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Screen and nonscreen sedentary behavior and sleep in adolescents☆

Vanessa C. Brunetti, MSc [a], Erin K. O'Loughlin, MA [c,d], Jennifer O'Loughlin, PhD [a,b,*], Evelyn Constantin, MD, MSc [e], Étienne Pigeon, PhD [b]

[a] Department of Social and Preventive Medicine, École de santé publique de l'Université de Montréal
[b] Institut national de santé publique du Québec
[c] Centre de recherche du centre hospitalier de l'Université de Montréal
[d] Department of INDI, Concordia University
[e] Pediatric Sleep Laboratory, Department of Pediatrics, Montreal Children's Hospital, McGill University Health Centre

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ABSTRACT

Objective: This study examined the associations between screen (computer, videogame, TV) and nonscreen (talking on the phone, doing homework, reading) sedentary time, and sleep in adolescents.
Participants: Data were drawn from AdoQuest, a prospective investigation of 1843 grade 5 students aged 10-12 years at inception in the greater Montreal (Canada) area.
Methods: Data for this cross-sectional analysis on screen and nonscreen sedentary time, sleep duration, and daytime sleepiness were collected in 2008-2009 from 1233 participants (67% of 1843) aged 14-16 years.
Results: Computer and videogame use >2 hours per day was associated with 17 and 11 fewer minutes of sleep per night, respectively. Computer use and talking on the phone were both associated with being a short sleeper (<8 hour per night) (odds ratio =2.2 [1.4-3.4] and 3.0 [1.5-6.2], respectively), whereas TV time was protective (odds ratio = 0.5 [0.3-0.8]). Participants who reported >2 hours of computer use or talking on the phone per day had higher daytime sleepiness scores (11.9 and 13.9, respectively) than participants who reported ≤2 hours per day (9.7 and 10.3, respectively).
Conclusions: Computer use and time spent talking on the phone are associated with short sleep and more daytime sleepiness in adolescents. Videogame time is also associated with less sleep. Clinicians, parents, and adolescents should be made aware that sedentary behavior and especially screen-related sedentary behavior may affect sleep duration negatively and is possibly associated with daytime sleepiness.
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Introduction

In 2006, 70% of Canadian students aged 14-18 years accumulated less than 8.5 hours of sleep per night.[1] More recently, in 2014, 29% of US adolescents aged 12-14 years and 56% of those aged 15-17 years did not meet the recommended 8 hours of sleep per night.[2] In studies of adolescents ranging in age from 11 to 18 years, poor sleep was associated with obesity,[3–5] depressive symptoms and anxiety,[6] substance abuse,[7] academic performance,[8] and working memory[9]; and it may predict poorer health in young adulthood.[10] Poor sleep can also result in daytime sleepiness, which related adversely to academic performance and daytime functioning in 11- to 15-year-olds in the United States.[11] In Canada, adolescents aged 14-18 years who reported daytime sleepiness missed social, sport, and work activities more often than those who did not report daytime sleepiness.[1] Long sleep of ≥10 hours a night is also worrisome because it has been associated with poor mental health in adolescents aged 12-18 years[12] and with risk behaviors including violence, alcohol consumption, illicit drug use, and unprotected sex in Taiwanese adolescents aged 12-18 years.[13]

Numerous articles identify risk factors for reduced and poor sleep in adolescents. According to a recent review, adolescents have an evening circadian phase preference for later bed and wake up times, which can result in reduced sleep on weeknights because of early school start times.[14] Longer travel times to school, more time spent on homework,[15] and part-time employment[14] may also underpin

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* Corresponding author at: CRCHUM, 850 Saint-Denis (S02-370), Montreal, Quebec H2X 0A9. Tel.: +1 514 890 8000x15858; fax: +1 514 412 7137.
E-mail address: jennifer.oloughlin@umontreal.ca (J. O'Loughlin).

