

SCIENTIFIC INVESTIGATIONS

Internet use and its impact on internalizing disorder symptoms and sleep in adolescents with an evening circadian preference

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Study Objectives: This study sought to examine the relationship between internet use, sleep, and internalizing disorder symptoms in adolescents with an evening circadian preference.

Methods: One hundred seventy-two adolescents aged 10–18 years with an evening circadian preference completed a week of sleep diaries and questionnaires about internet use and internalizing disorder symptoms.

Results: Adolescents reported internet use for 3.81 hours on weekdays and 5.44 hours on weekends, with > 90% having access to both a computer with internet and a personal cell phone. A majority of adolescents used the internet from 4–8 PM (71%) and from 9–11 PM (62%). Common online activities included listening to music (77%), watching videos (64%), communicating with others (64%), and doing homework (58%). Late-night internet use (9–11 PM) was associated with more internalizing disorder symptoms. Middle-of-the-night internet use (midnight–5 AM) was associated with a later bedtime, shorter total sleep time, and more internalizing disorder symptoms. Adolescents used the internet to fulfill social needs, to avoid or combat boredom, or for maladaptive activities. Using the internet for social interaction or avoidance/boredom was associated with higher internalizing disorder symptoms. Using the internet for maladaptive reasons was associated with more late-night and middle-of-the-night use.

Conclusions: Adolescent internet use late at night and in the middle of the night is common. Internet use may be motivated by desires for social connection, by boredom/avoidance, or for maladaptive behaviors. Because middle-of-the-night internet use was associated with higher internalizing disorder symptoms and worse sleep, it presents as a potential target for intervention.

Keywords: adolescents, eveningness chronotype, circadian, internet use, internalizing disorders

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BRIEF SUMMARY

Current Knowledge/Study Rationale: An evening circadian preference has a biological basis linked to the onset and progression of puberty; however, technology use has also been proposed as an important contributor to a later bedtime preference among adolescents. Although there is emerging interest in the content of media use, few studies to date have investigated youth internet behaviors and how they relate to both sleep and internalizing disorder symptoms.

Study Impact: Adolescent internet use late at night and in the middle of the night is common. Middle-of-the-night internet use was associated with higher internalizing disorder symptoms and worse sleep; it thus presents as a potential target for intervention to improve sleep among adolescents.

INTRODUCTION

Late bedtimes are common during adolescence, a developmental window that is critical for developing healthy sleep trajectories.^{1–7} An evening circadian preference is characterized by a preference for later sleep onset and offset⁸ and is associated with a greater risk for developing internalizing disorders (ie, depression and anxiety disorders) longitudinally,^{9,10} severe internalizing symptoms,^{11,12} and internalizing disorders that are less responsive to treatment.^{11,13,14} An evening circadian preference has also been identified as a modifiable risk factor.¹⁵

Although an evening circadian preference has a biological basis linked to the onset and progression of puberty,⁸ technology use has also been proposed as an important contributor to a later bedtime preference among adolescents via engaging content in the evening, which increases physiological arousal at night¹⁶ and thereby decreases the homeostatic sleep drive¹⁷ and/or may be so engaging

that it is hard to switch off (or disengage from); technology use may also contribute to later bedtime preference via exposure to bright light.¹⁸ Indeed, the circadian rhythm is heavily influenced by the timing of external cues in the environment, or *zeitgebers*.¹⁹ Light is the most powerful *zeitgeber*.²⁰ Therefore, light emitted from technology seems to be capable of delaying the circadian rhythm.¹⁸ Relatively little is known about the impact of the content of the technology being consumed on sleep.¹⁶ Many youth report using technology for communicating with friends and family, which constitutes social activity—another important *zeitgeber*.²¹ Others report using technology for gaming and for doing homework, both of which engage the arousal system, which interferes with sleep.²² Although there are nonreplications,^{2, 23,24} environmental, social, behavioral, and hormonal influences can be synergistic in their effects, resulting in delayed bedtimes, less time available for sleep, and greater difficulty falling and staying asleep.^{25,26} Not surprisingly, therefore, adolescents report that

they find it difficult to wake up for early-morning school start times and to stay awake at school²⁷; they then attempt to “catch up” on sleep on weekends, resulting in variability in timing of sleep and contributing to poor sleep quality.²⁸ As a result, adolescents who exhibit an evening circadian preference also experience short sleep duration, poor sleep quality, and daytime sleepiness.¹⁵

