33)	9:14 (1:32)	9:18 (1:30)	2.48*	.009	–
WE: SOL (min)	27 (30)	26 (26)	24 (24)	29 (28)	22 (21)	2.07	.008	–
WE: sleep duration (min)	8.9 (1.7)	8.9 (1.7)	8.9 (1.6)	8.5 (1.9)	8.5 (1.7)	3.37*	.012	–
Sleep disruption								
Bedtime delay	2.3 (.9)	2.6 (1.0)	2.7 (.9)	2.8 (.9)	2.7 (.9)	6.85*	.025	4>1
Extended SOL	1.7 (.9)	1.8 (1.0)	1.7 (.9)	1.9 (.9)	1.8 (.9)	.80	.003	–
Sleep interruption	1.6 (.9)	1.7 (.9)	1.7 (.9)	1.8 (.9)	2.0 (.9)	3.57	.013	–

ES effect size. Groups: 1 = 13 years, 2 = 14 years, 3 = 15 years, 4 = 16 years, 5 = 17 years, *WD* weekday (Mon-Thurs), *WE* weekend (Fri-Sun)

*p< .05

[a] Tukey HSD

Age and Sex Differences in Electronic Media Use and Sleep

A series of 2 (Sex: Male, Female) × 5 (Age: 13, 14, 15, 16, 17 years) ANOVAs were conducted to examine age and/or sex effects on all electronic media use, problem media use, and sleep activity variables. Table 1 presents a summary of the main effects of gender, and Table 2 presents a summary of the main effects of age. No significant interaction effects were identified.

Significant sex differences were identified, with males reporting higher levels of total screen-based electronic media use (largely accounted for by increased video-gaming frequency) as well as higher levels of pathological video-gaming than females, which were moderately sized effects. Males also reported later weekend bedtimes than females, although this difference was small. Females reported higher levels of extended SOL due to using electronic media before bedtime as well as sleep interference due to electronic devices causing awakening, however these effects were small. The remainder of the main effects of sex were non-significant.

Significant main effects of age were also identified. Older adolescents reported higher levels of pathological Internet use than younger adolescents, although these differences were small and not clinically significant (i.e., scores did not vary in whole numbers of criteria endorsed, nor did scores cross the clinical cut-off of 4 criteria). Adolescents aged 16 years and older reported significantly later bedtimes on weekdays and weekends than younger adolescents. Similarly, this age group (i.e., those aged 16 years and older) reported significantly shorter total sleep duration on weekdays than younger adolescents. The remainder of the main effects of age were non-significant.

According to the National Sleep Foundation (2006), adolescent sleep duration may be classified as either *optimal* (>9 h), *borderline* (8–9 h), or *insufficient* (<8 h). Using this categorisation, on weekdays 29.0 % of adolescents obtained optimal sleep, 30.4 % obtained borderline sleep, and 40.7 % obtained insufficient sleep. On weekend nights, 47.4 % of adolescents obtained optimal sleep, 27.8 % obtained borderline sleep, and 24.5 % obtained insufficient sleep. These figures were consistent with Short et al. (2013) study of 385 Australian adolescents aged 13–18 years, which reported that only 1 in 5 adolescents obtained optimal sleep.

Problem Media Use and Sleep

Figure 1 show that the majority of participants reported sleep interference as a consequence of electronic media use. The most prevalent type of sleep interference due to electronic media was bedtime delay (i.e., staying up later to use an electronic device). As shown in Table 1, no gender differences in bedtime delay were observed. In the overall sample, 22 % of adolescents reported that bedtime delay occurred on a nightly basis (i.e., "always"), followed by "often" (29 %), "sometimes" (37 %), and "never" (12 %). By comparison, extended SOL and sleep interruption due to electronic media use occurred on a nightly basis for 8 % and 6 % of the sample, respectively.