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reduced sleep in adolescents aged 12-19 years. Sedentary behavior—and in particular, screen-related sedentary behavior—is a particularly important risk factor for both poor sleep[5] and short sleep[16] in adolescents in grades 9 to 12. Although activities such as reading, doing homework, and talking on the telephone are usually considered to be sedentary, screen-related sedentary behaviors including media exposure[17–20] represent a subgroup of sedentary behaviors that are highly prevalent today and that are associated with decreased sleep in adolescents aged 14-19 years in many countries.[21] In a nationally representative study of 52,000 Canadian adolescents in grades 6-12 (aged 12-18 years),[22] average screen time was 7.8 hours per day, well above current Canadian guidelines for adolescents 12-17 years old of ≤2 hours a day.[23] In the United States, youth aged 8-18 years reported 10.8 hours of electronic media use per day.[24] Furthermore, multitasking (ie, using ≥2 screens at the same time) was frequent.[15] Seventy-two percent of US adolescents aged 13-18 years use cell phones, and 71% use the Internet on a computer or laptop[25] before trying to sleep. Hale and Guan[26] (2014) suggested that screen types with the most impact on sleep were (in order of importance) computers, videogames, mobile devices, and TV. Therefore, rather than studying total sedentary behavior, it is critical to differentiate type and duration of different screen and nonscreen sedentary behaviors in studies of the association between sleep and sedentary behavior.

Three mechanisms may link screen time and sleep.[27] First, screen time may directly displace sleep because it impedes on time that could otherwise be spent sleeping or doing other activities related to improved sleep such as physical activity.[28,29] Second, use of electronic media, particularly in the evening, increases alertness and physiological arousal in young adults, which may then impact sleep.[30]Third, the light emitted from light-emitting diodes (LED) screens, which are present on most electronic media, may negatively affect sleep by modifying melatonin production and thus circadian rhythm in adults, but it is unclear whether this association is operative in adolescents.[31] Reduced melatonin levels were observed with ≥2 hours of use of LED screens before going to bed[32] but not with ≤1 hour of use[32,33] in adolescents ranging in age from 13 to 23 years.

There are few studies on nonscreen sedentary behavior in adolescents.[16] As reported by Atkin et al,[34] studies on the association between sedentary behavior and sleep in adolescents often do not distinguish screen and nonscreen sedentary behavior, making it difficult to assess whether it is sedentary behavior or screens that are linked to poor sleep. A study of 9- to 16-year-old Australians reported that 60% of total sedentary time did not involve screens (ie, and instead represented time spent socializing, in passive transport, etc).[35] This suggests that nonscreen sedentary behavior can occupy a considerable amount of time in an adolescent's day and that, to study the association between sedentary behavior and sleep in adolescents comprehensively, screen and nonscreen sedentary behaviors should be investigated separately.

In addition to not differentiating screen and nonscreen sedentary behavior, studies on the link between sedentary behavior and sleep in adolescents usually examine sleep duration only, excluding other relevant outcomes such as daytime sleepiness. It is critical that the risk factors for a variety of indicators of poor sleep in adolescents are identified so that optimal preventive measures can be designed for use by clinicians, parents, and adolescents. The objective of this study was to examine the association between screen (computer, videogame, TV) and nonscreen (telephone, doing homework, reading) sedentary time, and sleep duration, type of sleeper (ie, short, normal, long sleeper), and daytime sleepiness in adolescents. We hypothesized that (1) screen-related sedentary behavior is negatively associated with sleep duration and positively associated with daytime sleepiness scores (Pediatric Daytime Sleepiness Scale [PDSS]) and that (2) nonscreen sedentary behavior is not associated with sleep.

Participants and methods

Data were available in AdoQuest, a prospective investigation of 1859 grade 5 students aged 10-11 years at cohort inception. The objective of AdoQuest was to investigate the natural course of the co-occurrence of health-compromising behaviors in children. A stratified random sample of schools was recruited from among all French-language schools with >90 grade 5 students located in Montreal, Canada. To assure equal representation of participants of high, middle, and low socioeconomic status, schools were stratified into tertile groupings based on a family deprivation indicator published by the Quebec Ministry of Education for each school in Quebec.[36,37] An equal number of schools were selected in each group: 10, 10, and 9 schools in the first, second, and third groups, respectively, agreed to participate. Participants who were recruited from all grade 5 classes in the 29 schools completed in-class self-report questionnaires in elementary school (grades 5 and 6) and mailed self-report questionnaires in high school (grades 7, 9, and 11). Mean (SD) age in grade 5, 6, 7, 9, and 11 was 10.0 (0.5), 11.7 (0.4), 12.9 (0.4), 15.2 (0.5), and 16.8 (0.5) years, respectively. Parents completed mailed self-report questionnaires in 2006-2007 and again in 2008-2009. All participants provided assent, and parents/guardians provided informed consent. The study received ethics approval from the Concordia University Human Research Ethics Committee and the Conseil sur l'éthique et la recherche at the Centre de recherche du Centre hospitalier de l'Université de Montréal.

