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Technology Use and Sleep Quality in Preadolescence and Adolescence

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Study Objectives: The purpose of this study was to analyze differences between preadolescents and adolescents on the use of technology and to test the contribution of using Internet and mobile phone, and circadian preference on sleep quality.

Methods: We recruited a sample of 850 (364 males) preadolescents and adolescents. Self-report questionnaires about sleep schedule, sleep wake behavior problems, circadian preferences, and the use of technology (e.g., Internet and mobile phone) were administered. Students were asked to fill out the School Sleep Habits Survey, a self-report questionnaire on the use of technology, the Mobile Phone Involvement Questionnaire (MPIQ), and the Shorter Promis Questionnaire (SPQ).

Results: Adolescents reported more sleep problems, a tendency toward eveningness, and an increase of Internet and phone activities, as well as social network activities, while preadolescents were more involved in gaming console and television viewing. The regression analysis performed separately in the two age groups showed that sleep quality was affected by the circadian preference (eveningness) in both groups. Adolescents' bad sleep quality was consistently associated with the mobile phone use and number of devices in the bedroom, while in preadolescents, with Internet use and turning-off time.

Conclusions: The evening circadian preference, mobile phone and Internet use, numbers of other activities after 21:00, late turning off time, and number of devices in the bedroom have different negative influence on sleep quality in preadolescents and adolescents.

Keywords: technology, circadian preferences, sleep quality, preadolescence, adolescence, electronic media

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Early studies suggest that sleep disruption in childhood and adolescence negatively affects several domains, including school performance, mood regulation, cognitive process, and general health.[1–4]

Recent studies have highlighted the important role of technology and media-related devices use in affecting sleep quality and habits of children and adolescents.[5,6] As of today, most people use electronic media, particularly devices such as smartphones or tablets during daytime and close to bedtime.

It should be noted that the number of households with access to a home computer has doubled from 1998 to 2008, and the number of households with Internet access had a 5-fold increase over the same time period.[5] Today, mobile phones provide a wide range of activities such as Internet surfing, instant messaging, social networking, music playing, emailing and playing games. They have become the most frequently used media devices (during day and night), and therefore, it is difficult to clearly differentiate between these activities. Furthermore, we should consider that in the last few years the availability of wireless connection in most houses have allowed preadolescents and adolescents to use their mobile phones in every room.[7]

The 2011 Sleep in America Poll by the National Sleep Foundation reported that 95% of the respondents used electronic media within the hour before bed.[7] In the last few years, electronic devices have become more and more lightweight and portable, and this has led people to use these devices in bed or at bedtime.[8] Furthermore, nearly all preadolescents and adolescents have at least one technological device in their room, such as a computer, videogame console, television, or mobile phone[5,6,9] for the urgency to be constantly connected to their friends.[10]

BRIEF SUMMARY

Current Knowledge/Study Rationale: Electronic media use during the evening/night in children and adolescents is associated with delayed bedtime, reduction in total sleep time and poor sleep quality. Due to the consistent increase of media devices and Internet use in preadolescence and adolescence, we investigated the effects of these technologies on the quality of preadolescent and adolescent sleep.

Study Impact: Electronic media use and especially Internet and mobile phone activities related to social networking at bedtime are positively associated with sleep problems, with an important effect of the circadian preference (eveningness). Our study allowed us to compare preadolescents and adolescents showing that after 21:00, adolescents were more frequently involved in Internet and mobile phone activities while preadolescents were more frequently involved in gaming console. The transition from preadolescence to adolescence should be considered at high risk for development of sleep problems associated to electronic media use and social networking. The prevention should focus on the preadolescence period to inform about the risks related to the use of technology at bedtime.

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Electronic media use during the evening/night in children and adolescents is associated with delayed bedtime and reduction in total sleep time.[5,6,11–13] The mechanisms by which the use of electronic devices at bedtime may impair sleep are related to cognitive, emotional, or physiological arousal,[5,14] while the displacement of sleep onset might be connected to exposure to bright light, especially with short wavelengths emitted by electronic devices, that can cause phase delays, typically postponing sleep onset.[15]

When studying sleep behavior of preadolescents and adolescents, circadian preferences or electronic device use should always be taken into account because they play an important role in affecting quality of sleep.[16] The morningness-eveningness (ME) preference explains the variation in the rhythmic expression of biological and behavioral patterns as a continuum between evening chronotypes (E-types) and morning chronotypes (M-types).[17–19] The types of circadian preference are intrinsic and heritable characteristics of the individual associated with differences in habits, performance rhythms, physiological, and behavioral variables.[20] According to the literature, M-type individuals wake up early in the morning, fall asleep at an early hour and prefer early morning activities, while E-types seem to have problems waking up in the morning (e.g., need to be waked up by parents),[20,21] staying awake during the day (especially during school time), and feeling more exhausted during the day.[20,22] Circadian preference changes from preadolescence and adolescence, when a consistent shift to evening preference has been reported.[21] As a consequence, adolescents' sleep is characterized by later bedtimes and later rising times. In adolescence, the quality of sleep is affected by a combination of psychosocial and emotional factors (e.g., decreased parental control of bedtime, school-related anxiety) and behavioral factors, such as the use of technology during nighttime.[21,23–25]

