A GOOD SLEEP: THE ROLE OF FACTORS IN PSYCHOSOCIAL HEALTH

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A GOOD SLEEP: THE ROLE OF FACTORS IN PSYCHOSOCIAL HEALTH

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Editorial: A Good Sleep: The Role of Factors in Psychosocial Health

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Editorial on the Research Topic

A Good Sleep: The Role of Factors in Psychosocial Health

A good night's sleep is vital for individuals of all ages to have effective cognitive and emotional processing (Kopasz et al., 2010; Yaffe et al., 2014; Garbarino et al., 2016; Tarokh et al., 2016). Furthermore, prior evidence shows that sleep is associated to physical and mental health, and to overall quality of life (Gradisar et al., 2008; Shochat et al., 2014; Garbarino et al., 2016), and therefore a good sleep is of great importance (Lin C.-Y. et al., 2018; Lin P.-H. et al., 2018). Unfortunately, it is not always easy for many people to achieve good sleep (Strong et al., 2018), especially in modern society that has rapid growth in technology. Indeed, a recent systematic review and meta-analysis found that internet addiction is highly associated with sleep disturbance (Alimoradi et al., 2019). Similarly, recent research shows the association between problematic social media use and poor sleep, which indicates a contemporary public health problem concerning sleep (Wong et al., 2020). In short, there is a need to investigate how different psychosocial factors are related to sleep in different stages of life.

Therefore, this special issue focuses on a variety of psychosocial factors associated with sleep in different age groups and contexts and comprises a systematic review and meta-analysis together with eight empirical papers. The systematic review and meta-analysis investigated by Magnavita et al. screened 749 studies, of which 34 were reviewed and seven were included in meta-analysis. They concluded that sleep problems could be increased by workplace violence (OR = 2.55; 95% CI = 1.77–3.66). In addition to the systematic review and meta-analysis, the other eight studies included in the special issue demonstrate the variety of different psychosocial factors that contribute to sleep across different populations. More specifically, four studies comprised Taiwanese populations, including female college students (Lin et al.), adolescents (Ho et al.; Hsieh et al.), and children (Lin), one study comprised Hong Kong children (Chien et al.), one study comprised the Polish general population (Herzog-Krzywoszanska and Krzywoszanski), and two studies comprised Swedish adolescents (Hedin et al.; Hena and Garmy).

Lin et al. recruited 503 female college students and found that students with a moderate to severe level of internet addiction had significantly poorer sleep quality than did those with mild or normal levels of internet addiction. Furthermore, those with mild levels of internet addiction had significantly poorer sleep quality than those not addicted to the internet. Logistic regression analysis further demonstrated the association between internet addiction and sleep quality (odds ratio = 1.05 95% CI = 1.03–1.06, $p < 0.01$). These findings echo the findings of the aforementioned systematic review and meta-analysis (Alimoradi et al., 2019).

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Ho et al. utilized a longitudinal secondary dataset (i.e., Taiwan Youth Project; Yi et al., 2009) and a marginal structural model with stabilized inverse probability-of-treatment weights to investigate the association between unhealthy sleep practice and substance use. Their findings indicated some degree of causality showing that unhealthy sleep practice leads to adulthood substance use. A similar association between sleep and alcohol abuse was found in another study comprising Taiwanese adolescents (Hsieh et al.) Hsieh et al. used data from the 2009 Project for the Health of Children and Adolescents in Southern Taiwan (Yen et al., 2010) and found that insomnia may result from alcohol abuse, suicidality, depression, and anxiety among 6,445 high school students.

Lin collected information from 320 Taiwanese child-parent dyads in a community-centered elementary school using a 12-week longitudinal design. She used an instrument with objective measures (i.e., a Xiaomi Mi Band 2 pedometer; Xie et al., 2018) to assess children's sleep over 12 consecutive weeks (i.e., the children were requested to wear the pedometer on their wrists during the 12 weeks). Moreover, parents of the children completed the Kid-KINDL (Lin et al., 2017; Lin, 2018) to assess the children's quality of life before they wore the pedometer. Her results found that better quality of life may lead to better sleep.

Chien et al. found in a study comprising 391 Hong Kong children that homework involvement was positively related to children's weekday sleep duration, and that frequency of television watching was negatively related to their weekday sleep duration. Moreover, overall participation in school activities was positively related to children's weekend sleep duration. However, given that Chien et al. used cross-sectional design, the causality was undetermined.