This current cross-sectional analysis used data collected in 2008-2009 when participants were in grade 9. Data on sociodemographic characteristics, screen and nonscreen sedentary time, sleep duration, and daytime sleepiness were collected from 1233 of the 1859 participants (67%).

Study variables

Sociodemographic variables included age, sex, employment, language spoken at home, and mother's education (data on mother's education were drawn from the parent questionnaire). Age was computed using birthdate and date of questionnaire completion. Sex was assessed by: “Are you a boy/male or a girl/female?” Employment was measured by: “How many hours per week do you work?” Students indicating any hours worked were categorized as employed. Mother's education was assessed by: “What is the highest level of schooling you have completed?” Response options included primary, secondary, professional certificate/diploma, CEGEP certificate/diploma, university. For analysis, mother's education was recorded as yes (completed university), no (not completed university), or missing. Language was assessed by: “What language do you speak most often at home?” Response options (English, French, English and French, other) were recorded as French or Other.

Time spent daily in each of 6 sedentary behaviors including 3 screen activities (watching TV, using a computer, playing videogames) and 3 nonscreen activities (talking on the phone, doing homework, reading) was measured by: (1) “How many hours a day do you usually spend....” Response options were <1, 1-2, 3-4, 5-6, and ≥7 h/d. In accordance with current guidelines,[23] responses were categorized as ≤2 h/d or >2 h/d for each of the 6 activities for analysis.

Sleep duration was measured by number of hours of sleep per night on weekdays and on the weekends by: (1) “During school days/weekends in the past month, at what time did you usually go to sleep at night?” and (2) “During school days/weekends in the past month, at what time did you usually wake up in the morning?” Number of hours slept was computed as the difference between “time usually go to sleep at night” and “time usually wake up in the morning.” Sleep duration for weekdays and weekends was multiplied by 5 and 2, respectively; the 2 numbers were summed and then divided by 7 to obtain mean number of hours of sleep per night. Based on recommendations by pediatric sleep experts,[38,39] participants were classified according to type of sleeper as short (<8 hours per night), normal (8-10 hours per night), or long (>10 hours per night) sleepers.

Daytime sleepiness was measured with the 8 items in the PDSS,[11] as follows: (1) "How often do you fall asleep or get drowsy during class periods?" (2) "How often do you get sleepy or drowsy while doing your homework?" (3) "Are you usually alert most of the day?" (4) "How often are you tired and grumpy during the day?" (5) "How often do you have trouble getting out of bed in the morning?" (6) "How often do you fall back to sleep after being awakened in the morning?" (7) "How often do you need someone to awaken you in the morning?" (8) "How often do you think that you need more sleep?" Response options included never, seldom, sometimes, frequently, and always (scored 0-4). Responses were summed across the 8 items (item 3 was reverse-coded) to obtain an overall score (range, 0-32). The mean PDSS was 15.3 (6.2) in the original study by Drake et al.[11] Cronbach α for the PDSS in our sample was 0.78, indicating adequate internal reliability.

Data analysis

After descriptive and univariate analyses, the associations between screen and nonscreen sedentary time and each of sleep duration, type of sleeper, and daytime sleepiness were modeled in separate multinomial logistic or linear regression models controlling for age, mother's education, and participant employed. The associations between screen and nonscreen sedentary time and type of sleep were modeled using multinomial logistic regression; the associations between these behaviors and the PDSS (daytime sleepiness) score were modeled using linear regression. Missing data for covariates ranged from 0% to 6% and, with one exception, were left as missing. Because 10% of participants were missing data on mother's education, we created a missing category. All analyses were conducted using SPSS software, Version 22 (Cary, NC).