The use of electronic media devices at bedtime seems to be affected not only by age but also by gender. Indeed, gender differences have been reported in previous studies especially at the transition between preadolescence and adolescence. Girls use mobile phones mostly to communicate with friends, while boys use computer till late for surfing the Internet, gaming, and social networking.[26]

The interplay between behavioral, homeostatic, and circadian factors has been often neglected in studies assessing the effect of electronic media use on sleep; also almost no studies have evaluated media use between preadolescents and adolescents in the same study.

Due to the consistent increase of Internet use in adolescence,[27,28] it is important to investigate the effects of these technologies and the other individual variables on the quality of preadolescent and adolescent sleep as an indicator of wellbeing.[29] Therefore we conducted a survey among preadolescents and adolescents, investigating whether exposure to different electronic media in bed before going to sleep was related to sleep disturbances. Overall, we expected the use of electronic media in bed to be related to poor quality of sleep, daytime sleepiness, and eveningness preference.[8]

Accordingly, we aimed to: (1) analyze differences between preadolescents and adolescents in sleep habits and problems, use of technology, and circadian preference; and (2) test the contribution of the use of Internet and mobile phone, and circadian preference to sleep quality.

METHODS

Participants

For this study, 850 Italian preadolescents and adolescents (364 males, 486 females) aged 11–16 years (mean age = 13.53 years, SD = 1.72) were recruited in junior and senior high schools of a middle class district of Rome, Italy. The younger group of participants included 434 preadolescents aged 11–13 years (222 males, mean age = 12.06 years, SD = 0.83; 212 females, mean age = 12.05 years, SD = 0.83); the older group of participants was composed of 416 adolescents aged 14–16 years (142 males, mean age = 15.04 years, SD = 0.85; 274 females, mean age = 15.09 years, SD = 0.81). Parental written consent was obtained for all participants. The study was reviewed and approved by the Ethics Commission of the Department of Developmental and Social Psychology of Sapienza, University of Rome.

Procedure

Questionnaires on sleep habits, sleep quality, circadian preference, and use of technology were administered in the classroom during a regular class period, under the supervision of the researchers who assisted the students in the compilation when needed. Although a whole hour was allowed to fill out the questionnaires, most students took approximately 30 minutes to complete all the questionnaires after the researchers gave the instructions. Participants were instructed that questionnaires were voluntary and that responses were anonymous and confidential.

Measures

School Sleep Habits Survey

Data were collected with the Italian version of the School Sleep Habits Survey developed by Carskadon and colleagues.[4,30,31] The questionnaire have been tested and already used in a previous study[21] and included:

1. Questions about sleep habits. The questionnaire contained two simple open questions about the habitual bedtime and rise time during schooldays. Sleep onset latencies for school-days were assessed through a single forced-choice item ("How long does it take usually you to fall asleep?") with 6 categories of response (1 = "0 to 5 minutes," 2 = "6 to 15 minutes," 3 = "16 to 30 minutes," 4 = "31 to 45 minutes," 5 = "46 to 60 minutes," 6 = "more than one hour").
2. Sleep-Wake Problems Behavior Scale (SWPBS) composed of 15 items assessing irregular sleep habits, prolonged sleep latency, and difficulties in waking up in the morning. Participants had to indicate how often in the last 2 weeks they had experienced some sleep related problems, with a 5-point answer format ("Never," "Once," "Twice," "Several Times," "Every day/night"). The total score, ranging from 10 to 50, was computed summing the items, with higher

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scores reflecting a better sleep quality. The internal consistency for the current study was 0.68.

3. Morningness/Eveningness Questionnaire (MEQ). The questionnaire on circadian preference, composed of 10 forced-choice items, aimed to measure the difficulties in waking up early in the morning and doing early morning activities. The MEQ total score, computed summing the items, ranged from 10 (extreme evening) to 43 (extreme morning). Following the procedure of Giannotti and colleagues,[32] we also decided to establish raw score cutoffs corresponding to the 10th to 90th percentiles of the distribution (E-type = 10–21; Intermediate = 22–31; M-type = above 32). The internal consistency for the present study was 0.71.