Similarly, the evidence suggests that adolescents who spend more time on technology—specifically, using the internet—also tend to exhibit higher rates of depression and anxiety.²⁹ Researchers theorize that social isolation, lack of physical activity, and exposure to cyberbullying or other negative content resulting from excessive internet use may contribute to associations between internet use and depression and anxiety.^{17,30} Another potential contributor is that internet use, especially late at night, contributes to disturbed sleep^{16,31,32}; as noted earlier, disturbed sleep is a well-documented contributor to increased internalizing disorder symptoms.^{9,10} However, there is a paucity of data to assess the role of internet use in the relationship between sleep and internalizing disorder symptoms. Moreover, although there is emerging interest in the content of media use,^{1,2} few studies to date have investigated youth internet behaviors and how they relate to both sleep and internalizing disorder symptoms.

The overall goal of the present study was to clarify the relationship between sleep, internet use, and internalizing disorder symptoms in a sample of youth who exhibit an evening circadian preference. The first aim was to characterize internet use in this sample. The second aim was to assess the relationship between time of day of internet use and both internalizing disorder symptoms and sleep patterns (eg, bedtime, sleep onset latency [SOL], and total sleep time [TST]). We hypothesized that more internet use late at night (9–11 PM) and in the middle of the night (12–5 AM) would be associated with more internalizing disorder symptoms, later bedtime, longer SOL, and shorter TST. The third aim was to explore the relationship between internet behavior (defined as reasons for using the internet) and internalizing disorder symptoms and time of day of internet use.

METHODS

Participants

The data for the present study were collected as part of a larger research project.¹⁵ Detailed information on study design can be found elsewhere.¹⁵ The goal of the larger project was to modify the psychosocial, behavioral, and cognitive processes that contribute to sleep problems and circadian dysfunction via the Transdiagnostic Sleep and Circadian Intervention for Youth.¹⁵ Adolescents with an evening circadian preference who were at risk in at least 1 of 5 health domains (behavioral, cognitive, emotional, social, physical) were recruited. The rationale for this focus is that an evening circadian preference is common during adolescence^{4,8,9} and is associated with adverse outcomes across health domains.¹⁰ The current study used data collected during the pretreatment period, before any adolescents received any treatment.

In the larger study a total of 398 participants were assessed for eligibility, and 220 (55.6%) were excluded for not meeting the inclusion criteria ($n = 154$) or refusing to participate ($n = 66$). A total of 176 participants were enrolled in the larger project.¹⁵ Adolescents

were eligible if they (1) were between 10 and 18 years old, living with a parent or guardian, and attending a class/job by 9 AM at least 3 days per week; (2) were fluent in English, (3) were able and willing to give informed assent, (4) reported an evening circadian preference as shown by scoring in the lowest quartile on the Children’s Morningness-Eveningness Preference Scale (27 or lower)⁸ and had a 7-day sleep diary showing a sleep onset time of 10:40 PM or later for ages 10–13 years, 11 PM or later for ages 14–16 years, and 11:20 PM or later for ages 17–18 years at least 3 nights per week and this pattern was present for at least 3 months; and (5) fell in the “at-risk” range on measures in at least 1 of the 5 health domains (behavioral, cognitive, emotional, social, physical) described in greater detail in **Table S1** in the supplemental material.¹⁵

Adolescents were ineligible to participate if (1) they could not communicate in English or Spanish; (2) they had an active, progressive physical illness or neurologic degenerative disease directly related to the onset and course of the sleep disturbance; (3) there was evidence from clinical diagnosis or report of sleep apnea, restless legs, or periodic limb movements during sleep; (4) they had an intellectual disability autism spectrum disorder, or other significantly impairing pervasive developmental disorder; (5) there was evidence from clinical diagnosis or report by the youth or the parent of bipolar disorder or schizophrenia; (6) they had a history of substance dependence in the past 6 months; and (7) there was a current suicide risk that would preclude treatment on an outpatient basis. Individuals ceased taking medications that alter sleep (eg, hypnotics) 4 weeks before the assessment (2 weeks for melatonin) or were excluded.

Participants were recruited for the current study via administrators and parent groups at local high schools and middle schools and advertisements on parent listservs, Craigslist, and Facebook.

