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The Effect of Presleep Video-Game Playing on Adolescent Sleep

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Study Objectives: Video-game use before bedtime has been linked with poor sleep outcomes for adolescents; however, experimental evidence to support this link is sparse. The present study investigated the capacity of presleep video-game playing to extend sleep latency and reduce subjective feelings of sleepiness in adolescents. The arousing psychophysiologic mechanisms involved and the impact of presleep video-game playing on sleep architecture were also explored.

Method: Thirteen male adolescent "evening types" (mean age = 16.6 years, SD = 1.1) participated in a counterbalanced, within-subjects design with experimental (active video gaming) and control (passive DVD watching) conditions. The experiment was conducted in the Flinders University Sleep Research Laboratory.

Results: Relative to the control condition, presleep video-game playing increased sleep-onset latency ($Z = 2.45$, $p = 0.01$) and reduced subjective sleepiness ($Z = 2.36$, $p = 0.02$)—but only slightly. Video gaming was related to changes in cognitive alertness (as measured by α power: $p < 0.01$) but not physiologic arousal (as measured by heart rate: $p > 0.05$). Contrary to previous findings, sleep architecture was unaffected (both rapid eye movement and slow wave sleep: $p > 0.05$).

Conclusions: Results suggest the direct effect of presleep video-game playing on adolescent sleep may be more modest than previously thought, suggesting that surveys linking stimulating presleep activities to poor sleep need substantiating with empirical evidence.

Keywords: Adolescent sleep, video-game playing, sleepiness, sleep architecture, physiologic arousal, DVD watching.

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The 24-hour circadian rhythm becomes increasingly delayed throughout puberty, making adolescents more prone to becoming "evening types."[1,2] During adolescence, increased alertness occurs later in the evening, making it difficult to initiate sleep at a reasonable hour.[1] As a result, the adolescent has "time to fill" late at night. This time is spent performing homework, casual work, or socializing,[3] as well as reading or using electronic media such as computer games, television, mobile phones, or the Internet.[4] Unfortunately, some of these activities are stimulating and can themselves promote late-night alertness. Emerging evidence suggests that playing video games before bedtime may be a particularly disruptive presleep activity for adolescents.[4]

Cross-sectional research has linked stimulating, nighttime video-game playing by adolescents to later bedtimes, insufficient sleep, and increased daytime tiredness.[4,5] However, sleep latency was not measured, providing little insight into the stimulation from video gaming on nocturnal sleep. Two experimental studies have investigated the effect on sleep latency, though their findings are inconsistent. In a study of 11 young adolescents (mean age = 13.5 years), Dworak et al.[6] found that playing video games for 60 minutes between 18:00 and 19:00 led to a mean 21.7-minute increase in sleep onset latency (SOL) relative to a control condition. In their study of 7 young adults (mean age = 24.7 years), Higuchi et al.[7] found that the participants' mean SOL was just 2.3 minutes longer after playing a video game for 2 hours and 45 minutes, relative to a control condition. This SOL extension[7] is considered to be too short to have any detrimental effects on adolescent sleep. Interestingly, SOL was short (< 7 minutes) in all conditions, most likely a reflection of increased homeostatic sleep pressure because lights out occurred at 02:00 (1 hour later than participants' typical lights-out time).[7] The present study seeks to address this limitation by verifying the extent to which presleep video-game playing can increase SOL for adolescents (aged 14-18 years) when sleep is attempted at their normal "lights-out" time.

BRIEF SUMMARY

Current Knowledge/Study Rationale: Cross-sectional evidence indicates adolescents playing video games prior to sleep results in sleep disturbance. The present study sought to confirm these findings using an experimental paradigm.

Study Impact: The magnitude of the effect of pre-sleep videogaming for adolescents may be more modest than previously thought. However, further experimental studies are needed to ascertain whether there is a cumulative effect of playing video games, and whether particular individuals (e.g., poor sleepers) are more susceptible to the ill effects of pre-sleep videogaming.

The most logical explanation as to how video-game playing can reduce sleepiness relates to the stimulating nature of the activity. The active participation of video-game playing has been consistently shown to increase physiologic arousal,[8,9] with heart rate the most common index used. Modern video games may evoke arousal through their interactive nature, particularly the "survival" of the player dependent on responding to stimuli rapidly and effectively[8] in a virtual world that graphically depicts realistic and violent subject matter.[10] However, physiologic arousal responses to videogaming have been mixed,[7,11] suggesting that multiple indicators of arousal should be employed.