Self-Report Questionnaire on the Use of Technology

To assess the exposure to different electronic media devices, after 21:00, based on the study of Calamaro and colleagues,[6] we used a questionnaire composed of 24 items aimed to measure: (1) number of technological devices in the bedrooms (e.g., computer, television, gaming console, music, iPad/tablet, and mobile phone); (2) turning off devices time at night; and (3) number of activities performed after 21:00. In the present study, we distinguished: (a) mobile phone-related activities (e.g., texting, talking, and surfing); (b) Internet-related activities (e.g., surfing using computer, social networks using computer, computer television/movies); (c) other activities (e.g., music, television, gaming console, sport). For each technological device and activity performed after 21:00 (i.e., Internet, mobile phone, and others), we assigned 0 for absence and 1 for presence; finally we summed the points to derive a score for number of technological devices and a score for activities performed after 21:00. The internal consistency for the current study was 0.75.

Mobile Phone Involvement Questionnaire (MPIQ)

The questionnaire, developed by Walsh and colleagues,[33] is composed of 8 items rated on a 7-point Likert-type scale (1 = strongly disagree, 7 = strongly agree). The questionnaire is aimed to measure the behaviors associated to mobile phone such as withdrawal, cognitive and behavioral salience, euphoria, loss of control, relapse and reinstatement, conflict with other activities, and interpersonal conflict. The internal consistency for the present study was 0.80.

Shorter Promis Questionnaire (SPQ)

The questionnaire is composed of 10 items rated on a 6-point Likert-type scale (0 = strongly disagree, 5 = strongly agree) describing Internet use and related compulsive behaviors, such as surfing the Internet to control stress and anxiety, loss of control, excitement and craving (e.g. "I surf the Internet to calm down when I'm nervous").[34,35] The internal consistency for the present study was 0.79.

Statistical Analysis

First, analyses of variance (ANOVAs) were conducted to assess gender and age differences among preadolescents and adolescents in study variables. Then, using χ^2 tests, we evaluated differences between preadolescents and adolescents in performing Internet, mobile phone, and other activities after 21:00. ANOVAs across 3 circadian preferences (i.e., E/M-types and Intermediate) were also conducted to assess differences in the study variables. To test the relationship between sleep and technology variables and circadian preference, Pearson correlation analyses were carried out.

Finally, a hierarchical multiple regression analysis was conducted separately for preadolescents and adolescents and was used to test the role of circadian preference and use of technology on sleep quality. Gender was entered in the first step as a control variable. Circadian preference was entered in the second step. In the final step, we added the number of activities (Internet, phone, other), the number of devices in the bedroom, the turning-off time, MPIQ, and SPQ scores.

Data analyses were conducted using the 21st version of the IBM Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL).

RESULTS

Descriptive statistics of the questionnaires data for gender and age are presented in **Table 1** and **2**. Females scored higher than males on number of Internet and phone activities and use of mobile phone. Conversely, males had higher scores than females on total sleep time, numbers of devices, and on the number of other activities after 21:00.

Adolescents showed a later bedtime and decreased total sleep time and sleep onset latency than preadolescents. They also reported more sleep problems in the sleep-wake problems behavior scale (where higher scores reflect less sleep quality-related problems) and a tendency toward eveningness in the MEQ scale (in which higher scores mean a morningness preference). Furthermore, they reported an increase of Internet and phone activities, as well as of use of mobile phone and a later turning off time (**Table 2**).

Figure 1A shows that adolescents were more frequently involved in Internet (i.e., surfing, 68.8% vs. 46.3%, $\chi^2(1) = 47.846$, $p < 0.001$, and social networks, 76.7% vs. 55.1% , $\chi^2(1) = 46.768$, $p < 0.001$, using computer) and mobile phone activities (i.e., mobile phone texting, 49% vs. 25.3%, $\chi^2(1) = 51.185$, $p < 0.001$, texting on social networks, 49.3% vs. 22.1%, $\chi^2(1) = 68.500$, $p < 0.001$, whatsApp/messenger, 44% vs. 20.3%, $\chi^2(1) = 55.000$, $p < 0.001$, talking, 23.6% vs. 13.8%, $\chi^2(1) = 13.296$, $p < 0.001$, and surfing, 39.7% vs. 21%, $\chi^2(1) = 32.274$, $p < 0.001$), while preadolescents were more involved in gaming console (38.2% vs. 20.7%, $\chi^2(1) = 30.802$, $p < 0.001$). **Figure 1B** shows that female preadolescents were more frequently involved in mobile phone texting (31.1% vs. 19.8%, $\chi^2(1) = 7.334$, $p < 0.01$) while male preadolescents were more frequently involved in gaming console (54.1% vs. 21.7%, $\chi^2(1) = 48.765$, $p < 0.001$) and television viewing (93.2% vs. 85.8%, $\chi^2(1) = 4.647$, $p < 0.05$). In **Figure 1C**, it is evident that female adolescents more consistently use the technology vs. males and in particular social networking (81.4% vs. 67.6%, χ^2 (1) = 11.221, $p < 0.001$), mobile phone texting (56.2% vs. 35.2%, $\chi^2(2) = 16.494$, $p < 0.001$), mobile phone texting on social networks (53.6% vs. 40.8%, $\chi^2(1) = 6.135$, $p < 0.01$), and music (69.7% vs. 53.5%, $\chi^2(1) = 12.111$, $p < 0.001$), while male adolescents use more gaming consoles (42.3% vs. 9.5%, $\chi^2(1) = 60.364$, $p < 0.001$) and do sports (20.4% vs. 8.4%, $\chi^2(1) = 12.291$, $p < 0.001$) after 21:00.