Herzog-Krzywoszanska and Krzywoszanski used two Polish samples to investigate factors related to bedtime procrastination. Their first sample comprised university students ($n = 431$) and their data were utilized to validate a Polish version scale of the Bedtime Procrastination Scale (BPS; Kroese et al., 2016). After confirming the good psychometric properties of the BPS, Herzog-Krzywoszanska and Krzywoszanski found that studying or working needs may delay bedtime in their second sample of general population ($n = 335$). However, similar to the study of Chien et al., the study was cross-sectional and cannot provide strong evidence of causal relationships.

Hena and Garmy used a cross-sectional study on Swedish adolescents ($n = 1{,}518$) and found that social jetlag (defined as the difference between bedtime and wake-up time on school days compared to holidays larger than 2 h; Wittmann et al., 2006) was significantly associated with increased screen time. This echoes Lin et al. 's findings of internet addiction's association with poor sleep. In the final paper, Hedin et al. conducted a qualitative study exploring the facilitators and barriers for a good night's sleep among adolescents ($n = 45$). Their findings indicated that adolescents understood and appreciated commonly recommended strategies for improving sleep. However, it was hard to balance their sleep and other activities. Consequently, they concluded that assisting adolescents to overcome the dilemma of finding a balance between sleep and other activities is crucial when designing sleep-promotion interventions.

AUTHOR CONTRIBUTIONS

C-YL wrote the first draft. AP, MG, MO, and AB provided critical comments and editorial suggestions for revisions. All the authors agreed on the submitted version.

REFERENCES

Alimoradi, Z., Lin, C. -Y., Broström, A., Bülow, P. H., Bajalan, Z., Griffiths, M. D., et al. (2019). Internet addiction and sleep disorders: a systematic review and meta-analysis. *Sleep Med. Rev.* 47, 51–61. doi: 10.1016/j.smrv.2019.06.004

Garbarino, S., Lanteri, P., Durando, P., Magnavita, N., and Sannita, W. G. (2016). Co-morbidity, mortality, quality of life and the healthcare/welfare/social costs of disordered sleep: a rapid review. *Int. J. Environ. Res. Public Health* 13:831. doi: 10.3390/ijerph13080831

Gradisar, M. M., Terrill, G. G., Johnston, A. A., and Douglas, P. P. (2008). Adolescent sleep and working memory performance. *Sleep Biol. Rhythms* 6, 146–154. doi: 10.1111/j.1479-8425.2008.00353.x

Kopasz, M., Loessl, B., Hornyak, M., Riemann, D., Nissen, C., Piosczyk, H., et al. (2010). Sleep and memory in healthy children and adolescents – A critical review. *Sleep Med. Rev.* 14, 167–177. doi: 10.1016/j.smrv.2009.10.006

Kroese, F. M., Evers, C., Adriaanse, M. A., and de Ridder, D. T. (2016). Bedtime procrastination: a self-regulation perspective on sleep insufficiency in the general population. *J. Health Psychol.* 21, 853–862. doi: 10.1177/1359105314540014

Lin, C.-Y. (2018). Comparing quality of life instruments: sizing them up versus PedsQL and Kid-KINDL. *Soc. Health Behav.* 1, 42–47. doi: 10.4103/SHB.SHB_25_18

Lin, C.-Y., Strong, C., Tsai, M.-C., and Lee, C.-T. (2017). Raters interpret positively and negatively worded items similarly in a quality of life instrument for children: Kid-KINDL. *Inquiry* 54, 1–7. doi: 10.1177/0046958017696724

Lin, C. -Y., Strong, C., Scott, A. J., Broström, A., Pakpour, A. H., and Webb, T. L. (2018). A cluster randomized controlled trial of a theory-based sleep hygiene intervention for adolescents. *Sleep* 41:zsy170. doi: 10.1093/sleep/zsy170

Lin, P.-H., Lin, C.-Y., Wang, P.-Y., and Yang, S.-Y. (2018). Association between sleeping duration and health-related behaviors in college student. *Soc. Health Behav.* 1, 31–36. doi: 10.4103/SHB.SHB_16_18