Cognitive alertness is another potential mechanism to impair efforts to initiate sleep,[12] and can be objectively measured by calculating electroencephalogram (EEG) alpha or beta activity, or by analyzing neuronal activity.[13] Only 1 study has examined the capacity of video-game playing to increase cognitive alertness.[13] Using functional magnetic resonance imaging (fMRI), Mathiak and Weber found video-game playing to heighten cognitive alertness, especially during violent scenes.[13] This is extremely relevant considering that more than half of video games (including the one used in the present study) depict violent scenes.[14] Therefore, physiologic arousal and cognitive alertness may be partially responsible for the previously reported effect of video-game playing on sleepiness. We propose that videogaming, compared with an opposing, presleep activity requiring passive observation, will result in participants' greater arousal that subsequently affects the sleep initiation process.

Research has also suggested that presleep video-game playing may influence sleep architecture, although again, findings have been inconsistent, with 1 study finding a reduction of 4.7 minutes of slow wave sleep (SWS) in young adolescents,[6] whereas, in another study, young adults experienced 15.8 minutes less rapid eye movement (REM) sleep.[7] Given that research has indicated that insufficient REM sleep and SWS may impair memory processes,[15,16] clarifying the impact that videogaming may have on sleep architecture for adolescents is important.

Much ambiguity remains regarding the potential for presleep video-game playing to directly affect adolescent sleep, an unfortunate situation considering the activity's widespread popularity.[17] With this in mind, we predict that presleep video-game playing will increase alertness (i.e., increased SOL and decreased subjective sleepiness), relative to control, and that this will be influenced by increased physiologic arousal and cognitive alertness. A more exploratory approach regarding the effect of presleep video-game playing on sleep architecture will be taken, due to the conflicting nature of previous findings.

METHOD

Participants

Thirteen male adolescent students aged between 14 and 18 years (mean = 16 years, 7 months, SD = 1.08 years) were recruited via a sample of convenience. Only males were considered for participation, as the menstrual cycle and use of oral contraceptive agents are capable of affecting sleep. Inclusion criteria specified that all adolescents were to be "evening types" (assessed via Owl and Lark Questionnaire[18]). Exclusion criteria included adolescents with excessive daytime sleepiness (Epworth Sleepiness Scale [Score > 10][19]), sleep disorders, or serious medical or psychological conditions (assessed via Flinders University Sleep History Questionnaire[20]; Depression Anxiety and Stress Scale-Short Form[21]). Informed consent was obtained from all adolescents, and the study was approved by the Flinders University Social and Behavioural Ethics Committee.

Measures and Apparatus

Sleep Diary

Sleep diaries provide a detailed assessment of an individual's sleep-wake routine[22] and are widely used in both sleep research and clinical practice.[23] All participants completed a 7-day sleep diary for the week prior to their initial testing night, enabling calculation of average school bedtimes for each participant. This information was then used to time the presleep activity and lights out in the experiment so that participants attempted sleep at their usual bedtime. A mean out-of-bed time of 07:00 was calculated across the sample, with participants awoken at this time on all testing occasions. Although a subjective measure, sleep diaries generally yield an accurate overview of a person's sleep pattern, especially if completed immediately upon awakening in the morning (as was instructed in the present study), rather than retrospectively.[22,23]

The Stanford Sleepiness Scale

Because presleep videogaming may shorten sleep time by reducing adolescents' subjective level of sleepiness to the point at which they no longer feel like turning out the lights and going to sleep,[4] adolescents' subjective sleepiness was assessed. The Stanford Sleepiness Scale assesses how subjectively sleepy a person is feeling at a particular moment, ranging from "very alert" to "very sleepy."[24] In the present study, the Stanford Sleepiness Scale was administered after completion of each presleep activity (i.e., just prior to lights out). This measure has high convergent validity with other subjective sleepiness scales.[25]

SOL, Sleep Architecture and Cognitive Alertness

EEG, electrooculography (EOG), and electromyography (EMG) measurements were used to assess SOL and sleep architecture. To calculate SOL, the LabVIEW 7.1 software program (National Instruments Corporation, Austin, TX) recorded and displayed EEG and EOG signals. SOL was calculated as the time from lights out to the first of 3 consecutive 30-second epochs of a 50% reduction from peak alpha-wave activity.[26] To assess sleep architecture, EEG, EMG, and EOG data were recorded on a 20-MB Flashdisk and analyzed retrospectively on a Compumedics Systems computer using the program Compumedics Portable Manager v.2.04 (Compumedics, Victoria, Australia). The EEG was also used to measure cognitive alertness, with a higher maximum alpha-power reading indicating reduced cognitive alertness.[27]