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Table 1—Means, standard deviations, and gender differences for the study variables.

	Total Sample		Males		Females				
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***F***	**Partial η²**	**p**
Bedtime (clock time/hours:minutes)	22:47	0:57	22:47	0:56	22:46	0:57	0.09	0.01	NS
Total sleep time (hours:minutes)	7:41	0:59	7:46	0:56	7:38	1:01	3.908	0.01	< 0.05
Sleep onset latency*	2.46	1.23	2.48	1.31	2.45	1.17	0.16	0.01	NS
Number of devices	4.49	1.74	4.80	1.79	4.26	1.67	21.029	0.02	< 0.001
Number of Internet activities	2.00	1.37	1.88	1.40	2.08	1.35	4.987	0.01	< 0.05
Number of phone activities	1.53	1.79	1.24	1.64	1.75	1.87	17.716	0.02	< 0.001
Number of other activities	2.49	1.26	2.60	1.36	2.41	1.17	6.857	0.01	< 0.01
"Turning-off" time (clock time/hours:minutes)	22:58	0:59	23:30	0:59	22:55	0:58	2.946	0.01	NS
Internet use (SPQ)	14.23	9.65	13.79	9.70	14.55	9.62	1.227	0.01	NS
Mobile phone use (MPIQ)	27.01	11.30	23.84	9.73	29.36	11.80	50.903	0.06	< 0.001
MEQ score	27.45	4.75	27.78	5.12	27.21	4.45	3.056	0.01	NS
Sleep problems (SWPBS)	57.88	7.72	58.13	7.86	57.69	7.62	0.673	0.01	NS

For bedtime and "turning-off" time, mean = clock time, SD = hours:minutes. *Sleep onset latency ranges from 1 to 6 (1 = 0 to 5 minutes, 2 = 6 to 15 minutes, 3 = 16 to 30 minutes, 4 = 31 to 45 minutes, 5 = 46 to 60 minutes, 6 = more than one hour). For MEQ higher scores mean a morningness preference. For SWPBS higher scores mean low level of sleep problems. SPQ, Shorter Promise Questionnaire; MPIQ, Mobile Phone Involvement Questionnaire; MEQ, Morningness/Eveningness Questionnaire; SWPBS, Sleep-Wake Problems Behavior Scale.

Table 2—Means, standard deviations, for the study variables in preadolescents and adolescents.

	Preadolescents		Adolescents				
Variable	**Mean**	**SD**	**Mean**	**SD**	***F***	**Partial η²**	**p**
Bedtime (clock time/hours:minutes)	22:40	0:54	22:55	0:59	15.860	0.02	< 0.05
Total sleep time (hours:minutes)	7:58	0:55	7:23	0:58	81.960	0.09	< 0.001
Sleep onset latency*	2.55	1.37	2.37	1.07	4.429	0.01	< 0.05
Number of devices	4.67	1.80	4.31	1.67	8.930	0.01	< 0.01
Number of Internet activities	1.76	1.43	2.23	1.27	26.022	0.03	< 0.001
Number of phone activities	1.03	1.53	2.06	1.89	76.474	0.08	< 0.001
Number of other activities	2.56	1.34	2.43	1.17	2.399	0.01	NS
"Turning-off" time (clock time/hours:minutes)	22:37	0:55	23:19	0:55	108.072	0.13	< 0.001
Internet use (SPQ)	14.25	10.33	14.22	8.95	0.02	0.01	NS
Mobile phone use (MPIQ)	25.50	10.70	28.54	11.68	15.193	0.02	< 0.001
MEQ score	28.53	4.97	26.33	4.24	47.871	0.05	< 0.001
Sleep problems (SWPBS)	58.50	8.11	57.24	7.25	5.655	0.01	< 0.05

For bedtime and "turning-off" time, mean = clock time, SD = hours:minutes. *Sleep onset latency ranges from 1 to 6 (1 = 0 to 5 minutes, 2 = 6 to 15 minutes, 3 = 16 to 30 minutes, 4 = 31 to 45 minutes, 5 = 46 to 60 minutes, 6 = more than one hour). For MEQ higher scores mean a morningness preference. For SWPBS higher scores mean low level of sleep problems. SPQ, Shorter Promise Questionnaire; MPIQ, Mobile Phone Involvement Questionnaire; MEQ, Morningness/Eveningness Questionnaire; SWPBS, Sleep-Wake Problems Behavior Scale.