Design

All procedures were approved by the University of California, Berkeley Committee for the Protection of Human Subjects. All participants provided informed consent or assent. Participants were invited for an in-person assessment. If the youth met the criteria after the in-person assessment, then they were enrolled in the study and scheduled for an overnight assessment. Seven to 10 days’ worth of daily sleep diary information was collected for each participant before each came into the laboratory for the overnight assessment. Participants completed the questionnaires (Youth Self-Report [YSR] and internet use measures) in the laboratory as part of the overnight assessment.

Measures of demographic characteristics

Demographic characteristics assessed included parent reports of the adolescents’ age, biological sex, race/ethnicity, and household income.

Sleep measures

Sleep diary

The daily sleep diary is a valid and sensitive measure in the detection of sleep timing and sleep quality.³³ In the present study, trained research assistants called the adolescents to collect their sleep diary each morning at an agreed-upon time. Daily sleep

diary data were collected for the 7- to 10-day period before the overnight assessment. Three average weekly variables of interest were extracted from the daily sleep diary: bedtime, SOL, and TST. We reasoned that these are the variables most likely to be impacted by technology use among youth.

Internalizing disorder symptoms

YSR composite risk score

The YSR comprised a composite score of depression and anxiety symptoms derived from 2 psychometrically validated questionnaires.³⁴ The standardized score (or *z* score) of each measure was taken, and then the scores were averaged. Depression symptoms were assessed via the Children's Depression Rating Scale, a 17-item scale with possible scores ranging from 17–113, with higher scores indicating depression.³⁵ Anxiety symptoms were measured via the Multidimensional Anxiety Scale for Children, a 39-item scale with possible scores ranging from 0–117, with higher scores indicating greater anxiety.³⁶

Internet use measures

Internet behavior checklist

In 2012 when the present study was started, there was no validated measure to assess internet behavior, which we defined as the

reasons for internet use. A team of interdisciplinary researchers from University of California Berkeley therefore conducted a review of the literature and found the 4 most theorized motivations for internet behaviors to be (1) social,³⁷ (2) emotion regulation,³⁸ (3) boredom or distraction,³⁸ and (4) engaging in risky/maladaptive behavior.³⁹ The team then surveyed existing validated questionnaires in the field investigating these 4 components^{40,41} and combined questions from these measures to derive the Internet Behavior Checklist, a new measure. Reliability (Cronbach's α) for the Internet Behavior Checklist was high ($\alpha = 0.91$).