Heart Rate

To measure heart rate, participants attached a Criticare Oximeter finger pulse rate probe (Criticare Systems, Waukesha, WI) to the end of their right index finger. This system allowed for participants' heart rates to be displayed in beats per minute (bpm) within the National Instruments LabVIEW 7.1 program on the same computer used to display EEG, EOG, and EMG data. This method of recording heart rate is commonly used in medical settings,[27] and, although this method is sensitive to motion, a high degree of accuracy is attainable if large-scale movement is eliminated during measurement.[28]

Electronic Media

The top-selling video game of 2007 (*Call of Duty 4*: Modern Warfare; Infinity Ward, 2007) was chosen for the study. Played in first-person perspective, the game can be described as a stress-filled tactical shooter moving at a frenetic pace.[29] It is thought to typify the engaging and realistic style of video games currently popular among adolescents.[29] A Playstation®3 gaming console (Sony Corporation, Minato, Tokyo, Japan) with a 60-GB hard disk[29] was used to play the game.

The DVD *March of the Penguins* (Warner Independent Pictures, 2005) was used for the control condition. The film, winner of the 2006 Academy Award for Best Documentary Feature, portrays the efforts of the Antarctic Emperor Penguin to survive against nature's extreme adversity. The documentary moves at a gradual pace and, although interesting, provides a decidedly tranquil viewing experience. The watching of a DVD, and this title in particular, was chosen for the control condition for a number of reasons. First, this activity provided a passive observation experience to the active participation of the experimental condition that allowed any negative sleep-related consequences of presleep video-game playing to be discerned in comparison. Second, the watching of a DVD in the same laboratory bedroom allowed a number of important variables, such as audiovisual and light stimulation, to be controlled. Third, watching DVDs is an activity that adolescents regularly perform before going to sleep.[17] Furthermore, the passive DVD watching allowed for the experimental manipulation of arousal relative to video-game playing. This highlights a clear advantage over both a "do-nothing" control condition (in which participants would have had to lay quietly for the allotted time) and that used by previous studies,[7] in which participants completed simple mental addition tasks for 2 hours and 45 minutes.

Procedure

Preexperiment Procedure

After passing prescreening questionnaires, participants reduced caffeine consumption and avoided alcohol consumption in the week prior to each testing. To reduce the likelihood of a "first-night effect,"[31] a habituation session was held in the Flinders University Sleep Laboratory on a late afternoon prior to each participant's initial experimental night.

Experimental Procedure

Testing occurred at the Flinders University Sleep Laboratory and was spread evenly across the week. Participants were instructed to eat their evening meal between 2 and 3 hours prior to testing to ensure that the sleep initiation process was not affected by excessive hunger or the digestive process.[32] On the first testing occasion, participants entered the Flinders University Sleep Laboratory approximately 1 hour before their presleep activity was due to commence. Dressed in night gear and with electrodes attached, they were led to their designated bedroom and assisted into a sitting-up position beneath the covers. All electrodes were connected to a Compumedics interface box (Compumedics) to measure sleep architecture (i.e., Stage 3 and 4 sleep, REM sleep, etc.), and impedance was checked for each mechanism (EEG, EOG, EMG). After recording was initiated, a baseline measure of heart rate and alpha-wave power was taken for 2.5 minutes. During every measurement period, particpants were instructed to keep their hand as still as possible to avoid inducing the motion artifact associated with this measure[28] and also to close their eyes to allow for alpha-wave power to be recorded through the EEG mechanism.

After baseline measures, adolescents began to either play the videogame (experimental condition) or watch the DVD (control condition), both for 50 minutes. This period of 50 minutes is considered the maximum amount of continuous video-game play recommended by Sony Corporation.[30] Given that both light stimulation and posture can influence alertness,[33,34] in both conditions, dim light conditions were held constant at approximately 32 lux, distance from the television monitor (an additional light source) was controlled (2 meters), adolescents were instructed to maintain a semisupine posture, and the volume was controlled to a speaker volume 17. Heart rate and alpha power were again measured at 25 minutes (midway) through the presleep activity. A postactivity measure of heart rate and alpha power was taken directly upon the completion of each presleep activity, followed by the completion of the Stanford Sleepiness Scale. Adolescents were then asked to attempt to go to sleep, and the lights were extinguished. On all testing occasions, adolescents remained in bed from lights out until awoken at 07:00 the next morning.

