Sleep quality and associated factors in adolescence

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Abstract

Purpose
To understand sleep patterns and predictors of poor sleep quality among high school students.

Method
Three hundred ninety-two students aged 16.32 (± 1.29) years from an urban Life High School completed a cross-sectional survey about sleep habits that included the Pittsburgh Sleep Quality Index (PSQI) and the Morningness–Eveningness Questionnaire (MEQ).

Results
The higher-grade students identified a significantly high rate of high-calorie foods, later sleep time, and, less sleep duration ($p = 0.002$, $p = 0.000$, $p = 0.010$). Sleeping with the smartphone in bed and smartphone sound mode had a significant negative effect on sleep quality; sleep time, sleep duration, MEQ score, and awaken rate by smartphone. Students reported disturbed sleep; 39.9% were categorized as poor-quality sleepers by the PSQI, and BMI, sleep time, sleep latency and sleep duration were significantly related to sleep quality ($p = 0.013$, $p = 0.003$, $p = 0.000$, $p = 0.000$, respectively). A significant difference was identified between sleep chronotypes based on MEQ score and sleep quality based on the PSQI score ($p = 0.025$).

Conclusions
These results demonstrate that smartphone and BMI are related to insufficient sleep and sleep quality. In addition, the evening type students had lower sleep quality. Given the close relationships between sleep quality and food habits and smartphone habits, intervention programs to modify the habits in this population should be considered.

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Introduction

A human spends almost 30% of the time sleeping in their life. It is well known that sleep is one of the most important factors for human's physical and psychosocial health. Especially, studies of adolescents and sleep are well published as it affects physical and emotional development. There were significantly more physical and psychological health problems for the students who have poor-quality sleep compared with good-quality sleep (Lund, Reider, Whiting, & Prichard, 2010, Wiggs, 2001). Research clearly demonstrates that adolescents who have less sleep duration showed higher chances of depression (Sivertsen et al., 2014). Cho, Lee & Kim (2019) found that 254 (36.8%) high school students reported depressed mood (Hospital depression scale, HDS ≥8). Brand et al. (2009) found that parents' sleep patterns play an important role in adolescents' sleep. In addition, the study revealed that there was a significant difference between the mother's poor sleep and the adolescents' psychological functioning and sleep. They recommend that family counseling be considered to treat adults' and adolescents' sleep problems. Nunes et al. (2009) reported that quality of sleep was the best predictor of quality of life in a patient with Chronic Obstructive Pulmonary Disease (COPD).

Research shows that the average sleeping time of each night is 7~9 hours for adult and 8~10 hours for teenagers (National Sleep Foundation, 2015). Cheng et al. (2012) described a decrease in sleep duration and an increase in sleep complaints in modern society. Approximately 70% of high school students in Canada have inadequate sleep duration compared with the recommended amount for their age (Brown, Qin & Esmail, 2017). At least 3 times a week, 60% of students reported that they were dragging, tired, or sleepy (Herrmann et al., 2018). The adolescent with shorter sleep duration complained about the increased sleepiness, irritability, decreased socialization, and hyper-sexuality. In addition, they were susceptible to illicit drug exposure, alcohol, and risky driving (Anderson, MacDonald & Frost, 2006).

Better sleep quality is one of the factors for high levels of academic performance (Cho et al., 2019). Sleepiness, sleep quality and sleep duration are the most significant variables for school performance (Dewald et al., 2010). University students with poor sleep quality showed lower academic performance compared with university students with good sleep quality (Howell, Jahrig, & Powell, 2004). According to a study for young children, they found a correlation between poorer sleep quality and lower test scores in cognitive tasks (Paavonen et al., 2010).