Shochat, T., Cohen-Zion, M., and Tzischinsky, O. (2014). Functional consequences of inadequate sleep in adolescents: a systematic review. *Sleep Med. Rev.* 18, 75–87. doi: 10.1016/j.smrv.2013.03.005

Strong, C., Lin, C.-Y., Jalilolghadr, S., Updegraff, J. A., Broström, A., and Pakpour, A. H. (2018). Sleep hygiene behaviors in Iranian adolescents: an application of the Theory of Planned Behavior. *J. Sleep Res.* 27, 23–31. doi: 10.1111/jsr.12566

Tarokh, L., Saletin, J. M., and Carskadon, M. A. (2016). Sleep in adolescence: physiology, cognition and mental health. *Neurosci. Biobehav. Rev.* 70, 182–188. doi: 10.1016/j.neubiorev.2016.08.008

Wittmann, M., Dinich, J., Merrow, M., and Roenneberg, T. (2006). Social jetlag: misalignment of biological and social time. *Chronobiol. Int.* 23, 497–509. doi: 10.1080/07420520500545979

Wong, H. Y., Mo, H. Y., Potenza, M. N., Chan, M. N. M., Lau, W. M., Chui, T. K., et al. (2020). Relationships between severity of internet gaming disorder, severity of problematic social media use, sleep quality and psychological distress. *Int. J. Environ. Res. Public Health* 17:1879. doi: 10.3390/ijerph17061879

Xie, J., Wen, D., Liang, L., Jia, Y., Gao, L., and Lei, J. (2018). Evaluating the validity of current mainstream wearable devices in fitness tracking under

various physical activities: comparative study. *JMIR mHealth uHealth,* 6:e94. doi: 10.2196/mhealth.9754

Yaffe, K., Falvey, C. M., and Hoang, T. (2014). Connections between sleep and cognition in older adults. *Lancet Neurol.* 13, 1017–1028. doi: 10.1016/S1474-4422(14)70172-3

Yen, C. F., Ko, C. H., Wu, Y. Y., Yen, J. Y., Hsu, F. C., and Yang, P. (2010). Normative data on anxiety symptoms on the multidimensional anxiety scale for children in Taiwanese children and adolescents: differences in sex, age, and residence and comparison with an American sample. *Child Psychiatry Hum. Deve.* 41, 614–623. doi: 10.1007/s10578-010-0191-4

Yi, C.-C., Wu, C.-I., Chang, Y.-H., and Chang, M.-Y. (2009). The psychological well-being of Taiwanese youth: School versus family context from early to late adolescence. *Int. Sociol.* 24, 397–429. doi: 10.1177/0268580909102914

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The Relationship Between Sleep Quality and Internet Addiction Among Female College Students

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Background: Over 40% of Taiwanese College students experience sleep problems that not only impair their quality of life but also contribute to psychosomatic disorders. Of all the factors affecting the sleep quality, internet surfing is among one of the most prevalent. Female college students are more vulnerable to internet-associated sleep disorders than their male counterparts. Therefore, this study aims to investigate (1) the relationship between internet addiction and sleep quality, and (2) whether significant variations in sleep quality exist among students with different degrees of internet use.

Methods: This structured questionnaire-based cross-sectional study enrolled students from a technical institute in southern Taiwan. The questionnaire collected information on the following three aspects: (1) demography, (2) sleep quality with Pittsburgh Sleep Quality Index (PSQI), and (3) severity of internet addiction using a 20-item Internet Addiction Test (IAT). Multiple regression analysis was performed to examine the correlation between PSQI and IAT scores among the participants. Logistic analysis was used to determine the significance of association between PSQI and IAT scores.

Results: In total, 503 female students were recruited (mean age 17.05 ± 1.34). After controlling for age, body mass index, smoking and drinking habits, religion, and habitual use of smartphone before sleep, internet addiction was found to be significantly associated with subjective sleep quality, sleep latency, sleep duration, sleep disturbance, use of sleep medication, and daytime dysfunction. Worse quality of sleep as reflected by PSQI was noted in students with moderate and severe degrees of internet addiction compared to those with mild or no internet addiction. Logistic regression analysis of the association between scores on IAT and sleep quality, demonstrated significant correlations between quality of sleep and total IAT scores (odds ratio = 1.05:1.03 ∼ 1.06, $p < 0.01$).