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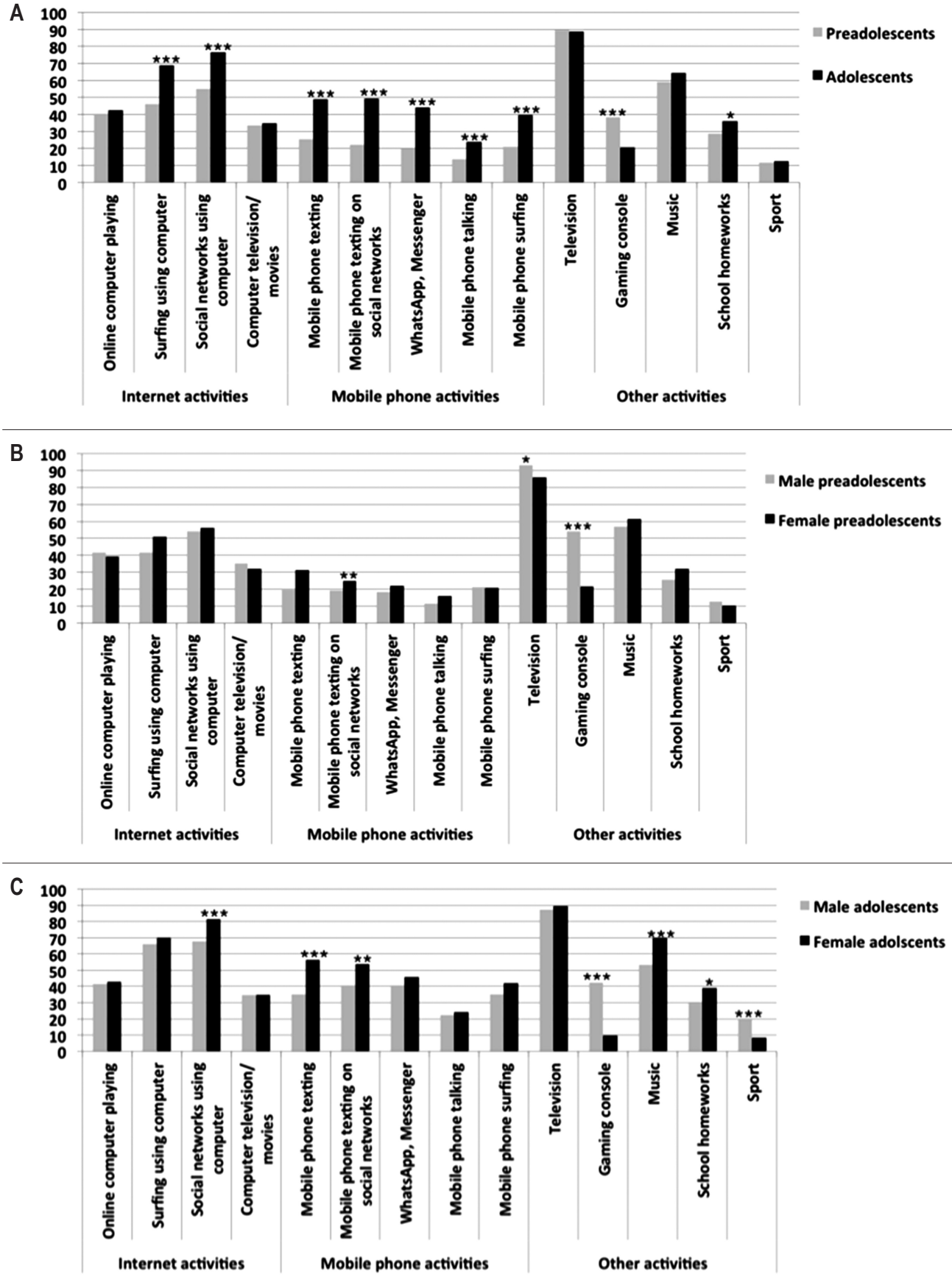
Table 3 reports means and standard deviations of the variables analyzed in the three circadian preference groups. The sample consisted of 86 E-types (10.1%; 44 males, 42 females), 174 M-types (20.5%; 91 males, 83 females), and of 588 intermediate I-types (69.2%; 227 males, 361 females). Of the total sample size (n = 850), 0.2% (n = 2) were not included in this analysis due to missing values on the items of the MEQ scale. The Bonferroni post hoc analysis showed that E-types vs. M-types and Intermediate-types had an increase of sleep onset latency, a poorer sleep quality, a greater number of devices in the room, more Internet, phone, and other activities after 21:00, and a later turning-off time.

The correlation analysis showed that bad sleep quality was related to the eveningness preference, use of Internet and mobile phone, and number of other activities (**Table 4**). In addition, morningness scores were negatively correlated with the time of turning off devices. The number of Internet activities was positively correlated with the number of phone activities, turning-off time, and Internet use. The phone activities were related to turning-off time and mobile phone use; finally, mobile phone use was positively associated with Internet use.