Evidence for the link between inflammation and sleep quality was reported. The patients with higher levels of inflammation slept longer (>8 hr) (Dowd, Goldman & Weinstein. 2011). Similarly, a study reported that a high level of CRP (C-reactive protein) was associated with short sleep duration including cardiovascular and metabolic diseases (Martinez-Gomez et al., 2011). Sleep deprivation had a negative effect on immunity for students and resulted in them being more susceptible to infections. Additionally, the research reported that there were several health problems for the sleep disorders of adolescents such as sleep apnea, narcolepsy, asthma, aggressive disorders, and anorexia nervosa (Anderson et al., 2006).

Sleep pattern is also influenced by societal factors and some studies reported the possible relationship with sleep. Internet usage is considered one of the factors of poor sleep quality and sleeps problems including mental health morbidity (Cheng et al., 2012). Age, minority status, and BMI were significantly related to total sleep time for younger adolescents (Moore et al., 2011). The relationship between BMI and sleep quality was identified as well (Herrmann et al., 2018). Family stress, parental age, and parental education are considerable factors for a child's sleep-wake assessment (Sadeh, Raviv & Gruber. 2000). As a result of these concerns, it is important to assess the factors that influence sleep quality and health outcomes among high school students.

There have been several studies on sleep quality and behavior among adolescents, especially in

developed countries, but to the best of my knowledge there have been no such studies in Cambodia. The purpose of this study is to provide information about overall sleep quality and habits among the students in a high school, Cambodia, and to understand sleep habits and patterns that affect sleep quality as well as the factors that increase the risk of sleep deprivation among students.

Methods

The design of this study was cross-sectional survey research. This research conducted surveys throughout grade 10, 11 and 12 students at Life School, Cambodia in October of 2019 and the survey was given to the classroom teachers and handed out to students. The student survey was developed in English originally and translated into Khmer by a professor with an excellent comprehension of the English language.

The main research questions were divided into three sub-questions and were addressed. Sub-question 1 is for demographic information and smartphone behaviors to consider the associations between factors of sleep behaviors including sex, age, grade, Body Mass Index (BMI), fast food eating habit, screen (TV, computer and smartphone) exposure time, and smartphone handling and behaviors. BMI (kg/m^2) was calculated by dividing weight (in kg) over height^2 (in m^2). For this study, spent time was measured by how often the participant used each device of television, computer and smartphone, and screen time was calculated by the sum time of all electronic devices used the hour before bedtime.

The diagnostic measures included the Pittsburgh Sleep Quality Index (PSQI) and Morningness-Eveningness Questionnaire (MEQ), used for sub-question 2 and 3 to understand sleep behaviors and assess chronotype.

To measure sleep quality and behavior, the PSQI was used. It consists of 19 self-rated questions and is grouped into seven component scores to measure sleep quantity and quality including, sleep latency, sleep duration, habitual sleep efficiency, the frequency, and severity of specific sleep-related problems, sleep medication, daytime dysfunction, and sleep quality over the last 4 weeks (Lai & Say, 2013). The seven component scores are summed to calculate a global PSQI score and the sum score of "5" or greater indicates poor sleep quality while less than "5" indicates good sleep quality. A sum score of greater than "10", which indicates severe sleep problem or sleep disorder. The PSQI sum score was reported with a good specificity and sensitivity between 0.82 and 0.89 (Schlarb et al., 2017).

To assess chronotype or the sleeping habit, the MEQ was used. Candidates were required to answer a total of 19 questions about preferred time for getting up, going to bed, practicing physical exercise or working in day time or evening time, and feeling during the day time. A sum score was calculated to differentiate the student as morning types (people with morningness) or evening types (people with eveningness) as five levels: Definitely morning type (70-86); moderately morning type (59-69); neither type (42-58); moderately evening type (31-41) and definitely evening type (16-30) (Schlarb et al., 2017).

This project has been followed by the Research Committee of Life University, Cambodia. While conducting this research study, all individuals and the parent/guardian participating in this study signed informed consent forms and answers given by all respondents were anonymously and confidentially processed.