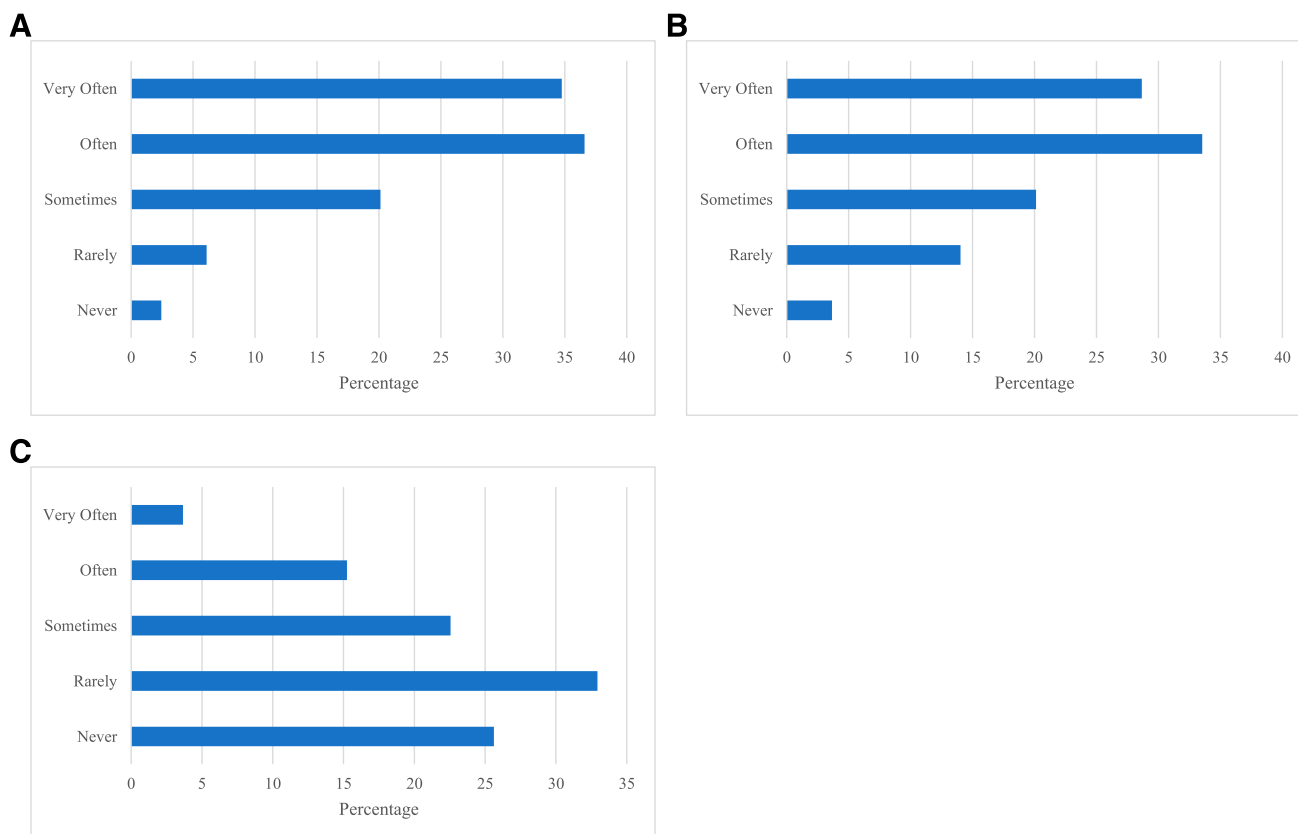
Technology use questionnaire

At the time when the study was initiated in 2012, no validated measure to assess technology use among youth was available. Therefore, questions from the National Sleep Foundation Sleep in America Poll assessing technology use were used in the present study (Figure 1 and Figure 2).⁴² Responses were given using a Likert scale: 0 = never, 1 = rarely, 2 = sometimes, 3 = often, 4 = very often. Reliability (Cronbach's α) for the technology use questionnaire was high ($\alpha = 0.98$). The Media and Technology Use Questionnaire is available in the supplemental material.