Two hierarchical multiple regression analyses were performed to understand the role of circadian preference and use of technologies and activities performed after 21:00 on sleep quality in preadolescents and adolescents. The regression analysis performed separately in the two age groups showed that the variance explained was 31% in preadolescents and 25% in adolescents (**Table 5**).

Figure 1—Prevalence of the different activities performed after 21:00.



*p < 0.05, **p < 0.01, ***p < 0.001.

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Table 3—Means, standard deviations, and differences between circadian preference types.

Variable	E-type Mean	E-type SD	I- type Mean	I- type SD	M-type Mean	M-type SD	*F*	Partial η²	p	Significant Comparisons
Bedtime (clock time/hours:minutes)	22:45	0:57	22:48	0:59	22:47	0:50	0.06	0.01	NS	
Total sleep time (hours:minutes)	7:32	1:02	7:41	1:00	7:46	0:55	1.49	0.01	NS	
Sleep onset latency*	2.93	1.44	2.49	1.21	2.14	1.11	12.60	0.03	< 0.001	E vs. I; E vs. M; I vs. M
Number of devices	4.98	1.99	4.48	1.67	4.27	1.82	4.77	0.01	< 0.01	E vs. I; E vs. M
Number of Internet activities	2.56	1.31	2.06	1.33	1.46	1.37	21.83	0.05	< 0.001	E vs. I; E vs. M; I vs. M
Number of phone activities	2.28	1.93	1.63	1.81	0.82	1.40	23.26	0.05	< 0.001	E vs. I; E vs. M; I vs. M
Number of other activities	2.88	1.21	2.51	1.24	2.26	1.31	7.07	0.02	< 0.01	E vs. I; E vs. M
"Turning-off" time (clock time/hours:minutes)	23:32	0:54	23:02	0:57	22:28	0:53	35.10	0.09	< 0.001	E vs. I; E vs. M; I vs. M
Internet use (SPQ)	16.87	9.56	14.49	9.54	11.96	9.70	7.80	0.02	< 0.001	E vs. M; I vs. M
Mobile phone Use (MPIQ)	30.77	12.70	27.76	11.18	22.52	9.64	19.97	0.05	< 0.001	E vs. M; I vs. M
Sleep Problems (SWPBS)	51.72	7.10	57.67	7.45	61.53	6.76	52.86	0.11	< 0.001	E vs. I; E vs. M; I vs. M

For bedtime and "turning-off" time, mean = clock time, SD = hours:minutes. *Sleep onset latency ranges from 1 to 6 (1 = 0 to 5 minutes, 2 = 6 to 15 minutes, 3 = 16 to 30 minutes, 4 = 31 to 45 minutes, 5 = 46 to 60 minutes, 6 = more than one hour). For SWPBS higher scores mean low level of sleep problems. SPQ, Shorter Promise Questionnaire; MPIQ, Mobile Phone Involvement Questionnaire; SWPBS, Sleep-Wake Problems Behavior Scale.

Table 4—Correlation between the study variables.

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Bedtime	–											
2. Total sleep time	**−0.55**	–										
3. Sleep onset latency	−0.03	−0.05	–									
4. Number of devices	0.01	−0.04	0.12	–								
5. Number of Internet activities	0.04	−0.12	0.07	0.20	–							
6. Number of phone activities	0.02	−0.16	0.12	0.18	**0.33**	–						
7. Number of other activities	−0.04	0.01	0.10	0.26	0.28	0.16	–					
8."Turning-off" time	0.08	−0.23	0.05	0.13	**0.30**	**0.33**	0.18	–				
9. Internet use (SPQ)	0.01	−0.01	0.02	0.13	**0.32**	0.28	0.22	0.19	–			
10. Mobile phone use (MPIQ)	0.03	−0.13	0.07	0.14	0.26	**0.41**	0.15	0.24	**0.52**	–		
11. MEQ score	−0.01	0.10	−0.20	−0.12	−0.25	−0.27	−0.13	**−0.35**	−0.14	−0.25	–	
12. Sleep problems (SWPBS)	0.02	0.04	−0.18	−0.20	−0.20	−0.22	**−0.30**	−0.25	**−0.31**	**−0.32**	**0.41**	–

Bold = correlations > 0.30 were significant at p < 0.01. SPQ, Shorter Promise Questionnaire; MPIQ, Mobile Phone Involvement Questionnaire; MEQ, Morningness/Eveningness Questionnaire; SWPBS, Sleep-Wake Problems Behavior Scale.

In detail, in preadolescents, at the first step gender was not significantly associated with sleep problems ($R^2 = 0.01$). At the second step, the addition of circadian preference significantly improved the variance explained ($R^2 = 0.14$). Finally, at the last step, the use of Internet, the number of other activities after 21:00, and turning-off time demonstrated significant regression coefficients ($R^2 = 0.16$).