Exactly 1 week later, adolescents returned to the laboratory to complete the presleep activity not yet undertaken. This time period was chosen for 2 reasons. First, because of the length of time between testing periods, the quality and duration of sleep achieved on the initial night was unable to influence participants' performance on the second testing occasion. Second, holding both testing occasions on the same night of the week maximized the likelihood that adolescents' level of sleepiness would be consistent across the 2 testing occasions, as a similar sleep routine from week to week was thought likely. As a further safeguard, a sleep diary was completed by all participants for the week between testing occasions. No significant differences in adolescents' sleep-wake routine were noted with the diary completed prior to the first testing session (all p values > 0.05). On the final testing session, the experimental procedure was exactly the same as the first night.

Statistical Analyses

A power analysis indicated that, for a probability level at $p = 0.05$ and power set at 0.80, 13 subjects were sufficient enough to detect significant differences. For heart-rate measurement, an unrealistic degree of variability (i.e., differences of greater than 20 beats per minute) was observed in both conditions. This is most likely the result of participants being unable to keep sufficiently still, inducing the motion artifact.[28] Thus, median heart rate was used. Three outliers were also identified in the baseline heart-rate data from the initial testing night—possibly from the "white-coat" effect[35] and were thus altered so as to not significantly affect the total sample. Two variables (SOL and subjective sleepiness in control condition) violated the assumption of normality associated with parametric tests. Visual inspection revealed that SOL was positively skewed, and subjective sleepiness was negatively skewed. Because this violation can reduce the accuracy of a parametric inferential test, the nonparametric Wilcoxon Signed Rank Test was used.

To test the capacity for physiologic arousal (heart rate) and cognitive alertness (alpha power) to influence the effects on SOL and subjective sleepiness, a 3 (measurement point: baseline, midway, post) × 2 (condition: video game, DVD) within-subjects analysis of variance (ANOVA) was initially performed for each variable. Whenever the assumption of sphericity was violated, the Greenhouse-Geisser corrected statistic was reported.

RESULTS

Presleep Video-Game Playing and SOL

The ranking system associated with the Wilcoxon Signed Rank Test revealed that 11 adolescents experienced an extended SOL following presleep video-game playing relative to control, whereas only 2 adolescents demonstrated a shorter SOL. The difference between groups was significant ($Z = -2.45$, $p = 0.01$), supporting our prediction that presleep video-game playing would increase SOL. Although significant, adolescents took slightly longer to fall asleep in the video-game condition (median = 7.5 min, interquartile range [IQR] = 7.8 min) than in the DVD-control condition (median = 3 min, IQR = 3.5 min).

Interestingly, EEG data revealed that, on 4 separate occasions of an adolescent falling asleep during the presleep activity, this occurred exclusively in the DVD-control condition. The Fisher Exact Test confirmed that the percentage of adolescents who fell asleep in the control condition (30.8%) differed significantly from the percentage in the experimental condition ($p = 0.048$).

Presleep Video-Game Playing and Subjective Sleepiness

The Wilcoxon Signed Rank Test demonstrated that 7 adolescents reported feeling less subjectively sleepy after presleep video-game playing, with 4 adolescents indicating the same level of subjective sleepiness for both and only 2 adolescents reporting lower subjective sleepiness in the DVD-control condition. This difference was also significant, ($Z = -2.36$, $p = 0.02$) confirming our prediction that presleep video-game playing would lead to decreased subjective sleepiness relative to control. Closer analysis revealed that participants reported only slightly less subjective sleepiness following video-game playing (median = 4, IQR = 2.5), compared with the DVD-control activity (median = 5, IQR = 1).

Effect of Physiologic Arousal and Cognitive Alertness

For heart rate, the 3 (measurement point: baseline, midway, post) × 2 (condition: video game, DVD) within-subjects ANOVA revealed no main effects for time ($F_{2,24} = 1.06$, $p = 0.36$) or condition ($F_{1,12} = 0.30$, $p = 0.60$). No interaction was observed between these variables in their effects on heart rate ($F_{2,24} = 0.51$, $p = 0.61$), confirming that heart rate did not differ between conditions at any of the measurement points.