Statistical analysis was done using SPSS version 16.0 (SPSS Inc. USA). For comparisons, group differences were analyzed using Chi-square test or Student's t Test or ANOVA. Furthermore, Spearman's correlations were carried between the sleep patterns, behavior and sleep-related variables. In all analyses, $P<0.05$ (2-tailed) was considered statistical significant.

Results

General characteristics

Sleep survey was distributed to a total of 528 students and 392 responded and attempted the questionnaire, yielding an initial response rate of

Table 1. Comparison of sleep patterns and behavior based on grade

Variable		Grade			p*
		Year 10 n (%)	Year 11 n (%)	Year 12 n (%)	
High School		118 (39.9)	94 (31.8)	84 (28.4)	
BMI		20.18(±3.98)	19.53(±3.39)	20.29(±3.56)	0.309
Fast food	(times/week)	2.59(±1.50)	2.86(±1.73)	3.67(±3.03)	0.002
Total Screen time	(min ± SD)	194.04(±154.62)	216.64(±160.02)	202.50(±238.65)	0.673
TV Time	(min ± SD)	33.26(±56.06)	25.79(±54.13)	24.23(±50.44)	0.432
Computer Time	(min ± SD)	17.22(±37.01)	14.04(±34.78)	16.01(±39.01)	0.823
Smartphone Time	(min ± SD)	143.56(±132.25)	176.81(±139.69)	162.26(±197.72)	0.299
Awaken rate by smartphone	(times/week)	0.97(±1.39)	0.71(±1.18)	1.27(±1.91)	0.046
MEQ Score		55.48(±6.46)	54.39(±7.58)	53.60(±7.29)	0.166
Sleep Time	(hr ±SD)	22.12(±1.01)	22.31(±0.86)	22.73(±1.00)	0.000
Sleep latency	(min ± SD)	22.96(±19.11)	21.17(±18.74)	19.23(±13.61)	0.332
Rise Time	(hr ± SD)	6.00(±0.84)	6.03(±0.85)	6.11(±0.73)	0.654
Sleep Duration	(hr ± SD)	7.53(±1.40)	7.66(±1.09)	7.12(±1.15)	0.010
PSQI Score		5.73(±2.34)	4.88(±1.90)	5.48(±2.47)	0.024
Based on MEQ score					
Morning Type	(59 ~ 86)	39	30	21	0.590
Intermediate Type	(42 ~ 58)	76	59	60	
Evening Type	(30 ~ 41)	3	5	3	
Based on PSQI score					
Bad Sleeper	(≥ 6)	53	32	33	0.273
Good Sleeper	(< 6)	65	62	51	

*p-value ANOVA test

74.2%. Out of the 392 responses, 96 (24.4%) of them were excluded from the study because they were incomplete answers, had lack of consent of the participants or their parents, and had chronic disease. With final respondents 296 (56.0%) students consisted of 149 (50.3%) females and 147 (49.7%) males, ranged between 13 to 20 years old with a mean age of 16.32 (±1.29 years). Among these 296 students, 118 (39.9%) were Grade 10 students, 94 (31.8%) were Grade 11 students and 84 (28.4%) were Grade 12 students. Average BMI was 20.01 (±3.69) and the frequency of having fast food or fried food was 2.98 (±2.15) times a week. There was a statistically significant difference between grades and the rate of having fast food (F=6.57, p=0.002) (Table 1). No significant difference was observed between genders considering BMI and the rate of having fast food.

The average time for watching TV was 28.32 (±53.87) minutes a day, however, 135 (45.6%) students did not watch TV. Spending time for using a computer or notebook was 15.87 (±36.80) minutes daily and only 104 (35.1%) students were involved. Most of the students, 277 (93.6%), had time using smartphone with an average of 159.43 (±155.84) minutes. 225 (76%) students slept putting their smartphone in the bed with "Off" for 33 (14.66%) students, "Vibration" for 51 (22.67%), and "On" mode for 141 (62.67%). 125 (42%) students were awake due to the smartphone and the average was 0.97 (±1.51) rate a week.