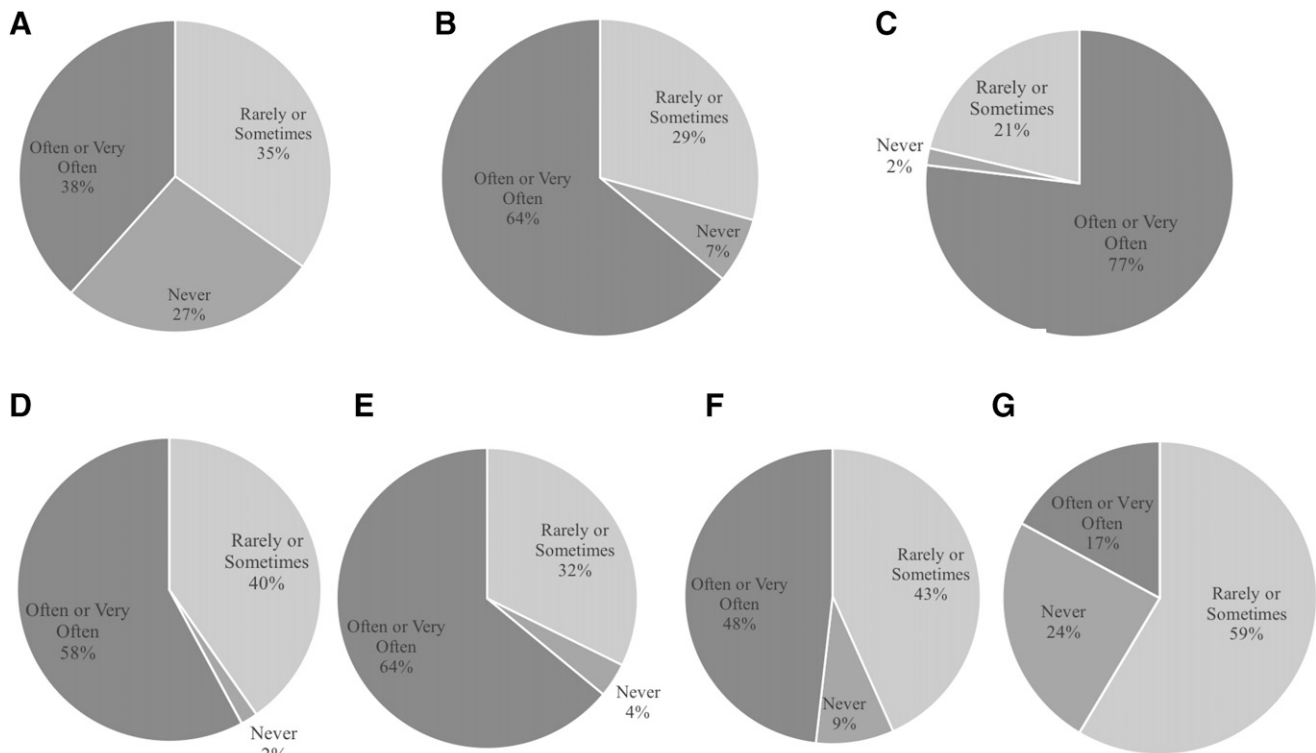
Missing data

There were 176 adolescents who participated in the larger study. Because of a missing laptop, we were missing data on 5

Figure 1—Response to the questions “What times of the day do you spend most of your time on the internet? How often do you usually spend on the internet at the following times?”



Percentage of participants endorsing internet use (A) in the afternoon (4–8 PM), (B) late at night (9–11 PM), and (C) in the middle of the night (midnight–5 AM). *n* = 164.

Figure 2—Responses to the question “How often do you use the internet to do the following things?”

Percentage of participants endorsing using the internet for (A) video games; (B) movies, television, or videos; (C) music; (D) homework; (E) communication; (F) gathering information; and (G) viewing the news. $n = 164$.

adolescents for the Internet Behavior Checklist and 10 adolescents for the technology questionnaires, with 4 adolescents missing both questionnaires (total n for this study = 172). No demographic, sleep, or internalizing disorders symptom differences were found in the participants whose data was lost.

Analysis plan

All analyses were conducted in SPSS, version 22 (IBM Corp., Armonk, NY). Statistical significance was evaluated using a 2-sided design with α set at 0.05.

Descriptive statistics were conducted to address the first aim, which was to characterize internet use in a sample of adolescents who exhibit an evening circadian preference. To address the second aim, which was to assess the relationship between time of day of internet use, internalizing disorder symptoms, and sleep patterns, linear regression analyses were conducted. Our third aim, which was to explore the relationship between internet behavior and internalizing disorder symptoms and time of day of internet use, involved a principal components (PC) analysis on the Internet Behavior Checklist to confirm that the behaviors assessed clustered into the predetermined indices of motivation for internet behaviors. An eigenvalue reflects the amount of variance captured by a given factor. The eigenvalue-1 criterion (eigenvalue ≥ 1) was used to decide how many PCs to be retained.^{43,44} A factor loading of 1 independent variable was considered to be large if its absolute value exceeds 0.45. Once PCs were identified, we

assessed the relationship between internet behavior PCs and internalizing disorder symptoms and time of day of internet use using multivariate regression analyses.

RESULTS

Participant characteristics are presented in [Table 1](#). [Figure 1](#) and [Figure 2](#) display the internet use characteristics of the sample from the technology use questionnaire.

The majority of the participants (96%) had a personal cell phone. In addition, 70% had a personal computer and 28% had access to a shared family computer. More than 90% of participants had access to both a computer with internet and a personal cell phone. Adolescents in this sample reported daily internet use.

Average internet use was estimated by participants in response to the question “On an average weekday, how many hours a day do you spend on the Internet?” and “On an average weekend day, how many hours a day do you spend on the Internet?” Participants estimated that they spent 3.81 hours (standard deviation = 2.74) on weekdays and 5.44 hours (standard deviation = 3.81) on weekends. Adolescents reported that they used the internet “often” or “very often” between 4 and 8 PM (71.34%; [Figure 1A](#)) and between 9 and 11 PM (62.20%; [Figure 1B](#)).

Taking the “often” and “very often” response options together, the internet was most commonly used to play video games (38%;

Table 1—Participant characteristics.

Characteristic	n ^a	%
	Mean	SD
Female	101	58.72
Race		
White	111	64.53
African American or Black	12	6.98
Asian	18	10.47
Native Hawaiian or other Pacific Islander	2	1.16
Mixed Race	29	16.86
Ethnicity		
Hispanic or Latino	26	15.12
Not Hispanic or Latino	146	84.88
Family annual income (\$)		
≤ 20,000	6	3.49
20,001–50,000	21	12.21
50,001–100,000	40	23.26
100,000	100	58.14
Refused to answer/missing	5	2.91
Current grade		
5	5	2.91
6	7	4.07
7	14	8.14
8	25	14.53
9	25	15.53
10	46	26.74
11	24	13.95
12	25	14.53
College	1	0.58
Age (y)	14.77	1.85
Sleep variables		
Bedtime (hh:mm)	23:07	1:02
SOL (min)	38.99	44.10
TST (decimal h)	7.39	1.16

^aTotal n = 172. SD = standard deviation, SOL = sleep onset latency, TST = total sleep time.