Table 3 presents a summary of Mann–Whitney U tests assessing differences in sleep activity and electronic media-related sleep interference according to status of pathological media use (PMU). The results indicated that PMU adolescents (N= 134) reported significantly later bedtimes on weekdays and weekends than normal adolescents, with PMU adolescents going to bed, on average, approximately 35–40 min later. PMU adolescents reported significantly longer SOL (i.e., 11 min) on weekdays and weekends than normal adolescents. Notably, the between-groups difference in SOL crossed the cut-off of 30 min that is used to

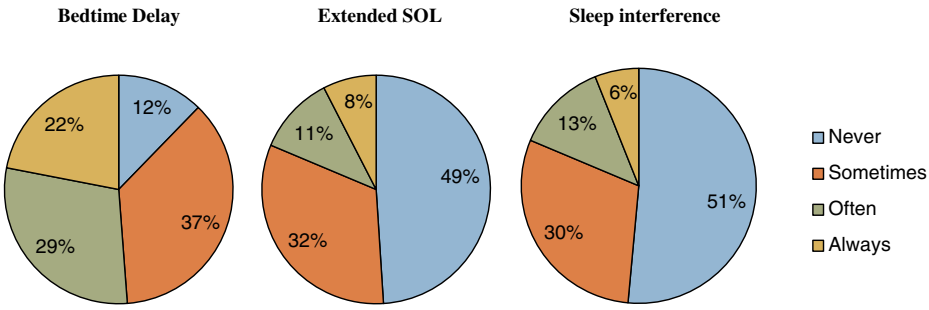

Fig. 1 Pie charts indicating the prevalence of electronic media-related sleep interference effects in the overall sample (*N*= 1,287)

indicate healthy limits (Espie et al. 2001). PMU and normal adolescents did not differ in terms of wake time on weekdays or weekends, which indicated that PMU adolescents were not simply delaying their sleep-onset times (i.e., shifting forward their timing of sleep), but were obtaining less sleep each night without sleep recovery on weekends. Pathological media users reported significantly more frequent electronic media-related effects than normal adolescents, including sleep delay, extended SOL, and sleep interruption. Among this group, 40 % reported that bedtime delay occurred on a nightly basis (i.e., "always"), followed by "often" (31 %), "sometimes" (17 %), and "never" (7 %). Extended SOL and sleep interruption due to electronic media use occurred on a nightly basis for 15 % of this group.

Electronic Media Use as a Predictor of Sleep Activity

Table 4 presents a series of Pearson correlations to assess bivariate relationships between screen-based electronic media use and sleep variables. Electronic media use was significantly negatively correlated with weekday and weekend sleep duration, as well as bedtime delay. However, electronic media use was not significantly correlated with sleep-onset latency. This result was consistent with a body of experimental research that reports no significant

Table 3 A comparison of sleep activity of pathological and normal media users

	No PMU (*N*= 991)			PMU (*N*= 134)			Group differences	
	M	*SD*	M. Rank	*M*	*SD*	M. Rank	Mann–Whitney U	Sig.
WD: Bedtime	22:25	1:08	544.4	23:00	1:20	700.2	48004.5	<.01
WE: Bedtime	23:46	1:34	559.5	0:38	1:41	588.8	62938.0	<.01
WD: Wake time	7:03	0:35	543.4	7:03	0:51	707.9	46973.0	.31
WE: Wake time	9:03	1:32	557.3	9:19	1:45	605.5	60699.0	.10
WD: SOL (min)	28.3	24.5	549.1	39.2	32.8	665.6	52649.0	<.01
WE: SOL (min)	24.6	24.5	550.5	35.3	35.6	655.2	54037.0	<.01
WD: Sleep duration (hr)	8.9	1.7	578.8	8.1	2.0	446.0	50721.5	<.01
WE: Sleep duration (hr)	8.3	1.5	580.7	7.5	1.9	432.1	48863.5	<.01
EME: Sleep delay	2.5	.9	541.6	3.1	.9	722.1	45072.0	<.01
EME: Extended SOL	1.7	.9	553.5	2.0	1.0	633.1	57003.0	<.01
EME: Sleep interruption	1.7	.9	547.9	2.1	1.1	674.9	51391.0	<.01