Sleep patterns and behaviors

The average bedtime of the students was 10.20 p.m. (±1.23 hours) and rise time was at 6.00 a.m. (±0.81 hours). In the whole sample, 8.4% reported sleep latency of more than 30 min, with an average of 21.33 (±17.61) minutes. They had an average of 7.69 (±1.14) hours of daily sleep duration. The results showed that sleep time and rise time was significant correlated with time spending with smartphone (r=0.229, p=0.000; r=0.216, p=0.000, respectively) (Table 6).

There was a statistically significant difference between grades and sleep duration (F=4.636, p=0.010) (Table 1), however, no association of gender with sleep duration was observed. Statistically, a significant difference was

Table 2. Comparison of sleep patterns and behavior based on phone behavior

Variable	Phone in bed		p*	Phone mode			p**
	No M (SD)	Yes M (SD)		Off M (SD)	Vibration M (SD)	On M (SD)	
Sleep Time (hr ±SD)	22.05(±0.93)	22.45(±0.99)	0.003	22.13(±0.98)	22.54(±1.15)	22.45(±0.91)	0.012
Sleep latency (min ± SD)	17.93(±14.31)	22.40(±18.43)	0.062	19.88(±15.55)	24.33(±21.38)	21.31(±17.53)	0.337
Rise Time (hr ± SD)	6.08(±0.76)	6.03(±0.83)	0.612	6.09(±0.78)	6.05(±0.95)	6.00(±0.78)	0.689
Sleep Duration (hr ± SD)	7.72(±1.07)	7.38(±1.30)	0.044	7.55(±1.28)	7.35(±1.56)	7.42(±1.11)	0.592
PSQI Score	5.00(±2.06)	5.51(±2.32)	0.098	5.14(±2.44)	5.63(±2.48)	5.48(±2.06)	0.367
MEQ Score	56.66(±5.38)	53.95(±7.44)	0.005	55.91(±6.44)	53.92(±7.30)	53.88(±7.38)	0.064
Awaken Rate by smartphone	0.48(±1.19)	1.13(±1.56)	0.001	0.49(±1.14)	1.37(±1.98)	1.18(±1.47)	0.000

*p-value T test **p-value ANOVA test

Table 3. Comparison of the incidence of frequency of sleep disturbance

Reason for having trouble sleeping	Not during the past month n (%)	Less than a week n (%)	Once or twice a week n (%)	3 or more times a week n (%)
cannot get to sleep within 30 minutes	99 (33.4)	93 (31.4)	77 (26.0)	27 (9.1)
wake up in the middle of the night or early morning	87 (29.4)	97 (32.8)	73 (24.7)	39 (13.2)
have to get up to use the bathroom	94 (31.8)	78 (26.4)	63 (21.3)	61 (20.6)
cannot breathe comfortably	158 (53.4)	90 (30.4)	35 (11.8)	13 (4.4)
cough or snore loudly	204 (68.9)	60 (20.3)	23 (7.8)	9 (3.0)
feel too cold	104 (35.1)	93 (31.4)	68 (23.0)	31 (10.5)
feel too hot	111 (37.5)	97 (32.8)	62 (20.9)	26 (8.8)
have bad dreams	119 (40.2)	105 (35.5)	50 (16.9)	22 (7.4)
have pain	193 (65.2)	66 (22.3)	23 (7.8)	14 (4.7)

Table 4. Comparison of sleep patterns, behavior and variables based on sleep quality