In adolescents, at the first step, gender was not significantly related to sleep problems ($R^2 = 0.01$). At the second step, the circadian preference significantly improved the variance explained ($R^2 = 0.15$). At the final step, the mobile phone use, the number of other activities after 21:00, and the number of devices in the bedroom showed significant regression coefficients ($R^2 = 0.09$).

Therefore, sleep disturbances were associated with the circadian preference (eveningness) and number of other activities in both groups, but in adolescents also with mobile phone use and number of devices, while in preadolescents with Internet use and turning-off time.

DISCUSSION

The main goal of the present study was to investigate the relation between use of technology, circadian preference, and sleep quality in two age groups: preadolescents and adolescents.

There are several studies published on the use of technology and its effects on sleep but the dissimilar methodology used, the different age ranges, the lack of standardized questionnaires, disparate outcome variables (sleep duration, sleep latency, sleep problems, circadian preference, etc.), and the fast evolution of the technology (with the recent mobile phone performing different activities) made it very difficult to compare various studies.

Our findings showed that evening circadian preference, mobile phone and Internet use, number of other activities after 21:00, late turning-off time and number of devices in the bedroom have a negative influence on sleep quality. Different from previous studies in the literature, our study allowed to compare preadolescents and adolescents showing that after

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Table 5—Hierarchical regression analysis with the Sleep-Wake Problems Behavior Scale as the dependent variable.

	Step 1			Step 2			Step 3		
Variables	**B**	**β**	**p**	**B**	**β**	**p**	**B**	**β**	**p**
Preadolescents									
Gender	0.08	0.05	0.35	0.96	0.06	0.24	0.27	0.02	0.74
MEQ score				0.61	0.37	0.001	0.44	0.27	0.001
Number of devices							−0.43	−0.10	0.08
Number of Internet activities							0.25	0.05	0.43
Number of phone activities							0.28	0.06	0.33
Number of other activities							−0.79	−0.13	0.01
"Turning off" Time							−1.04	−0.12	0.05
Internet Use (SPQ)							−0.18	−0.24	0.001
Mobile Phone use (MPIQ)							−0.08	−0.12	0.06
Adolescents									
Gender	−1.13	−0.08	0.17	−0.10	−0.07	0.19	−0.34	−0.02	0.66
MEQ score				0.69	0.39	0.001	0.52	0.30	0.001
Number of devices							−0.43	−0.10	0.05
Number of Internet activities							0.07	0.01	0.82
Number of phone activities							−0.07	−0.02	0.74
Number of other activities							−1.00	−0.16	0.01
"Turning off" Time							−0.15	−0.02	0.71
Internet Use (SPQ)							−0.07	−0.08	0.15
Mobile Phone use (MPIQ)							−0.09	−0.14	0.05

For the dependent variable, higher scores mean low level of sleep problems. SPQ, Shorter Promise Questionnaire; MPIQ, Mobile Phone Involvement Questionnaire; MEQ, Morningness/Eveningness Questionnaire.

21:00, adolescents were more frequently involved in Internet and mobile phone activities while preadolescents were more frequently involved in gaming console.

Sleep quality was differently affected in the two age groups: in adolescents, mobile phone use and number of devices, while in preadolescents Internet use and turning-off time were associated with sleep problems.

We found gender differences in the technology use after 21:00 with female preadolescents more frequently involved in mobile phone texting while male preadolescents in gaming console and television viewing. In general, female adolescents used more consistently the technology vs. males, particularly social networking and music, while male adolescents used more gaming consoles and did sports after 21:00, in agreement with the literature reporting that males and females favor different Internet/phone activities.[36–38]

Our group of preadolescents and adolescents reported having 4 or more media devices (TV, computer, console, mobile phone) in the bedroom; this has been related to delayed bedtimes, shorter sleep duration, increased bedtime resistance, and higher level of sleep disturbance.[5,6,9,14,39] American adolescents, on average, engage in 4 (range: 0–8) technology activities after 21:00,[6] which is similar to our study since adolescents were involved in a mean of 2.23 Internet activities and 2.06 mobile phone activities.

Moreover, it has been reported that as many as 82% of American adolescents watch television after 21:00[6]; this is consistent with our results since about 90% of our sample watched TV. The other data on the use of technology are slightly different from the ones of our study: after 21:00, 34% of the adolescents report text messaging (vs. 49% of our adolescents), 44% report talking on the telephone (vs. 23.6% of our adolescents), 24% play computer games (vs. 20.7% of our adolescents), 82% report watching some television (vs. 88.7% of our adolescents), and 42% use a MP3 player (vs. 64.2% of our adolescents). The higher prevalence of the Internet-related activities in our sample is probably linked to the increase in the use of technology by adolescents in the last few years. This observation is corroborated by the data from the National Sleep Foundation's 2011 Sleep in America Poll showing that about 90% of participants use technological devices before bed (with TVs the most popular; 60%), with those under 30 years of age more likely to use cell phones than those over 30 years.[7]