PMU pathological media use

Table 4 Correlations between electronic media use variables and sleep variables

Variable	2	3	4	5	6	7	8	9	10
1. Electronic media use[b]	.22[a]	.19[a]	.04	.03	−.24[a]	−.22[a]	.28[a]	.04	.10[a]
2. Pathological video-gaming[c]		.52[a]	.07	.07	−.13[a]	−.13[a]	.11[a]	.05	.10[a]
3. Pathological Internet use[c]			.13[a]	.09[a]	−.19[a]	−.15[a]	.25[a]	.15[a]	.17[a]
4. SOL – WD				.74	−.40[a]	−.28[a]	.05	.10[a]	.05
5. SOL – WE					−.30[a]	−.34[a]	.02	.09[a]	.05
6. Sleep duration – WD						.48[a]	−.19[a]	−.06	−.09[a]
7. Sleep duration – WE							−.15[a]	−.05	−.13[a]
8. EME: Bedtime delay								.33[a]	.27[a]
9. EME: Extended SOL									.30[a]
10. EME: Sleep interruption									

EME electronic media effect, *SOL* sleep-onset latency, *WD* weekday, *WE* weekend

[a] <.01

[b] Mean daily screen-based electronic media use

[c] Endorsed criteria on the PTU checklist

differences in SOL following differing levels of pre-sleep electronic media exposure in adolescents (Weaver et al. 2010; Ivarsson et al. 2009; King et al. 2013b). Pathological electronic media use was slightly but significantly negatively correlated with weekday and weekend sleep duration.

Two forward stepwise regressions were conducted with weekday and weekend total sleep time as outcome variables. In each model, age was entered on Step 1 (sex was excluded due to non-significance), and electronic media use, pathological media use, and electronic media-related sleep effects were entered on Step 2. Table 5 presents a summary of these two models. For Model 1, age

Table 5 Hierarchical regression analysis of age and electronic media use variables predicting total sleep time (TST)

	B	SE	*t*	β	95 % CI	
					Lower	Upper
Model 1: predicting weekday TST						
Constant	11.56	.44				
Age	.19	.03	6.6[a]	.15	−.20	−.10
Electronic media use (WD)	.00	.00	6.2[a]	.19	.00	.00
Pathological media use	.04	.01	2.8[a]	.08	−.07	−.01
EM Sleep disruption	.06	.02	2.3[a]	.02	−.09	.01
Model 2: predicting weekend TST						
Constant	11.71	.50				
Age	.11	.03	3.2[a]	.10	−.06	.35
Electronic media use (WE)	.00	.00	5.1[a]	.16	.00	.00
Pathological media use	.07	.02	2.9[a]	.10	−.14	−.04
EM Sleep disruption	.05	.02	2.8[a]	.09	−.09	−.02

[a] <.01

as a single predictor explained only 3.7 % of the variance in total weekday sleep duration ($F(1)=42.9$, $p<.01$). The inclusion of electronic media variables as predictors explained only an additional 6.0 % of the variance in weekday sleep duration (overall model: $F(5)=29.6$, $p<.01$). Weekday electronic media use was the strongest electronic media-related predictor of weekday sleep duration ($\beta=.19$, $t(4)=6.2$, $p<.01$). For Model 2, age as a single predictor explained only 1.6 % of the variance in total weekend sleep duration ($F(1)=19.3$, $p<.01$). The inclusion of electronic media variables as predictors explained only an additional 5.0 % of the variance in weekend sleep duration (overall model: $F(5)=20.7$, $p<.01$). Weekend electronic media use was the strongest electronic media-related predictor of weekend sleep duration ($\beta=.16$, $t(4)=5.1$, $p<.01$). Taken together, these results indicated that electronic media use factors were statistical significant but relatively weak predictors of total sleep time.