Conclusion: The results of this study demonstrated significant negative association between the degree of internet addiction and sleep quality, providing reference for educational institutes to minimize adverse effects associated with internet use and improve students' sleep quality.

Keywords: sleep quality, internet dependence, Pittsburgh Sleep Quality Index, Internet Addiction Test, college students

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INTRODUCTION

Adequate sleep is essential for growth hormone secretion that is required for normal physical development, particularly in adolescents. Previous studies revealed sleep problems in up to 40% of Taiwanese college students (Kang and Chen, 2009; Lin et al., 2018). With the increasing popularity of smartphones together with all its advanced technology, the use of the smartphone before sleep has become a habit for adolescents that could prolong sleep latency and decrease sleep duration (Yang et al., 2019). Of all the factors affecting sleep quality in college students, internet use is among one of the most prevalent. A previous study has shown that college students in Taiwan spend an average of up to 16.27 h per week on the Internet. Furthermore, the sleep quality of over half of those students was found to be adversely affected by the use of internet for chatting, playing games, and watching movies before sleeping (Lin et al., 2015). Previous studies have already underscored the link between internet use and sleep quality. A study investigating the correlation between internet use and sleep in 380 medical students concluded that overuse of mobile phones and social networks could impair sleep quality (Mohammadbeigi et al., 2016).

A number of studies have reported a poorer sleep quality in female college students than that in their male counterparts (Cheng et al., 2012; Surani et al., 2015; Saygın et al., 2016). Although the finding may be attributable to puberty-related female hormonal changes such as sleep quality impairment during menstruation (Baker and Driver, 2007; Orff et al., 2014), the increasing popularity of daily electronic product use (e.g., smartphones) also has an important part to play in sleep quality impairment in females (Hysing et al., 2015; Liu et al., 2018). The issue was further highlighted in another study showing a significantly higher mental impact of smartphone use on female adolescent students than that on males (Yang S.-Y. et al., 2018). The long-term indulgence in internet usage among college students could be attributed to the easy accessibility of their electronic devices to the internet that enables their participation in a variety of entertaining and social activities (e.g., online games, movies, and social media).

Regarding gender difference in susceptibility to internet-associated sleep disturbance, a study based on 4,750 adolescents has shown a significant increased risk in females compared to that in males (Yang J. et al., 2018). Together with the finding that female college students are more likely to develop internet dependence than male students (Chiu et al., 2013), the issue of the effect of internet addiction on sleep quality in female college students needs to be seriously addressed. The correlation between the extent of internet use and the quality of sleep among female college students needs more attention. In an attempt to elucidate the correlation between Internet addiction and sleep deprivation and to provide reference for minimizing inappropriate internet use to facilitate sleep quality improvement in female college students, the present study aimed at exploring (1) the correlation between internet addiction and sleep quality in female college students, and (2) whether variations in sleep quality exist among students with different degrees of internet use.

MATERIALS AND METHODS

Study Design and Subject Recruitment

This cross-sectional study recruited college students from a technical institute in southern Taiwan who were required to complete a structural questionnaire between September 15 and November 15, 2018. Full explanation was given to all participants who were fully aware of their right to withdraw from participation anytime during the study period. Inclusion criteria were participants who were (1) female, (2) able to communicate in Mandarin Chinese, and (3) willing to complete the questionnaire. Individuals who were (1) pregnant or had children, (2) participating in night-time jobs at the time of this study, (3) unable to complete the questionnaire, or (4) diagnosed with psychiatric disorders regardless of severity were excluded from the present study. Ethical approval for the study was obtained from the National Cheng Kung University Human Research Ethics Committee (No. NCKU HREC-E-106-108-2). All participants gave their informed consents before participating in the present study. A total of 505 female college students were invited and returned written consents and were recruited into the study. Additionally, written informed consent was obtained from the parents or guardians of the participants who were under the age of 16. Sample size was estimated using G-power software (3.1.0). Based on a previous study in which R^2 was reported to be 0.06 (Tan et al., 2016). 350 subjects were needed after estimating the condition of a type I error 0.05 to a power of 0.95.