Results

More than half (57%) of participants were female. The mean (SD) age was 15.2 (0.5) (range, 12-17). Twenty-three percent of participants were employed, and these participants worked 14.0 (11.9) hours per week on average; 23% of participants had mothers who were university educated.

Most participants (77%) reported 8-10 hours of sleep per night, 9% were short sleepers, and 9% were long sleepers (5% were missing data) (Table 1). The mean (SD) number of hours of sleep per night was 9 hours 2 minutes (ie, 9h02min) (range, 2h08min-16h34min); 6.6% of participants reported 7-8 hours of sleep per night, 32.3% reported 8-9 hours of sleep per night, 42.1% reported 9-10 hours of sleep per night, and 10.8% reported 10-11 hours of sleep per night. Sleep duration was longer on weekends than on weekdays (9h49min vs 8h42min, $P < .0001$). Median (interquartile range [IQR]) for wake-up time and bedtime was, respectively, 7:00 AM (IQR, 6:00-7:20 AM) and 10:00 PM (IQR, 9:30-10:30 PM) for weekdays and 10:00 AM (IQR, 9:00-10:30 AM) and 11:00 PM (IQR, 10:00 PM-12:00 AM) for weekends.

There was no statistically significant difference in sleep duration according to sex, mother's education, or participant's employment status. The mean (SD) PDSS was 10.5 (5.7). Females had a statistically significantly higher mean PDSS than males (11.0 vs 9.8, $P < .0001$). Participants who were employed had a statistically significant higher mean PDSS than participants who were not employed (11.3 vs 10.2, $P = .003$).

Computer use for more than 2 h/d was reported by 35% of participants; watching television, playing videogames, doing homework, and talking on the phone for more than 2 h/d were reported by 31%, 8%, 7%, 7%, and 5% of participants, respectively. Mean (SD) sedentary time including both screen and nonscreen time was 8h58min (3h12min) per day. Mean (SD) screen time was 6h48min (2h54min) per day, and mean nonscreen time was 2h12min (1h23min) per day.

Computer use and videogame use of >2 h/d were associated with a mean (SD) of 17 (61) and 11 (70) fewer minutes of sleep per night, respectively (Table 1). Table 1 also shows the proportion of normal,

Table 1
Hours of sleep per night; daytime sleepiness scores; and proportion of short, normal, and long sleepers according to screen and nonscreen sedentary time (AdoQuest 2008-2009).

Hours per day	n[a]	h:min sleep/night mean (SD)	*P*	PDSS mean (SD)	*P*	Type of sleeper			*P*
						Short %	Normal %	Long %	
Total	1205	9:02 (00:54)	–	10.5 (5.7)	–	8.8	77.1	9.2	
Screen									
Using computer			<.0001		<.0001				<.0001
≤2	769	9:08 (00:49)		9.7 (5.4)		6.8	81.3	11.9	
>2	426	8:51 (01:01)		11.9 (5.8)		13.8	80.4	5.8	
Playing videogames			.053		.391				.272
≤2	1046	9:03 (00:53)		10.5 (5.6)		9.0	81.5	9.4	
>2	95	8:52 (01:10)		10.0 (6.4)		13.8	75.5	10.6	
Watching TV			.053		.430				.035
≤2	820	9:00 (00:57)		10.4 (5.7)		10.6	79.3	10.0	
>2	378	9:06 (00:47)		10.6 (5.5)		6.3	85.1	8.7	
Nonscreen									
Doing homework			.668		.381				.545
≤2	1109	9:02 (00:53)		10.4 (5.6)		9.1	81.5	9.5	
>2	82	9:04 (01:13)		11.0 (6.2)		11.1	76.5	12.3	
Reading			.455		.470				.104
≤2	1070	9:01 (00:53)		10.4 (5.6)		9.5	81.5	9.0	
>2	90	9:06 (1:08)		10.9 (5.7)		8.0	76.1	15.9	
Talking on the telephone			.858		<.0001				.003
≤2	1117	9:02 (00:52)		10.3 (5.5)		8.6	81.7	9.7	
>2	60	9:00 (01:34)		13.9 (6.4)		22.2	70.4	7.4	

[a] Totals differ because of missing data.

short, and long sleepers according to sedentary time. Only 6.3% of participants who watched TV >2 h/d were short sleepers compared with 10.6% of those who watched TV ≤2 h/d, whereas both computer use and telephone use >2 h/d were associated with being a short sleeper. There was no statistically significant difference in type of sleeper according to sex, mother's education, or participant employment status.