Discussion

This study provides empirical evidence that electronic media usage may impact on adolescent sleep in several ways. The most prevalent type of electronic media-related sleep interference was bedtime delay, which 1 in 5 adolescents reported occurred on a nightly basis. Most adolescents reported non-optimal sleep duration on weekday (71 %) and weekend nights (53 %). Sleep interference effects due to electronic media use were significantly more prevalent among adolescents who met clinical criteria for pathological media use. Although electronic media use was significantly negatively correlated with weekday and weekend sleep duration, multivariate analysis indicated that electronic media use was a relatively weak predictor of total sleep duration. Therefore, the extent to which electronic media use affects adolescent sleep may be subtle in the context of individual and environmental factors. However, in line with recent reviews (Griffiths et al. 2012; Kuss and Griffiths 2012) and similar empirical studies (e.g., Choi et al. 2009; Dworak et al. 2007), the results suggest that adolescent sleep may be significantly disrupted when electronic media is used pathologically.

Theoretical models have proposed several mechanisms by which electronic media may negatively impact on sleep (Cain and Gradisar 2010), including (i) media directly displacing sleep, (ii) media causing increased cognitive, emotional, or physiological arousal, (iii) bright light exposure from media causing circadian rhythm delay. The present study assessed the mechanism of media causing direct sleep displacement, in addition to two other media-sleep effects (i.e., extended SOL and sleep interruption) on which currently there is a paucity of empirical literature. This study therefore provides needed base rate data on the prevalence of these electronic media-related sleep effects among Australian adolescents. Bedtime delay due to media use was the most prevalent sleep problem among the majority of adolescents in this study. About 50 % of the participants had experienced extended SOL or sleep interruption due to electronic media use at least "sometimes". These results are therefore consistent with research studies that indicate pre-sleep electronic media use may threaten sleep quality (Eggermont and Van den Bulck 2006; King et al. 2013b; Van den Bulck 2003, 2004).

As predicted, the impact of electronic media on sleep was most notable among adolescents who met the criteria for pathological media use. Although pathological media use is recognised as a growing problem among adolescents (Gentile 2009; King et al. 2012b), only a limited number of studies (e.g., Choi et al. 2009; Dworak et al. 2007; Tazawa and Okada 2001) have focussed specifically on the sleep patterns of adolescent pathological users of electronic media. In the present study, adolescent pathological media users went to bed, on

average, approximately 35 to 40 min later than normal adolescents. These findings were consistent with Choi et al. (2009) and Cheung and Wong's (2011) findings that adolescents with Internet addiction are more likely to report clinically significant insomnia symptoms and lower sleep quality. In the present study, pathological media users reported significantly longer SOL than their normal peers, with a mean SOL time in the clinical range (i.e., indicating sleep problems) (Espie et al. 2001). This significant between-group difference was also found in Cheung and Wong's (2011) study, and was consistent with earlier research indicating that excessive use of electronic media before bedtime can delay or displace sleep, with associated physical signs of sleep deprivation (Tazawa and Okada 2001). Pathological media users reported significantly more frequent electronic media-related effects than normal adolescents, including sleep delay, extended SOL, and sleep interruption. The present study also found that pathological media users reported shorter sleep duration in comparison to normal adolescents, suggesting that these users may either function on less sleep or may compensate with naps and/or longer sleeps on occasion to recover sleep debt. This finding was not consistent with Cheung and Wong's (2011) study, suggesting a need for further research, employing prospective designs to assess sleep patterns over time, to examine the extent to which decreased sleep duration is a persistent issue among pathological users.

In considering the role of sleep problems within a clinical formulation of pathological media use, it must be noted that statements of causality are precluded due to the cross-sectional design of this study. Therefore, it was not clear whether pathological media users had pre-existing sleep difficulties which lead them to seek out night-time media activities, or if pathological media use had caused disrupted sleep routines. One possibility is that the relationship between pathological media use and poor sleep is cyclic in nature, where emerging or 'full-blown' pathological media use contributes to poorer sleeping patterns, and poor sleeping habits, in turn, escalate and maintain pathological media use. Further research using repeated measures designs to examine sleep-related physiological changes that may accompany shifts from normal to pathological media use may aid in understanding whether poor sleep is a consequence of excessive media use or a common biological vulnerability among pathological media users.