Research Instrument

All participants were required to complete a structural questionnaire that comprised of three parts. Because past studies have pointed out that some demographic variables such as smoking and drinking habits are predictors of sleep quality (Vargas et al., 2014; Warren et al., 2017; Hill et al., 2018; Kesintha et al., 2018; Yang et al., 2019), we collected variables that can affect sleep quality in Part One of the questionnaire. Part One included information on demography (i.e., age), anthropometry [i.e., body weight and height, body mass index (BMI)] as well as habits of tobacco consumption (defined as the smoking of at least one cigarette per day in the past 6 months) and alcohol consumption (defined as the drinking of alcoholic beverages at least once per week in the past 6 months), religious beliefs, and the habit of smartphone use before sleep (defined as smartphone use within 1 h before going to sleep at a frequency of at least five nights per week in the past 6 months).

Part Two of the questionnaire assessed the quality of sleep by using the Taiwanese version of the Pittsburgh Sleep Quality Index (PSQI) which is a parameter based on self-reported items in a questionnaire first developed by Buysse et al. (1989) and is one of the popular tools for the evaluation of sleep quality in the past 1 month. PSQI contained seven items each of which carries a score of 0 to 3 that signifies the frequency of each condition mentioned in each item, giving a range of scores between 0 and 21 (Buysse et al., 1989). The higher the score, the poorer the quality of sleep. The seven items assessed seven aspects of sleep quality: (1) Subjective sleep quality: Self-reported

satisfaction with sleep quality in the past 1 month. The higher the score, the more unsatisfactory the subject felt; (2) Sleep latency: A higher score signifies a longer time required for falling asleep after going to bed; (3) Sleep duration: A higher score denotes a shorter sleep duration; (4) Habitual sleep efficiency: The higher the score, the lower the efficiency; (5) Sleep disturbances: The higher the score, the more severe the disturbance; (6) Use of sleep medication: A higher score represents a more frequent requirement; and (7) Daytime dysfunction: The higher the score, the more problems one encounters when engaging in daily activities (e.g., staying awake while driving, eating, or participating in social activities (Buysse et al., 1989). In the current study, the PSQI score >5 or PSQI score ≤ 5 was chosen to distinguish the quality of sleep in each student. A total score of ≤ 5 represents satisfactory quality of sleep, whilst that of >5 signifies a poor quality of sleep (Buysse et al., 1989). The Taiwanese version of PSQI has been shown to have good reliability and validity (Tsai et al., 2005). The Cronbach's α coefficients of the PSQI were 0.74 in this study.

Part Three evaluated the severity of internet addiction through the adoption of the 20-item Internet Addiction Test (IAT) first proposed by Young (1998). Because of the popularity of IAT in assessing the degree of internet use among adults and adolescents, it has been translated into different languages (Widyanto and McMurran, 2004), and the Taiwanese version of IAT has been widely used in adolescents with good psychometrics (Dhir et al., 2015). Each of the 20 items in IAT carries a score on a Likert scale of 0 (i.e., not applicable) to 5 (i.e., always), giving a total score ranging from 0 to 100. The higher of the score, the more severe the internet addiction. There are four degrees of internet addiction according to the IAT score: A score of 0–30 reflects normal internet use, while a score of 31–49 denotes mild degree of internet addiction. At the other end of the spectrum, a score of 50–79 indicates moderate level of internet addiction, whilst a score of 80–100 signifies severe dependence upon the Internet (Young, 1998). IAT assessed six patterns of symptoms, including (1) Salience (5 items): The higher the score, the more likely that the participant focuses on the internet with possible indifference to other activities and/or relationships. A sense of boredom and emptiness may arise if internet is not available; (2) Excessive Use (5 items): The score is positively associated with excessive internet use which is defined as staying on the internet for a duration longer than expected. The individual may feel panic or frustration after prolonged inaccessibility to the internet; (3) Neglect Work (3 items): A higher score reflects the probability that the participant tends to consider the internet to be something indispensable in daily life comparable to television or telephone on which spending a considerable amount of time is justified, resulting in impaired academic or work performance as well as overall productivity; (4) Anticipation (2 items): The higher the score, the stronger the anticipation of internet access; (5) Lack of Control (3 items): A higher score indicates probable lack of self-control over the amount of time spent on the internet and that may cause annoyance to others; and (6) Neglect Social Life (2 items): A higher score suggests that the participants are likely to neglect their real-world social life and prefer to participate in social activities on the internet. Psychometric analysis has shown satisfactory reliability and validity of IAT (Widyanto and McMurran, 2004). The Cronbach's α coefficients of the IAT were 0.93 in this study.