Figure 2A); to watch movies, television, or videos (64%; **Figure 2B**); to listen to music (77%; **Figure 2C**); to do homework (58%; **Figure 2D**); to communicate with others (64%; **Figure 2E**); to gather information (48%; **Figure 2F**); and to view the news (17%; **Figure 2G**).

Table 2 presents linear regression analyses examining the contribution of internet use late at night (9–11 PM) and in the middle of the night (midnight–5 AM) to internalizing disorder symptoms,

bedtime, SOL, and TST, controlling for age and sex. The results indicate that more internet use late at night ($\beta = 0.156$; $P < .05$) and in the middle of the night ($\beta = 0.176$; $P < .05$) was associated with more self-reported internalizing disorder symptoms. More internet use in the middle of the night was associated with a later average weekly bedtime ($\beta = 0.320$; $P < .05$) and shorter average weekly TST ($\beta = -0.238$; $P < .05$) but was not associated with average weekly SOL. Internet use late at night was not associated with any of the sleep variables.

Next, we conducted a PC analysis on the Internet Behavior Checklist. The eigenvalues of the first 3 PCs were 10.288, 3.392, and 2.203, respectively, and the proportions of variation explained by these 3 PCs were 25.721%, 8.481%, and 5.506%, respectively. The first 3 PCs explained 39.70% of the total variation. The rotated factor patterns of the first 3 PCs are presented in **Table 3**. In terms of loading score, the PC₁ can be viewed as a measure of social behavior online. PC₂ can be viewed as a measure of internet use for boredom/avoidance. PC₃ seems to capture a measure of maladaptive internet behavior.

Table 4 presents linear regression analyses examining the association between each of the PCs and internalizing disorder symptoms, controlling for age and sex. The results indicate that more use of the internet for social interaction (PC₁) and boredom/avoidance (PC₂) was associated with higher internalizing disorder symptoms. The maladaptive PC (PC₃) was not associated with higher internalizing disorder symptoms. However, more use of the internet for maladaptive PC (PC₃) was associated with more use of the internet late at night and in the middle of the night. There was no relationship between use of the internet for social interaction (PC₁) and boredom/avoidance (PC₂) and time of day of internet use.

DISCUSSION

The overall goal of the present study was to assess the relationship between sleep, internet use, and internalizing disorder symptoms in a sample of youth who exhibit an evening circadian preference. We found that higher internalizing disorder symptoms were associated with more internet use late at night (9–11 PM) and in the middle of the night (midnight–5 AM). Internet use in the middle of the night (midnight–5 AM) was also associated with later bedtime and shorter TST. Moreover, higher internalizing disorder symptoms were associated with more use of the internet for social and boredom/avoidance reasons. Although the use of the internet for social interaction or boredom/avoidance was not associated with more use at any particular time of day, maladaptive use of the internet was associated with more internet use late at night and in the middle of the night. These findings suggest that youth with an evening circadian preference who use the internet in the middle of the night may be a particularly high-risk group and that internet use in the middle of the night may be a potential target for intervention.

The first aim was to characterize internet use in a sample of adolescents with an evening circadian preference. Overall, adolescents in our sample reported > 3.5 hours of internet use per day during the week and > 5 hours of internet use per day on the

Table 2—Aim 2 analyses: weighted beta coefficients, *P* values, and 95% CI for all predictors from regression models predicting time of day of internet use.