Several clinical implications are noted in light of study findings. First, with regard to assessment, it is important that researchers examining pathological media use, including the proposed DSM-5 "Internet Gaming Disorder", should screen for co-occurring sleep problems in the context of harm (see Beard 2005). Sleep problems are not often specifically examined in studies of pathological media use, although several recent studies suggest that sleep is an issue receiving increased attention. For example, a review by King et al. (2013c) reported that only 5 out of 18 pathological video-gaming instruments assess negative sleep consequences of pathological video-gaming. Second, case conceptualisation models of pathological media use should not overlook poor sleep functioning as a possible contributing factor in excessive and pathological electronic media use. Where appropriate, scheduled changes or modifications to sleep routine may be a useful target for behavioural change, even if this involves rescheduling (rather than reducing) media use to times of the day that do not impact on sleep in the case of clients who report low motivation to change. Third, behavioral therapies for pathological Internet use and video-gaming often include activity scheduling for stress and boredom management (King et al. 2011, 2012a, b; Kouimtsidis et al. 2007). Scheduling alternative night-time activities that have predetermined endpoints may be useful in minimising electronic media-related sleep displacement.

Limitations

This study provides needed data on adolescents' use of electronic media use in the context of sleep. Up-to-date data are critical for the development of an informed understanding, given that the types, availability, and functional uses of electronic media technologies are constantly evolving. Strengths of this study include its large sample of adolescents drawn from the general population, and the inclusion of measures that assessed the direct impact of electronic media on sleep. However, this research had several limitations that warrant caution in interpreting the results. First, this study relied on adolescents' self-reported data on sleep and electronic media use, which may be influenced by biases and limitations in memory and recall. However, this is a typical drawback of most survey-based studies. Nevertheless, a sleep diary completed prospectively would have obtained more accurate sleep data. This study also would have been improved by including measures of daytime functioning (e.g., learning, memory, concentration, subjective sleepiness). However, these factors are generally considered to be outcome variables in theoretical models of media and sleep (e.g., Cain and Gradisar 2010). Therefore, exclusion of such variables was not a threat to the validity of this study in its examination of electronic media use as a mechanism of sleep interference.

Another issue is this study did not take into account parental restrictions and/or supervision of electronic media use, which may be moderating factors in the relationship between media and sleep (Cain and Gradisar 2010). This study also did not screen for general sleep type (i.e., morning or evening type sleepers) or clinical sleep difficulties, such as insomnia or delayed sleep phase disorder. Although pre-sleep electronic media use in relation to sleep patterns was examined, the specific details of situational context of pre-sleep electronic media use (e.g., bedroom, living room) were not obtained. Further studies of electronic media use and sleep should measure these variables in accounting for the potential impact of electronic media on sleep.

Conclusion

This study provides a detailed view of adolescents' electronic media use and sleep patterns in the Australian context, thereby enabling comparison with several published studies internationally (e.g., Choi et al. 2009; Li et al. 2007; National Sleep Foundation 2011; Schochat et al. 2010). A somewhat novel aspect of this study was its examination of sleep patterns in the context of pathological media use, which to date has received relatively less attention than general electronic media use in the academic sleep literature. Adolescent pathological media users were found to be at significantly greater risk of insufficient sleep and extended SOL than normal adolescents, which is a finding that warrants further empirical attention. Research evidence may guide clinicians in developing standards in assessment and improvements to therapies for sleep problems associated with pathological media use. In view of the potential negative impacts of excessive media use, there is a need for the continuing development and dissemination of public health guidelines to educate young people, parents, and teachers about responsible electronic media use during adolescence.

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References

Allison, S. E., von Wahlde, L., Shockley, T., & Gabbard, G. O. (2006). The development of the self in the era of the internet and role-playing fantasy games. *American Journal of Psychiatry, 163*, 381–385.