Variable		Sleep quality (based on PSQI score)		p*
		Good Sleeper M (SD)	Bad Sleeper M (SD)	
Body weight		51.94(±10.95)	55.62(±12.76)	0.008
BMI		19.57(±3.40)	20.66(±4.01)	0.013
Fast food	(times/week)	2.99(±2.05)	2.97(±2.31)	0.912
TV Time	(min ± SD)	27.92(±45.59)	28.93(±64.60)	0.875
Computer Time	(min ± SD)	12.47(±26.95)	17.98(±48.05)	0.422
Smartphone Time	(min ± SD)	145.84(±142.14)	179.92(±173.11)	0.065
Total Screen Time	(min ± SD)	188.23(±161.78)	226.83(±210.71)	0.076
Awaken Rate by phone	(times/week)	0.91(±1.56)	1.07(±1.43)	0.379
MEQ Score		55.44(±6.57)	53.34(±7.67)	0.012
Sleep Time	(hr ± SD)	22.21(±0.95)	22.56(±1.02)	0.003
Sleep latency	(min ± SD)	17.24(±12.38)	27.50(±22.10)	0.000
Rise time	(hr ± SD)	6.02(±0.66)	6.07(±1.00)	0.616
Sleep duration	(hr ± SD)	7.90(±0.94)	6.79(±1.38)	0.000

*p-value T test

Table 5. Comparison of sleep chronotypes based on sleep quality

Sleep chronotype (based on MEQ score)	Sleep quality (based on PSQI score) Good Sleeper n (%)	Bad Sleeper n (%)	p*
Morning Type	63 (70)	27 (30)	
Intermediate Type	110 (56.4)	85 (43.6)	0.025
Evening Type	4 (36.4)	7 (63.6)	

*p-value Chi-Square test

observed between genders and spending time on the computer of daily total time (t=3.35, p=0.001), however, it was not the total amount of screen time.

Sleep quality

As measured by PSQI, 35 (11.8%) students reported that their overall sleep was very good, 228 (77%) - fairly good, and 33 (11.1%) - fairly bad. The total score of PSQI was above the cutoff for good sleepers suggesting that sleep quality was impaired. More specifically, the average was 5.39 (±2.27), and the majority of the students (60.1%) were good sleepers, 118 (39.9%) students had impaired sleep quality with a PSQI total score above 5, and 11(3.7%) students had severe sleep problems according to the PSQI (>cut-off 10). Sleep time, sleep latency and sleep duration were significantly related to sleep quality (p=0.003, p=0.000, p=0.000, respectively) (Table 4). Genders and grades did not differ concerning the proportion of bad sleep quality and severe sleep problems.

Results indicated students' genders showed no differences in overall sleep quality, as the number of female students who had good sleep quality (n=131; 87.9%) was similar to males (n=132; 89.8%) – consistent with the PSQI scores which showed no significant difference. However, there were significant differences in overall sleep quality between grades regarding sleep time, sleep duration and PSQI score (p=0.000, p=0.010, p=0.024, respectively) (Table 1).

The result showed that the self-reported incidence of frequency of sleep disturbance based on the PSQI survey (Table 3).

More specifically, students' genders were significant differences in having a bad dream and coughing or snoring loudly. Girls experienced bad dreams significantly more often (χ^2=9.60, p=0.022), and boys showed more sleeping trouble with cough or snore loudly than girls (χ^2=13.93, p=0.003). Between grades, sleeping trouble resulting in their inability to get to sleep within 30 minutes (χ^2=13.45, p=0.036) was observed with significant differences.

Although many students were reported as significantly facing sleep disturbance, only 33 students admitted to taking medicine to help them sleep. 84 (28.4%) students of them had no problems at all in having enough energy in getting things done, 148 (50%) students had only a very slight problem, 58 (19.6%) students had somewhat of a problem and only 6 (2%) students had a very big problem. Statistically, a significant difference was observed between genders and the problem with having enough energy in getting things done (χ^2=19.70, p=0.000).

Most of the students (M=105, F=113) had no bed partner/roommate. Among the 78 students who had sleep partners/roommate, 33 (M=13, F=20) students reported that they slept on in the same bed. More specifically, 8 (10.3%) students who slept on in the same bed with partners/roommates reported legs twitching while sleep once or twice a week and 10 (12.8%) thrice or more often. For episodes of disorientation during sleep, 10 (12.8%) had once or twice a week and 9 (11.5%) thrice or more often.