Statistical Analysis

The statistical software of SPSS version 22.0 for Mac was used for the whole study. The participants were divided into two groups: those with PSQI score ≤ 5 (i.e., satisfactory sleep quality) and those with PSQI score >5 (i.e., poor sleep quality) according to descriptive statistics of demographic variables. Student's *t*-test (continuous variables) and Fisher's Exact Test (categorical variables) were used to analyze the significance of difference in demographic data and IAT scores between the two groups, while one-way ANOVA was utilized for determining the significance of difference in total PSQI scores and sub-scores on the seven aspects of sleep quality among normal internet users (0–30) as well as those with mild (31–49) and moderate to severe (50–100) internet addiction. *Post hoc* was tested using Tukey adjustment. After setting total PSQI scores and sub scores on the seven items as dependent variables as well as total IAT scores and scores on the six patterns of symptoms as independent variables, multiple regression analysis was performed to examine the correlation between PSQI and IAT scores among the participants. Because age (Hsieh et al., 2018; Kesintha et al., 2018), BMI (Canan et al., 2014; Vargas et al., 2014), smoking and drinking habits (Lee and Lee, 2017; Warren et al., 2017), religion (Hill et al., 2018; Nadeem et al., 2018), habitual use of smartphone before sleep (Ayar et al., 2017; Wang et al., 2019) might have impacted on sleep quality and internet addiction, thus these variables were controlled during analysis. Finally, logistic analysis was used to determine the significance of association between PSQI and IAT scores after setting the quality of sleep (i.e., 0: good; 1: poor) as dependent variable, while setting total IAT scores and scores on the six patterns of symptoms as independent variables after controlling for confounding factors. Average values are expressed as mean ± standard deviation (SD). A p value of less than 0.05 is considered statistically significant. In addition, before all regression analysis, preliminary analyses were conducted to ensure that no violation of the assumptions of normality, linearity and multicollinearity existed.

RESULTS

Demographic, Anthropometric, and Lifestyle Characteristics as Well as Sleep Quality and Level of Internet Addiction

In total, 503 female college students who completed the questionnaire were recruited for the current study, and two participants were excluded due to questionnaires incompleteness. The demographic, anthropometric, and lifestyle characteristics of the participants as well as their scores on internet addiction are shown in **Table 1**. The mean age of the participants was 17.30 ± 1.34 (range, 15 – 22). Over 95% had no habit of tobacco or alcohol consumption. On the other hand, over

TABLE 1 | Demographic, anthropometric, and lifestyle characteristics as well as sleep quality and level of internet addiction.

		Sleep quality		*p*
	Total ***N* = 503**	**Good** **(*n* = 229)**	**Poor** **(*n* = 274)**	
Age (mean ± SD)	17.30 ± 1.34	17.31 ± 1.31	17.29 ± 1.36	0.83[b]
BMI (mean ± SD)	20.57 ± 4.08	20.30 ± 3.45	20.79 ± 4.54	0.18[b]
Smoking habit (n, %)				0.01[a,*]
No	482 (95.80%)	225 (98.30%)	257 (93.80%)	
Yes	21 (4.20%)	4 (1.70%)	17 (6.20%)	
Drinking habit (n, %)				0.05[a]
No	485 (96.40%)	225 (98.30%)	260 (94.90%)	
Yes	18 (3.60%)	4 (1.70%)	14 (5.10%)	
Religion (n, %)				0.42[a]
No	258 (51.30%)	122 (53.30%)	136 (49.60%)	
Yes	245 (48.70%)	107 (46.70%)	138 (50.40%)	
Smartphone use before sleep (n, %)				0.67[a]
No	22 (4.40%)	11 (4.80%)	11 (4.00%)	
Yes	481 (95.60%)	218 (95.20%)	263 (96.00%)	
IAT level (n, %)				
Normal	164 (32.60%)	102 (44.50%)	62 (22.60%)	<0.01[a*]
Mild	265 (52.70%)	103 (45.00%)	162 (59.10%)	
Moderate	70 (13.90%)	22 (9.60%)	48 (17.50%)	
Severe	4 (0.80%)	2 (0.90%)	2 (0.70%)	
Symptoms (mean ± SD)				
Total score	37.34 ± 12.00	34.34 ± 11.32	39.85 ± 11.99	<0.01[b*]
Salience	7.58 ± 3.10	6.70 ± 2.87	8.32 ± 3.10	<0.01[b*]
Excessive use	10.22 ± 3.36	9.34 ± 3.09	10.96 ± 3.41	<0.01[b*]
Neglect of work	4.78 ± 1.86	4.61 ± 1.86	4.92 ± 1.84	0.06
Anticipation	3.64 ± 1.51	3.42 ± 1.38	3.82 ± 1.58	<0.01[b*]
Lack of control	5.66 ± 2.18	5.16 ± 2.05	6.08 ± 2.20	<0.01[b*]
Neglect of social life	4.20 ± 1.71	3.88 ± 1.61	4.47 ± 1.75	<0.01[b*]