Andraessen, C. S., Tosheim, T., Brunborg, G. S., & Pallesen, S. (2011). Development of a Facebook addiction scale. *Psychological Reports, 110*, 501–517.

Australian Communications and Media Authority. (2008). *Internet use and social networking by young people.* Retrieved 20/02/2013 from: http://www.acma.gov.au/webwr/_assets/main/lib310665/no1_internet_use_social_networking_young_people.pdf

Bahammam, A., Bin Saeed, A., Al-Faris, E., & Shaikh, S. (2006). Sleep duration and its correlates in a sample of Saudi elementary school children. *Singapore Medical Journal, 47*, 875–881.

Bakken, I. J., Wenzel, H. G., Gotestam, K. G., Johansson, A., & Oren, A. (2009). Internet addiction among Norwegian adults: a stratified probability sample study. *Scandinavian Journal of Psychology, 50*, 121–127.

Beard, K. W. (2005). Internet addiction: a review of current assessment techniques and potential assessment questions. *Cyber Psychology & Behavior, 8*, 7–14.

Brunborg, G. S., Mentzoni, R. A., Molde, H., et al. (2011). The relationship between media use in the bedroom, sleep habits and symptoms of insomnia. *Journal of Sleep Research, 20*, 569–575.

Cain, N., & Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: a review. *Sleep Medicine, 11*, 735–742.

Cheung, L. M., & Wong, W. S. (2011). The effects of insomnia and Internet addiction on depression in Hong Kong Chinese adolescents: an exploratory cross-sectional analysis. *Journal of Sleep Research, 20*, 311–317.

Choi, K., Son, H., Park, M., Han, J., Kim, K., Lee, B., & Gwak, H. (2009). Internet overuse and excessive daytime sleepiness in adolescents. *Psychiatry and Clinical Neuroscience, 63*, 455–462.

Choo, H., Gentile, D. A., Sim, T., Li, Dongdong, L., Khoo, A., & Liau, A. K. (2010). Pathological video-gaming among Singaporean youth. *Annals Academy of Medicine, 39*, 822–829.

Durkin, K., & Barber, B. (2002). Not so doomed: computer game play and positive adolescent development. *Journal of Applied Developmental Psychology, 23*, 373–392.

Dworak, M., Schierl, T., Bruns, T., & Strüder, H. K. (2007). Impact of singular excessive computer game and television exposure on sleep patterns and memory performance of school-aged children. *Pediatrics, 120*, 978–985.

Eggermont, S., & Van den Bulck, J. (2006). Nodding off or switching off? The use of popular media as a sleep aid in secondary-school children. *Journal of Pediatrics and Child Health, 42*, 428–433.

Espie, C. A., Inglis, S. J., Tessier, S., & Harvey, L. (2001). The clinical effectiveness of cognitive behaviour therapy for chronic insomnia: Implementation and evaluation of a sleep clinic in general medical practice. *Behavior, Research & Therapy, 39*, 45–60.

Ferguson, C. J., Coulson, M., & Barnett, J. (2011). A meta-analysis of pathological gaming prevalence and comorbidity with mental health, academic and social problems. *Journal of Psychiatric Research, 45*, 1573–1578.

Foundation, N. S. (2006). *2006 sleep in America poll*. Washington DC: National Sleep Foundation.

Gaina, A., Sekine, M., Kanayama, H., Sengoku, K., Yamagami, T., & Kagamimori, S. (2005). Short-long sleep latency and associated factors in Japanese junior high school children. *Sleep and Biological Rhythms, 3*, 162–165.

Gentile, D. A. (2009). Pathological video-game use among youth ages 8 to 18: a national study. *Psychological Science, 20*, 594–602.

Griffiths, M. D., Kuss, D. J., & King, D. L. (2012). Video game addiction: Past, present and future. *Current Psychiatry Reviews, 8*, 308–318.