Chronotype

Concerning chronotype based on MEQ score, in the whole sample, 32.1% were morning types, 64.2% were neutral types and 3.7% declared to be evening types, and the average was 54.60 (±7.09). In this study, 101 of the students were categorized into moderately (n=85), definitely morning (n=5), moderately (n=9) and definitely evening type (n=2). A significant difference was identified between sleep chronotypes based on MEQ score and sleep quality based on PSQI score (χ^2=7.34, p=0.025) (Table 5).

MEQ score was significantly correlated with PSQI score, time spending with a smartphone, and the total amount of screen time, indicating that there was negative relationship (r=- 0.174,

Table 6. Correlation of sleep patterns, behaviour and MEQ Score among the variables

variables	r	p*	variables	r	p*
Smartphone Time and MEQ	-0.268	0.000	Age and Sleep Time	0.153	0.008
Smartphone Time and PSQI Score	0.137	0.018	Age and Rise Time	0.126	0.030
Total Screen Time and MEQ Score	-0.280	0.000	Fast Food craving and MEQ Score	-0.170	0.003
Total Screen Time and PSQI Score	0.109	0.060	BMI and PSQI score	0.173	0.003
Smartphone Time and Sleep time	0.229	0.000	MEQ Score and Sleep time	-0.369	0.000
Smartphone Time and Rise Time	0.216	0.000	MEQ Score and Rise time	-0.207	0.000
Smartphone Time and Sleep duration	-0.123	0.034	MEQ Score and Sleep duration	0.194	0.001
Total Screen Time and Sleep duration	-0.116	0.046	MEQ Score with PSQI score	-0.174	0.030

*p-value Pearson Correlation test

p=0.030; r=-0.268, p=0.000; r=-0.280, p=0.000, respectively) between morningness-eveningness and sleep quality of the students in this study. A significant relationship was with MEQ score considering sleep time, rise time and sleep duration (r=-0.369, p=0.000; r=-0.207, p=0.000; r=0.194, p=0.001, respectively) (Table 6). There was no significant difference in the MEQ scores concerning genders and grades.

BMI, food craving of high-calorie foods and sleep quality

The results showed that BMI was significantly correlated with all PSQI score (r=0.173, p=0.003) (Table 6) and sleep amount (F=3.560, p=0.030). Body weight and BMI were significantly related to sleep quality (p=0.008, p=0.013, respectively) (Table 4).

However, BMI was not correlated with MEQ scores (r=0.048, p=0.409). Similarly, BMI class was not associated with the total sleep time. Meanwhile high-calorie food craving had a significant correlation with MEQ (r=- 0.170, p=0.003) (Table 6), but not PSQI (r=- 0.004, p=0.943).

Smartphone and sleep quality

There was a statistically significant difference between grades and the rate awakened by smartphone (F=3.12, p=0.046) (Table 1). Additionally, there was a significant difference between sleep with the smartphone in bed regarding sleep time, sleep duration, MEQ score, and awaken rate by smartphone (p=0.003, p=0.044, p=0.005, p=0.001, respectively). A significant difference was noticed between smartphone sound mode and sleep time, and awaken rate by smartphone (p=0.012, p= 0.000, respectively) (Table 2).

Discussion

This study aimed to assess sleep habits and patterns that affect sleep quality and the factors that increase the risk of sleep deprivation among Cambodian high school students. In this cross-sectional study, a sample of 392 adolescents was investigated by using a self-administered questionnaire. The study found that the mean reported sleep duration was 7. 69 (±1.14) hours, bedtime was 10.20 p.m. (±1.23) hours, and rise time was 6.00 a.m. (±0.81) hours.