	Late-Night Internet Use (9–11 PM)			Middle-of-the-Night Internet Use (midnight–5 AM)		
	β	<i>P</i>	95% CI	β	<i>P</i>	95% CI
Internalizing disorder symptoms	0.156	< .05*	0.014–0.416	0.176	< .05*	0.041–0.434
Average bedtime	0.123	> .05	–0.037 to 0.301	0.320	< .05*	0.174–0.489
Average SOL	–0.021	> .05	–0.004 to 0.003	–0.031	> .05 ^a	–0.005 to 0.003
Average TST	–0.096	> .05	–.004 to 0.001	–0.238	< .05*	–0.006 to 0.001

^aAn additional ad hoc model was run predicting the relationship between middle-of-the-night internet use and SOL, controlling for TST. In this model, SOL becomes a significant predictor of middle-of-the-night internet use ($\beta = -0.168$; *P* = .04; 95% CI, –.008 to 0.000). CI = confidence interval, SOL = sleep onset latency, TST = total sleep time.

weekends for any purpose. Youth tended to report the highest rates of internet use in the afternoon/evening (71.34% between 4 and 8 PM and 62.20% between 9 and 11 PM reported using the internet “often” or “very often”). Moreover, the most common uses of the internet were to watch television, videos, or movies; listen to music; or communicate. The frequency of adolescent technology use is consistent with a recent survey of U.S. adolescents⁴² and builds on prior research by identifying why adolescents choose to use the internet both during the day and at night.

The second aim was to assess the relationship between time of day of internet use and both internalizing disorder symptoms and sleep patterns (eg bedtime, SOL, and TST). Our hypotheses that more internet use late at night and in the middle of the night would be associated with more internalizing disorder symptoms, later bedtime, and shorter average TST were confirmed. This finding is consistent with data indicating that more internet use overall is associated with higher reported depression symptoms²⁹ and that late-night/middle-of-the-night screen time use is associated with later bedtimes and less time available for sleep.^{16,17} Interestingly, contrary to our hypothesis, late-night use (9–11 PM) was not associated with any of the sleep variables (bedtime, SOL, and TST). Note that participants in the present sample were selected to have an evening circadian preference with an average bedtime of 11:07 PM. It may be that late-night internet use is early enough relative to their bedtime so as not to affect their sleep. Although this finding represents a divergence from the larger literature that points to a negative relationship between digital media use at night and sleep, there are some data showing that sleep effects of internet use during the hour before bed are most influenced by the type of digital media used/internet activity.³² Moreover, middle-of-the-night internet use was not associated with differences in SOL as hypothesized.^{25,26} It is difficult to contextualize this finding; however, it is plausible that youth who use the internet commonly at this hour have such high homeostatic sleep pressure by the time they get in bed that their SOL is not affected. Moreover, 1 large study found that links between digital screen time and pediatric sleep outcomes were modest, with little practical effect on pediatric sleep.¹ Overall these findings indicate that youth with higher internalizing disorder symptoms may be engaging in more internet use late at night and in the middle of

the night, and that higher internet use in the middle of the night is associated with a later bedtime and shorter TST; both later bedtime and shorter TST were independently associated with internalizing disorders. This study indicates that reducing middle-of-the-night internet use may be an important target for intervention for both sleep and internalizing disorder outcomes.

The third aim was to explore the relationship between internet behavior and internalizing disorder symptoms and time of day of internet use. The results indicated that higher rates of internalizing disorder symptoms were associated with more internet use for social interaction and boredom/avoidance. Use of the internet for social interaction and boredom/avoidance was not associated with use of the internet at any particular time of day. This may reflect adolescents’ desire to use the internet to attempt to reduce their internalizing symptoms by engaging with others and distracting from and/or avoiding their feelings. Indeed, 1 study found that adolescents reported fewer anxiety and depression symptoms on days when they engaged in more social activities online.⁴⁵ Although maladaptive internet behavior was not associated with more internalizing disorder symptoms, internalizing disorder symptoms were associated with more late-night and middle-of-the-night internet use.

The results of the present study should be interpreted within the confines of several limitations. First, data on internet use were obtained via retrospective self-report and may not accurately reflect actual internet use of youth.² Moreover, questions were taken from validated questionnaires and combined to appropriately assess the relevant questions in our sample rather than using 1 validated questionnaire.^{39,41} Second, data from the present study were collected between 2013 and 2015. Technology patterns among youth change rapidly, and this may not accurately reflect internet use in youth at present day.⁴⁶ Third, note that these data were collected in a sample of adolescents with an evening circadian preference who were interested in modifying their sleep. Although not all adolescents will experience sleep disturbance or an evening circadian preference, sleep problems are associated with increased substance use, psychopathology, suicidality, and decreased academic achievement.^{47–50} Because the results may not be generalizable to the general population, future research should examine whether the results of the present study are

Table 3—Factor loadings for each Internet Behavior Checklist question.