*$p < 0.05$; [a]*Significance of difference determined using Fisher's exact test;* [b]*Significance of difference determined using Student t-test; BMI, Body mass index; and IAT, Internet Addiction Test.*

95% of participants reported habitual smartphone use before bedtime. The prevalence of a smoking habit was significantly higher in students with poor sleep quality than those with good quality of sleep ($p < 0.01$) (**Table 1**). According to IAT scores, normal Internet users and those with mild degrees of Internet dependence comprised over 80% of the study population. Students with good quality of sleep had significantly lower IAT score totals compared to the scores of those with bad sleep quality ($p < 0.01$). Consistently, with the exception of neglect of work, scores on the other five patterns of symptoms were significantly lower in participants with good sleep quality than the respective scores in those with poor sleep quality (all $p < 0.01$).

Sleep Quality in Participants With Different Degrees of Internet Addiction

ANOVA on PSQI total scores and scores on the different components in students with different degrees of internet addiction revealed significant lower scores in normal internet users and those with mild internet dependence compared to those with moderate to severe internet addiction on all items with the exception of habitual sleep efficiency (**Table 2**). The results of significant differences between the two groups in *post hoc* were also shown in **Table 2**. In the total scores, subjective sleep quality and sleep latency of PSQI, the mean scores in moderate to severe internet addiction users were significantly higher than those in mild internet dependence users and normal internet users; the mean scores in mild internet users were significantly higher than those in normal internet users (**Table 2**).

Association Between Internet Addiction and Sleep Quality

The VIFs were between 1.02∼1.03 and therefore considerably lower than the recommended threshold of 10, suggesting that multicollinearity did not exist. In addition, the study also used linearity regression method to test the relationships of the two variables with raw data. The result of **Table 3** was supported by **Appendixes 1**, **2**, which present that each symptom in Internet addiction is significantly associated with sleep quality. From an overall point of view, the results of linearity regression analysis in **Appendix 1** can reveal important data for this study.

The results of multiple regression analysis demonstrated significant associations of IAT total scores with the total score of PSQI and the sub-scores on its six items, except the item of habitual sleep efficiency (**Table 3**). Likewise, the total score of PSQI was significantly correlated with the scores on five of the six symptom patterns of internet addiction (all $p < 0.01$) with the exception of neglect of work. Focusing on the associations between different components of sleep quality and the symptom patterns of internet addiction, sleep latency was significantly related to four symptom patterns including salience ($p < 0.01$), excessive use ($p < 0.01$), anticipation ($p < 0.05$), and lack of control ($p < 0.01$). On the other hand, sleep duration was associated with three symptom patterns of internet addiction, namely, salience ($p < 0.01$), excessive use ($p < 0.01$), and lack of control ($p < 0.05$). Interestingly, habitual sleep efficiency was the only item on PSQI that showed no significant correlation with any symptom patterns of internet addiction (**Table 3**). With the exceptions of neglect of work and neglect of social life, there were significant correlations between sleep disturbance and the other four symptom patterns. In addition, use of sleep medication among the participants was associated with four of the symptom patterns of internet addiction except lack of control and neglect of social life, while daytime dysfunction was significantly related to all symptom patterns of IAT except neglect of work.

Table 4 shows that the odds ratio was 1.05, and the 95% confidence interval was 1.03∼1.06 as a risk ratio. It means that Internet addiction influenced the poor sleep quality group (coded 1) more seriously than the good sleep quality group (coded 0). After controlling for confounding variables including age, BMI, smoking and drinking habits, religion, and habitual use of smartphone before sleep (**Table 4**), logistic regression analysis of the association between scores on IAT and sleep

TABLE 2 | The Pittsburgh Sleep Quality Index (PSQI) total scores and scores on its different components in students with different degrees of internet addiction.