Another 3 × 2 within-subjects ANOVA was performed to test whether presleep video-game playing reduced cognitive alertness (alpha power) relative to control. Similar to heart rate, no main effects for time, ($F_{1.16,11.64} = 0.25$, $p = 0.67$) or condition ($F_{1,10} = 0.64$, $p = 0.44$) were revealed. However, these variables interacted in their effect on alpha power ($F_{2,20} = 8.99$, $p < 0.01$). Pairwise comparisons, using the Bonferroni correction, found that, despite the significant interaction, none of the comparisons were significant (all p values > 0.05). However, within-subjects effect sizes showed no effect at baseline ($d = 0.03$) but moderate effects midway ($d = 0.50$) and after ($d = 0.37$) the presleep activity. Thus, the small increase in the video-game condition ($d = 0.18$) accompanied by the small decrease in the control condition ($d = -0.31$) from the baseline to midway measurement points, indicated that the alpha power was affected by both presleep activities.

Sleep Architecture

Paired-samples t tests were performed to investigate the impact of presleep video-game playing on sleep architecture. Unfortunately, due to technical difficulties, data regarding sleep architecture are available for only 9 of the 13 participants. Because variations in total sleep time may influence quantities of both REM sleep and SWS, these variables were measured as a percentage of total sleep time. No significant differences were found between conditions in the percentage of total sleep time comprised of REM sleep ($t_8 = -0.65$, $p > 0.05$) or SWS ($t_8 = -0.55$, $p > 0.05$). Further, there was no significant difference between conditions for the duration of the first REM-sleep period ($t_8 = 0.50$, $p = 0.64$), as was found in a previous study.[7]

DISCUSSION

The present study found that adolescents experienced longer SOL and reduced subjective sleepiness following presleep video-game playing when compared with a passive control. The alerting nature of presleep video-game playing was further highlighted by the fact no one fell asleep during this activity, whereas 4 participants failed to remain awake in the DVD control condition. However, in contrast with our prediction, physiologic arousal (i.e., heart rate) was not associated with the effects of presleep video-game playing on SOL and subjective sleepiness, yet, it appears that cognitive alertness (i.e., alpha power) was. In contrast with previous studies, there were no differences between conditions on sleep architecture (i.e., REM or SWS sleep).

Although presleep video-game playing negatively influenced adolescents' sleep initiation, the extent to which the results reflect a genuine impairment is questionable. The present study was designed to manipulate the underlying arousal mechanisms by comparing a highly activating video game with a passive DVD to observe the greatest effect on sleep initiation. Despite this design, the observed increase in SOL (< 10 minutes for most participants) was small, and in reality, such an increase is unlikely to have any perceptible ramifications for adolescent sleep. In addition, the effect on SOL remains considerably smaller than the 21.7-minute increase reported by Dworak et al.[6] One salient difference between these studies is the age of participants. Dworak et al.[6] observed younger adolescents (mean age = 13.5 years), whereas adolescents in the present study were older (mean age = 16.6 years). Therefore, the capacity for presleep video-game playing to extend SOL may decrease as adolescents become older. Higuchi et al.'s[7] findings may support this notion, as SOL in their sample of young adults (mean age = 24.7 years) was only slightly extended by presleep video-game playing. One could argue, however, that the sleep restriction, rather than age of participants in the Higuchi et al.[7] study, was responsible.

Given that presleep video-game playing extended SOL relative to the control condition, this provides sound evidence that this activity was, albeit only slightly, detrimental to the sleep-initiation process in adolescents. Similarly, the reduction in subjective sleepiness after presleep video-game playing (1 point on the 7-point scale) is also unlikely to have dramatic consequences. Although undoubtedly a small effect, a reduction of this nature may promote a decision to postpone lights out until a greater level of sleepiness has been attained, thereby reducing total sleep time on school nights.

Although the results suggest that the direct effect of presleep video-game playing on SOL and subjective sleepiness may be only marginal, a number of issues should be considered. First, the present study was performed on good sleepers with no sleep-initiation impairment (all SOLs < 15 minutes). The median SOL after video-game playing was exactly 1.5 times longer than after watching the DVD. Thus, what constitutes a minor increase in SOL for good sleepers may become very large if the same ratio were to exist in adolescents who normally take a long time to initiate sleep. The potential for presleep video-game playing to further extend SOL in adolescents with difficulties initiating sleep should be further investigated, as it may be that these adolescents replace their nighttime alertness in bed with an activity. Second, adolescents were recruited via a sample of convenience, and thus perhaps only adolescents took part who enjoy video games and play regularly. This is important if, as is thought likely, frequent video gaming desensitizes players to its physiologically and cognitively stimulating effects.[36] The present results may therefore underrepresent the impact of presleep video-game playing on sleep initiation for adolescents who play only occasionally, of which there are many.[17] Third, the impact of presleep video-game playing may actually be cumulative, with ramifications becoming greater the more video games are played late at night. Emotional investment in a game may become greater with more play, due to the large amount of time and effort devoted. Thus, physiologic and cognitive responses to game events may become more intense, promoting greater impairment of sleep initiation by increasing alertness. In having only examined 1 isolated game-playing period of 50 minutes, the present study may have merely touched upon the consequences of this presleep activity for adolescents. Future studies should confirm whether the impact of presleep video-game playing differs between regular and nonregular gamers and specify whether desensitisation "protects" regular gamers or actually enhances the response to game playing. This information would not only aid in the interpretation of results of future studies, it would also be useful for parents, allowing them to better structure their child's video-game use to minimize sleep-related consequences.