Multivariately, both computer use and telephone use >2 h/d were associated with a higher likelihood of being a short sleeper, whereas TV use >2 h/d was associated with a decreased likelihood of being short sleeper (Table 2). Computer use >2 h/d was associated with a decreased likelihood of being a long sleeper. Doing homework and reading were not associated with sleep duration.

Compared with participants who reported ≤2 h/d, the mean (SD) PDSS was higher among participants who used a computer (11.9 [5.8] vs 9.7 [5.4]) or talked on the telephone (13.9 [6.4] vs 10.3 [5.5]) ≥2 h/d (Table 1). The results from the multivariable linear regression analyses were concordant with the univariate observations. Computer use and telephone use >2 h/d were both statistically significantly associated with higher daytime sleepiness scores (Table 3). None of TV, videogames, doing homework, or reading was associated with daytime sleepiness.

Table 4 summarizes the results. Overall, each screen activity was associated with at least 1 of the 3 sleep indicators. Computer use was associated with all 3 indicators, whereas videogame use and TV use were each associated with 1 indicator. Among nonscreen activities, only telephone time was associated with sleep, and it was associated with 2 of the 3 sleep indicators.

Discussion

This study reports associations between screen and nonscreen sedentary time and several sleep indicators in adolescents. All 3 screen activities were associated with sleep. Specifically, >2 h/d of computer use was associated with reduced sleep duration, being a short sleeper, and greater daytime sleepiness. More than 2 h/d of videogame use was associated with reduced sleep duration, and more than 2 h/d of TV use was associated with a lower probability of being a short sleeper. Among nonscreen activities, >2 h/d of telephone time was associated with being a short sleeper, greater daytime sleepiness, and a lower probability of being a normal sleeper. Shortened sleep related to computer use and telephone use may have affected sleep to the extent that some adolescents experienced sleepiness during the day. Reading and doing homework were not associated with any sleep indicators.

Our findings align with previous studies that report associations between screen time and short sleep in adolescents.[40,41] Also, similar to our results on daytime sleepiness, others have reported links between screen time and sleepiness indicators including alertness and falling asleep at school.[40,42,43] The only nonscreen activity associated with sleep in our study was telephone time. Most studies to date on telephone time[8,14,26,27,40,44–50] report exclusively on use of mobile phone devices, which can include text messaging or other mobile phone functionalities, which we did not measure.

In contrast to our findings, most studies on TV viewing report adverse associations between TV viewing and sleep.[26] However, the only study which used actigraphy to measure sleep duration did not report a significant association.[51] Furthermore, Foti et al[16] (2011) reported higher odds of sufficient sleep with ≥4 hours of TV viewing per day. High computer use and videogame use were both associated with reduced sleep duration, but high TV use decreased the likelihood of being a short sleeper. Although all 3 are screen activities, computer and videogame use can be viewed as “active” because users actively participate in the content and flow of screen material, they must engage in mental work, and use usually results in physiological arousal. In contrast, TV viewing can be characterized as “passive” (ie, the person is not directly involved in the content that is being displayed). It may be that the level of arousal elicited by sedentary activities is important to sleep. The hypothalamic pituitary axis is key to maintenance of alertness as well as sleep and circadian rhythm modulation,[52] and it is possible that an increase in stress induced by interactive screen activities modifies the activity of stress hormones (such as cortisol), ultimately modifying circadian rhythm and sleep. Thus, interactive and passive activities might elicit different physiological arousal responses affecting sleep. It is also possible that the greater distance between the TV and the user compared with using a computer or playing videogames[32] may moderate the effects of melatonin inhibition through blue light with exposure to LED screens.[30]

Limitations of this analysis include possible selection bias due to loss to follow-up in the AdoQuest cohort. Because our analyses were cross-sectional, we were unable to assess directionality of the

Table 2
Odds ratio (OR) (95% confidence intervals [CI]) from multinomial logistic regression analyses for the association between screen and nonscreen sedentary behaviors and type of sleeper (AdoQuest 2008-2009; n = 1062).