Students reported that 39.9% were categorized as poor-quality sleepers by the PSQI score and 51.4% did not have the appropriate amount of sleep (<8 hours). This finding is consistent with other surveys on high school students who reported 56% had not proper sleep duration (Chahine et al., 2018). In Canada, approximately 70% of adolescents complained about not enough sleep duration compared with the recommended amount for their age (Brown et al., 2017). However, result in this study indicated that only 11.1% of students reported that their overall sleep was fairly bad compared with 11.8 % who reported that theirs was very good and 77% was fairly good as the PSQI subclass question. Similarly, 74.11% of students presented their sleep quality as good compared with 25.88% who had a poor quality of sleep (Badicu, 2018).

Another interesting finding was that higher grade students identified later sleep time and less sleep duration. The analysis in this study supported the other studies that the difference in

sleep time and sleep duration were significant difference among groups divided into three age-related (11 to 18 years old) (Muluk et al., 2015). In the group of grade 9 to 12 students there was a decrease in total sleep time reported with the higher grades and a significantly longer sleep duration in ninth Grade compared with other groups (Gupta et al., 2008).

A significant finding was that between sleep chronotypes based on MEQ score and sleep quality based on the PSQI score. There was a negative correlation between the MEQ score and PSQI score. Research showed that the students with higher MEQ scores had significantly higher academic performance, and were likely to have lower PSQI scores (Cho et al., 2019). However, in Malaysia study reported that there was no significant correlation between MEQ and PSQI score (Lai & Say, 2013). It might be that all of the students in their study reported as categorized into neither type, definitely and moderately morning type.

Findings revealed a significant correlation between BMI and PSQI scores. This result supports that the relationship between BMI and sleep quality was identified (Moore et al., 2011, Herrmann et al., 2018). Further, this study found that there was a significant correlation between BMI and sleep duration. On the contrary, researchers have discovered that BMI was not correlated with PSQI, MEQ scores, and sleep duration (Lai & Say, 2013). Based on the demographic results, the higher grade students identified a significantly high rate of high-calorie foods. However, there were no differences in BMI.

Regarding sleep quality, sleeping with the smartphone in bed and smartphone sound mode had a significant negative effect on sleep quality; sleep time, sleep duration, MEQ score, and awaken rate by smartphone. 277 (93.6%) students had time using smartphone with an average of 159.43 (±155.84) minutes. In addition, 225 (76%) students fell asleep with their smartmobile in the bed with while only 33 (14.66%) students were setting the mode “Off”. 125 (42%) students reported disturbance in their sleep due to the smartphone and the average was 0.97 (±1.51) rate a week. This finding is consistent with other surveys. An increasing mobile phone addiction level was correlated with decreasing sleep quality (Sahin et al., 2013). Using a smartphone longer resulted in a later bedtime, however, there was no relation with sleep disturbance (Lemola et al., 2015). In high school students who were using more smartphones at night showed significantly a decreasing academic performance (Cho et al., 2019).

One problem with the study is that the analyses are based on self-reported data on sleep quality. Any other objective measures of sleep were not used to quantify the data. However, although additional standardized measures were considered to support the quality of the survey of perceived sleep quality, the survey will be used for further studies to reduce participant load and increase survey completion rates.

It may be another limitation to generalize the findings to all high school students in Cambodia or to other racial or ethnic groups while the participants represent a single school-based sample of sleep quality in Cambodia.

Another limitation of this study is that no information was taken from the participants on sleep disorders and other comorbidities. Although some chronic health problems were excluded, sleep disorders other than insomnia could not be excluded. Even though the prevalence is very low in adolescents, consequently, the possibility was not ruled out that some of the sleep complaints are associated with these disorders. Further, the details of hypnotics (e.g. type, dosage, and duration of exposure) were not collected.

Further studies in larger groups conducting in a broader set up in a multi-centric way are recommended in view of the potentially significant impact of sleep deprivation in this age group.

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