This prevalence is similar in civilized countries since another study found mobile phone use after lights out in 62% of adolescents[13]; a Japanese study reported daily mobile phone use by 84.4% of adolescents.[40]

A different prevalence has been found in younger preadolescents (10–11 years) in whom more than half (57%) reportedly used the electronic entertainment and communication devices (EECDs; TV or gaming console, computer and mobile phone) after they were expected to go to sleep. Watching TV (41%) after they were expected to go to sleep was the most commonly reported nighttime activity but this was lower than that reported in our preadolescents (approximately 90%). The prevalence of video gaming, of use of Internet, of social networking, and of mobile phone texting was slightly lower than in our preadolescents, probably because of the age difference.[41]

In a recent paper by Arora and colleagues[42] that used the same sleep questionnaire as our study (School Sleep Habits Survey) in 738 preadolescents (11–13 years of age), it was not specified if the use of technology was performed after 21:00

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and data were based on "generic whole day use of technology." For this reason the data are not comparable with our findings, and the prevalence of media use (mobile phone 59.6%, Internet 48.8%, video gaming 42.4%, television 51.4%) was lower than in our study. However, according to our findings, these authors showed that frequent video gamers, social networkers, music listeners, and mobile phone users reported an increased risk for difficulty falling asleep.[42]

We agree with the literature that Internet and mobile phone use negatively affects sleep: Internet use is related to delayed bedtime,[9,40] shorter total sleep time,[43] and higher levels of subjective insomnia.[5,39,43] Mobile phone use has been associated with shorter sleep duration,[42,44] whereas mobile phone use for calling and for sending text messages after lights out was associated with sleep disturbance.[5,6,43]

The interesting finding of our study, although cross-sectional and not longitudinal, is that the increase of media use appears to be related to the passage from preadolescence to adolescence. This result is indirectly corroborated by other studies showing that older adolescents (mean age 16 years) were woken up by text messages significantly more often than younger adolescents (mean age 13 years).[13] This behavior might be related to the switch from morning chronotype to evening chronotype with age, since the use of a mobile phone for playing, surfing, and texting in bed and of Internet was associated with evening chronotype in both adolescents and young adults.[45–47]

Possible explanations of this finding may be that the evening chronotype leads to the use of media devices because of the preference for staying up late.[5,8] On the other hand, media devices may act as a direct displacement of sleep, and may also replace activities that promote good sleep, increasing cognitive, emotional or physiological arousal, which may, in turn, impair sleep.[5,15,47] Finally, the exposure to the bright light emitted by many electronic devices, can cause phase delays, typically postponing sleep onset.

Limitations

There are some limitations to acknowledge. All data collected were self-reported and may be subject to biases or inaccuracies, therefore upcoming studies may benefit from a multi-method procedure that includes more objective methodology (actigraphy), observation methods (sleep diary or daily media use measures using the same mobile phone) together with a self-report evaluation.

Furthermore, we do not have specific data on the socioeconomic and educational status of the families participating in the study. However, the city district selected was mostly represented by middle-class families and, therefore, the relative homogeneity of the sample could limit the differential impact of socioeconomic and educational status on the technology use and sleep habits in this study.

In addition, along with the majority of previous studies, we used cross-sectional data, and thus we were unable to test more causal links among the variables. Experimental and/or longitudinal studies should be carried out to reveal possible causal relations between the use of electronic media devices and sleep disturbances evaluating the mediating role of other environmental, psychological and life habits variables.

Finally, we did not include multiple measures of socioemotional and academic competence such as peer-rated measures and life habits (foods, sports, etc.) that should be taken into account in future studies.

CONCLUSIONS

From our findings it can be argued that electronic media use and especially Internet and mobile phone activities related to social networking at bedtime are positively associated with sleep problems, with an important effect of the circadian preference (eveningness).

The transition from preadolescence to adolescence should be considered at high risk for development of sleep problems associated to bad sleep habits. Therefore it is extremely important for prevention to focus on the preadolescence period in order to inform about the risks related to the use of technology at bedtime.

In fact, the lack of good sleep exposes adolescents to a general vulnerability, concerning the quality of life: bad sleep has been related to depression,[48] negative social relationships, and poor school performance.[49]

Since healthy sleep has been demonstrated to be important during development, especially in adolescence,[50] public health systems should adopt prevention strategies informing about the importance of sleep and recovery, including advice about limits for the use of electronic media devices close to and after bedtime. Individual and group sleep promotion programs should be conducted in schools and associations to endorse good sleep habits.[51]

From the family point of view, parents should keep monitoring bedtime and limit access to technological devices late in the evening, especially during the transition from preadolescence to adolescence.

ABBREVIATIONS

MEQ, Morningness/Eveningness Questionnaire
MPIQ, Mobile Phone Involvement Questionnaire
SPQ, Shorter Promis Questionnaire
SWPBS, Sleep-Wake Problems Behavior Scale

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