Potential correlate	Type of sleeper		
	Normal	Short	Long
		OR (95% CI)	OR (95% CI)
Screen			
Using computer (ref ≤ 2 h/d)	Ref	**2.2 (1.4-3.3)**[a]	**0.5 (0.3-0.8)**
Playing videogames (ref ≤ 2 h/d)	Ref	1.6 (0.7-3.4)	1.2 (0.6-2.5)
Watching TV (ref ≤ 2 h/d)	Ref	**0.5 (0.3-0.8)**	0.9 (0.6-1.6)
Nonscreen			
Doing homework (ref ≤ 2 h/d)	Ref	1.1 (0.5-2.6)	1.4 (0.6-3.1)
Reading (ref ≤ 2 h/d)	Ref	0.8 (0.3-2.0)	1.9 (1.0-3.8)
Talking on the telephone (ref ≤ 2 h/d)	Ref	**3.1 (1.5-6.4)**	1.1 (0.4-3.2)

Model controlled for sex, mother's education, and student employed.
[a] Entries in bold indicate OR with 95% CIs that do not include 1.0.

Table 3
β coefficients (95% CIs) from multivariable linear regression analyses for the association between screen and nonscreen sedentary behaviors and PDSS scores (AdoQuest 2008-2009; n = 1091).

Hours per day	β (95% CI)
Screen	
Using computer	**2.274 (1.6-3.0)**[a]
Playing videogames	−0.230 (−1.5 to 1.1)
Watching TV	0.038 (−0.7 to 0.8)
Nonscreen	
Doing homework	0.199(−1.2 to 1.6)
Reading	−0.068 (−1.3 to 1.3)
Talking on the telephone	**3.165 (1.7-4.7)**

Model controlled for sex, mother's education, and student employed.
[a] Entries in bold indicate 95% CIs for coefficients that do not include 0.0.

Table 4
Summary of statistically significant findings from multivariate analyses on the association between screen and nonscreen sedentary time and sleep (AdoQuest 2008-2009).

	Sleep duration	Type of sleeper			Daytime sleepiness
		Short	Normal	Long	
Screen					
Computer	−	+	○	−	+
Videogame	−	○	○	○	○
TV	○	−	○	○	○
Nonscreen					
Telephone	○	+	○	○	+
Reading	○	○	○	○	○
Doing homework	○	○	○	○	○

+: positive association; −: negative association; ○: no association.

associations of interest. Misclassification due to self-report data might have attenuated the estimates. In addition, we did not collect data on several communication technologies that are now commonly used by adolescents (ie, Facebook, Instagram, Snapchat) because they were not widespread or simply did not exist in 2008-2009. Furthermore, we did not collect detailed data on when during the day each activity occurred, distance to screens, parental monitoring, type of TV watched (LED), use of smartphones, multitasking, or screen content (ie, violent vs nonviolent), which might elicit different responses. We were unable to measure whether cell phones were used (ie, text messaging, Web surfing, calling), which could alter the associations with poor sleep in adolescents. We chose to classify telephone use as a nonscreen sedentary behavior because our participants responded to: “How many hours per day do you spend talking on the phone?” which, by definition, did not include text messaging or Web surfing. However, misinterpretation of the questions may have resulted in misclassification. Finally, participants had to choose between categories of duration of sedentary behaviors that were defined as <1, 1-2, 3-4, 5-6, and >7 h/d, which may have led to random misclassification.

Conclusion

Computer, videogame, and telephone times were associated with shorter sleep duration and daytime sleepiness in adolescents. Future research differentiating screen and nonscreen sedentary behavior should focus on the timing, type, and content of sedentary behavior to provide better insight into the mechanisms linking sleep and sedentary behaviors in adolescents. Adolescents, parents, and clinicians should be made aware that decreasing time spent in these activities may improve sleep duration and daytime sleepiness.

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Disclaimers

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