	PC1	PC2	PC3
1. If I don't go online I feel like I'm not connected to what my friends are doing.	0.45		
2. When I'm not online I feel like I'm missing out.	0.54		
3. My online friends understand me better than other people.	0.63	-0.39	
4. I am more myself online than in real life.	0.71	-0.35	
5. I open up more to people online than in other communication modes.	0.71	-0.37	
6. Most of my friends I know from online.	0.57	-0.48	
7. I prefer communicating online to face-to-face communication.	0.42		
8. I am friendlier online than in real life.	0.61	-0.30	
9. Going online has made it easier for me to make friends.	0.69	-0.34	
10. I have more fun with the people I know online than others.	0.65	-0.49	
11. I have a network of friends made online.	0.60	-0.41	
12. I go online to talk to others when I am feeling alone.	0.62		
13. When I'm feeling down or anxious, I go online to make myself feel better.	0.68		
14. I sometimes go online to escape from pressure.	0.69		
15. When I go online, I feel less anxious or stressed.	0.68		
16. I avoid going online for information because there is too much to weed through.			
17. I go online to distract myself from feelings.	0.61		
18. I like the speed of communicating online.	0.49		
19. I have shared intimate secrets online.	0.54		
20. The anonymity of being online is liberating.	0.62		
21. I have never gotten into a fight with a friend or significant other online.			
22. Sometimes I pretend I am someone I am not while online.	0.55		0.43
23. I have played a joke on a friend or classmate online.	0.38		0.33
24. I have bullied other kids online.			0.45
25. I feel less connected interpersonally when I communicate online.		0.38	
26. I go online when I am bored or have nothing better to do.		0.50	
27. I go online to waste time.		0.50	
28. I go online to procrastinate.	0.34	0.62	
29. I prefer the telephone to communicating online.			
30. I have been told that I spend too much time online.	0.54		
31. I have routinely gotten less sleep to spend more time online.	0.60	0.45	
32. I have missed social engagements because of online activities.	0.33		0.52
33. I have missed classes or work because of online activity.	0.33		0.36
34. I have tried to spend less time online but have not been able to.	0.53	0.38	
35. I feel guilty about time spent online instead of at other required work.	0.38	0.42	
36. If it has been a long time since I last logged on, I find it hard to stop thinking about what will be waiting for me when I do.	0.55		
37. I have tried to hide from others how much time I am actually online.	0.51		0.39
38. I have gotten into trouble with my employer or school because of being online.	0.32		0.65
39. When I'm online my parents can't control what I do.	0.39		
40. When I'm online I enjoy the freedom to go wherever and do whatever I want.	0.49		

PC = principal component.

Table 4—Aim 3: weighted beta coefficients, *P* values, and 95% CI for all predictors from regression models predicting internalizing disorder symptoms and time of day of internet use.

	Internalizing Disorder Symptoms			Late-Night Internet Use (9–11 PM)			Middle-of-the-Night Internet Use (midnight–5 AM)		
	β	<i>P</i>	95% CI	β	<i>P</i>	95% CI	β	<i>P</i>	95% CI
Social PC (PC ₁)	0.157	< .05*	0.007–2.58	0.147	> .05	–0.013 to 0.274	0.037	> .05	–0.113 to 0.179
Emotional PC (PC ₂)	0.184	< .05*	0.031–0.276	0.131	> .05	–0.029 to 0.259	0.104	> .05	–0.055 to 0.237
Risk PC (PC ₃)	0.268	> .05	–0.084 to 0.300	0.219	< .05*	0.048–0.333	0.249	< .05*	0.077–0.364

**P* value < .05. β = beta coefficient, CI = confidence interval, PC = principal component.

replicated in other chronotypes or in individuals who are not experiencing health risk or are not seeking treatment.

Taken together, these results highlight that late-night and middle-of-the-night internet use among adolescents with an evening circadian preference may be associated with higher internalizing disorder symptoms, and their internet use may be motivated by desires for social connection and boredom/avoidance. Internet use during the middle of the night was associated with high internalizing disorder symptoms, later bedtimes, shorter TST, and maladaptive internet behavior (ie, bullying other kids; missing social events, school, or work). Therefore, youth with an evening circadian preference who use the internet more in the middle of the night (midnight–5 AM) may represent a particularly high-risk group, and internet use in the middle of the night may be a potential target for intervention and/or a way to identify youth at high risk.

ABBREVIATIONS

PC, principal component
 SOL, sleep onset latency
 TST, total sleep time
 YSR, Youth Self-Report

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