Video-Gaming and Arousal

Previous research indicates that video-game playing can increase both physiologic arousal and cognitive alertness, with these phenomena shown to impair efforts to fall asleep.[11] The video game used in the present study is on par with the current standard for intense game play in realistic virtual environments[29]; thus, it was expected that this would affect arousal. Instead, physiologic arousal was unaffected. This contrasts with Ivarsson et al.'s[11] finding of greater variability in heart rate for adolescent boys who had played a violent video game, as opposed to a nonviolent game. The most likely explanation for our results relate to measurement limitations. The capacity of the heart-rate measure to reflect subtle physiologic alterations was compromised by its inability to record data in parallel with game playing. A time lag of between 30 seconds and 1 minute was evident between the pausing of the video game and the recording of heart-rate data. Any alterations in heart rate may have "disappeared" by the time heart rate was finally recorded. Indeed, in healthy adolescents (such as the current sample), elevated heart rate can return to baseline levels very quickly (< 1 minute) after even substantial increases in physiologic arousal are induced by moderate aerobic activity.[37] Thus, future research should use measures of physiologic arousal in parallel with video-game playing.

This is the first study to have used alpha power in this context, with findings showing it to be a sensitive enough measure to detect subtle changes in cognitive alertness associated with small impairments in sleep initiation. The fMRI technique used by Mathiak and Weber[13] provides a more sensitive measurement of cognitive alertness due to its superior spatial resolution of brain activity, and as such may be a preferable (albeit costly) option for future studies. fMRI has the added temporal advantage of detecting changes in relation to specific activity content (i.e., responses to violent imagery). Nonetheless, alpha power may prove to be an alternative and cost-effective indicator of cognitive alertness.

Video-Gaming and Sleep Architecture

Results of the exploratory analyses performed on sleep architecture suggest that presleep video-game playing does not affect adolescents' REM sleep or SWS in the subsequent sleep period. However, we must be cautious in our conclusions given that sleep-architecture data were available for only 9 out of the 13 adolescents. Thus, there may have been insufficient power to detect significant differences. Nevertheless, given evidence that both REM sleep and SWS are important for memory,[15,16] the present findings are encouraging. The results differ though from those of Dworak et al.,[6] who observed a modest reduction in SWS of just 4.7 minutes. Perhaps more meaningful, the findings also contrast those of Higuchi et al.,[7] who reported a reduction in the first REM sleep period by an average of 15.8 minutes. Higuchi et al.[7] suggested that the increased secretion of catecholamines (amines thought to have REM sleep-suppressing effects) operating as part of the physiologic response to video games may suppress REM sleep in the first REM-sleep period. In support of this, given that presleep video-game playing in the present study did not substantially increase physiologic arousal, catecholamines were likely not secreted in above-average quantities. Future research should seek to confirm the existence of such mechanisms.

CONCLUSIONS

Findings of the present study suggest that presleep video-game playing may have a more modest impact on the sleep-initiation process in adolescents than was previously thought.[4,5] However, given the small sample of convenience used in the present study, future research is required to ascertain whether this impact is greater for poor sleepers, and for regular or non-regular gamers, and whether increases in playing time produce a larger effect on the sleep-initiation process. The effects on sleepiness appear to be related to cognitive alertness, yet further investigations are needed to determine the psychophysiologic mechanisms behind the observed effects on SOL and subjective sleepiness. Contrary to reports from previous research, this study found that video-game playing does not influence either REM sleep or SWS in the subsequent sleep period. In a practical sense, although presleep video-game playing may not be the destructive force many thought, the old adage "everything in moderation" may presently be the best advice for parents of adolescents.

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