Hussain, Z., & Griffiths, M. D. (2009). The attitudes, feelings and experiences of online gamers: a qualitative analysis. *Cyber Psychology and Behavior, 12*, 747–753.
Ivarsson, M., Anderson, M., Akerstedt, T., & Lindblad, F. (2009). Playing a violent television game affects heart rate variability. *Acta Paediatrica, 98*, 166–172.
King, D. L., & Delfabbro, P. H. (2013). Issues for DSM-5: video-gaming disorder? *Australian and New Zealand Journal of Psychiatry, 47*, 20–22.
King, D. L., Delfabbro, P. H., Griffiths, M. D., & Gradisar, M. (2011). Assessing clinical trials of internet addiction treatment: a systematic review and CONSORT evaluation. *Clinical Psychology Review, 31*, 1110–1116.
King, D. L., Delfabbro, P. H., & Griffiths, M. D. (2012a). Clinical interventions for technology-based problems: excessive internet and video game use. *Journal of Cognitive Psychotherapy: An International Quarterly, 26*, 43–56.
King, D. L., Delfabbro, P. H., Griffiths, M. D., & Gradisar, M. (2012b). Cognitive-behavioral approaches to outpatient treatment of Internet addiction in children and adolescents. *Journal of Clinical Psychology, 68*, 1185–1195.
King, D. L., Delfabbro, P. H., Zwaans, T., & Kaptsis, D. (2013a). Clinical features and axis I comorbidity of Australian adolescent pathological internet and video-game users. *Australian and New Zealand Journal of Psychiatry, 47*, 1058–1067.
King, D. L., Gradisar, M., Drummond, A., Lovato, N., Wessel, J., Micic, G., Douglas, P., & Delfabbro, P. H. (2013b). The impact of prolonged violent video-gaming on adolescent sleep: an experimental study. *Journal of Sleep Research, 22*, 137–143.
King, D. L., Haagsma, M. C., Delfabbro, P. H., Gradisar, M., & Griffiths, M. D. (2013c). Toward a consensus definition of pathological video-gaming: a systematic review of psychometric assessment tools. *Clinical Psychology Review, 33*, 331–342.
King, D. L., Delfabbro, P. H., Kaptsis, D., & Zwaans, T. (2014). Adolescent simulated gambling via digital and social media: an emerging problem. *Computers in Human Behavior, 31*, 305–313.
Kouimtsidis, C., Reynolds, M., Drummond, C., Davis, P., & Tarrier, N. (2007). *Cognitive-behavioural therapy in the treatment of addiction*. West Sussex: Wiley.
Kuss, D. J., & Griffiths, M. D. (2012). Online gaming addiction in adolescence: a literature review of empirical research. *Journal of Behavioral Addictions, 1*, 3–22.
Li, S., Jin, X., Wu, S., Jiang, F., Yan, C., & Shen, X. (2007). The impact of media use on sleep patterns and sleep disorders among school-aged children in China. *Sleep, 30*, 361–367.
Mentzoni, R. A., Brunborg, G. S., Molde, H., Myrseth, H., Mår Skouverøe, K. J., Hetland, J., & Pallesen, S. (2011). Problematic video game use: estimated prevalence and associations with mental and physical health. *Cyber Psychology, Behavior, and Social Networking, 14*, 591–596.
National Sleep Foundation. (2011). *2011 Sleep in America Poll: Communications Technology in the bedroom.* Washington, DC: The Foundation. Available from: http://www.sleepfoundation.org/2011poll
Oka, Y., Suzuki, S., & Inoue, Y. (2008). Bedtime activities, sleep environments, and sleep/wake patterns of Japanese elementary school children. *Behavioral Sleep Medicine, 6*, 220–233.
Porter, G., Starcevic, V., Berle, D., & Fenech, P. (2010). Recognising problem video game use. *Australian and New Zealand Journal of Psychiatry, 44*, 120–128.
Punamaki, R., Wallenius, M., Nygard, C., Saarni, L., & Rimpela, A. (2007). Use of information and communication technology (ICT) and perceived health in adolescence: the role of sleeping habits and waking-time tiredness. *Journal of Adolescence, 30*, 569–585.
Rehbein, F., Kleimann, M., & Mossle, T. (2010). Prevalence and risk factors of video game dependency in adolescence: results of a German nationwide survey. *Cyber Psychology, Behavior and Social Networking, 13*, 269–277.
Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). *Generation M: Media in the lives of 8- to 18-year-olds.* Report published by the Kaiser Family Foundation. Retrieved online from: http://eric.ed.gov/?id=ED527859
Schochat, T., Flint-Bretner, O., & Tzischinksy, O. (2010). Sleep patterns, electronic media exposure and daytime sleep-related behaviours among Israeli adolescents. *Acta Paediatrica, 99*, 1396–1400.
Short, M. A., Gradisar, M., Lack, L. C., Wright, H. R., & Dohnt, H. (2013). The sleep patterns and well-being of Australian adolescents. *Journal of Adolescence, 36*, 103–110.
Sim, T., Gentile, D. A., Bricolo, F., et al. (2012). A conceptual review of research on the pathological use of computers, video games, and the Internet. *International Journal of Mental Health and Addiction, 10*, 748–769.
Smyth, J. M. (2007). Beyond self-selection in video game play: an experimental examination of the consequences of massively multiplayer online role-playing game play. *Cyber Psychology & Behavior, 10*, 717–721.
Strasberger, V. C., Jordan, A. B., & Donnerstein, E. (2010). Health effects of media on children and adolescents. *Pediatrics, 125*, 756–767.
Subrahmanyam, K., Greenfield, P., Kraut, R., & Gross, E. (2001). The impact of computer use on children's and adolescents' development. *Journal of Applied Developmental Psychology, 22*, 7–30.

Suganuma, N., Kikachi, T., Yanagi, K., Yamamura, S., Morishima, H., Adachi, H., Kumango, T., Mikami, A., Sugita, Y., & Takeda, M. (2007). Using electronic media before sleep can curtail sleep time and result in self-perceived insufficient sleep. *Sleep and Biological Rhythms, 5*, 204–214.

Tazawa, Y., & Okada, K. (2001). Physical signs associated with excessive television-game playing and sleep deprivation. *Pediatrics International, 43*, 647–650.

Tejeiro, R. A., Gomez-Vallecillo, J. L., Pelegrina, M., Wallace, A., & Emberley, E. (2012). Risk factors associated with the abuse of video games in adolescents. *Psychology, 3*, 310–314.

Thomas, N. J., & Martin, F, H. (2010). Video-arcade game, computer game and Internet activities of Australian students: participation habits and prevalence of addiction. *Australian Journal of Psychology, 62*, 59–66.

Van den Bulck, J. (2003). Text messaging as a cause of sleep interruption in adolescents: evidence from a cross-sectional study. *Journal of Sleep Research, 12*, 263.

Van den Bulck, J. (2004). Television viewing, computer game playing, and internet use and self-reported time to bed and time out of bed in secondary-school children. *Sleep, 27*, 101–104.

†Van Rooij, A. J., Schoenmakers, T. M., Vermulst, A. A., van de Eijnden, R. J. J. M., & van de Mheen, D. (2010). Online video game addiction: Identification of addicted adolescent gamers. *Addiction, 106*, 205–212.

Weaver, E., Gradisar, M., Dohnt, H., Lovato, N., & Douglas, P. (2010). The effect of pre-sleep video-game playing on adolescent sleep. *Journal of Clinical Sleep Medicine, 6*, 184–189.

Wolniczak, I., Ca'ceres-DelAguila, J. A., Palma-Ardiles, G., Arroyo, K. J., Solıs-Visscher, R., et al. (2013). Association between facebook dependence and poor sleep quality: a study in a sample of undergraduate students in Peru. *PLoS ONE, 8*, e59087. doi:10.1371/journal.pone.0059087.

Yen, J. Y., Ko, C. H., Yen, C. F., Chen, S. H., Chung, W. L., & Chen, C. C. (2008). Psychiatric symptoms in adolescents with Internet addiction: comparison with substance use. *Psychiatry and Clinical Neuroscience, 62*, 9–16.