	Normal (a)		Mild (b)		Moderate to severe (c)		*p*	*Post hoc*
Components	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**		**Tukey**
Total score	4.97	2.90	6.49	2.94	6.85	2.91	<0.01*	(c) > (b) > (a)
Subjective sleep quality	0.94	0.80	1.24	0.78	1.28	0.77	<0.01*	(c) > (b) > (a)
Sleep latency	0.72	0.78	1.15	0.86	1.00	0.89	<0.01*	(c) > (b) > (a)
Sleep duration	0.81	0.95	0.97	0.96	1.14	1.04	0.04*	(c) > (a)
Habitual sleep efficiency	0.18	0.50	0.23	0.63	0.26	0.62	0.56	–
Sleep disturbance	0.93	0.58	1.19	0.57	1.14	0.58	<0.01*	(b) > (a); (c) > (a)
Use of sleep medication	0.06	0.35	0.08	0.42	0.22	0.56	0.02*	(c) > (b); (c) > (a)
Daytime dysfunction	1.34	0.92	1.62	0.85	1.82	0.80	<0.01*	(b) > (a); (c) > (a)

*$p < 0.05$; **$p < 0.01$.

TABLE 3 | Regression coefficients from multiple regression analysis on associations of the six patterns of symptoms in Internet Addiction Test (IAT) with the seven items on sleep quality in Pittsburgh Sleep Quality Index (PSQI)†.

PSQI IAT	Total score	Subjective sleep quality	Sleep latency	Sleep duration	Habitual sleep efficiency	Sleep disturbance	Use of sleep medication	Daytime dysfunction
Total score	0.06**	0.01**	0.01**	0.01*	< 0.01	0.01**	0.01**	0.02**
Salience	0.30**	0.05**	0.05**	0.05**	0.02	0.04**	0.02**	0.07**
Excessive use	0.20**	0.03**	0.03**	0.03**	0.01	0.02**	0.02**	0.06**
Neglect of work	0.14	0.02	0.01	0.01	0.01	0.02	0.05**	0.03
Anticipation	0.27**	0.03	0.06*	0.02	0.01	0.05**	0.03*	0.07**
Lack of control	0.31**	0.05**	0.05**	0.05*	0.02	0.05**	0.02	0.08**
Neglect of social life	0.25**	0.05*	0.04	0.05	< 0.01	0.03	0.02	0.06**

†*Controlled for age, body mass index (BMI), smoking and drinking habits, religion, habitual use of smartphone before sleep; *$p < 0.05$; **$p < 0.01$.*

quality demonstrated significant correlations between quality of sleep and total score of IAT (B = 0.04, S.E.: 0.01, $p < 0.01$) as well as sub-scores on five of the symptom patterns, namely, salience (B = 0.20, S.E.: 0.04, $p < 0.01$), excessive use (B = 0.16, S.E.: 0.03, $p < 0.01$), anticipation (B = 0.19, S.E.: 0.06, $p < 0.01$), lack of control (B = 0.22, S.E.: 0.05, $p < 0.01$), and neglect of social life (B = 0.22, S.E.: 0.06, $p < 0.01$). The results indicated that the degree of Internet addiction (including five patterns of symptoms) was positively associated with poor sleep quality. In other words, the participants with poor sleep quality were significantly more likely to show these symptom patterns of Internet addiction than those with good sleep quality.

TABLE 4 | Logistic regression analysis on association between scores on Internet Addiction Test (IAT) and sleep quality†.

Item	B	S.E.	OR (95% CI)	*p*
Total score	0.04	0.01	1.05 (1.03 – 1.06)	<0.01*
Salience	0.20	0.04	1.22 (1.14 – 1.30)	<0.01*
Excessive use	0.16	0.03	1.17 (1.10 – 1.25)	<0.01*
Neglect of work	0.09	0.05	1.10 (0.99 – 1.21)	0.07
Anticipation	0.19	0.06	1.21 (1.07 – 1.38)	<0.01*
Lack of control	0.22	0.05	1.24 (1.13 – 1.36)	<0.01*
Neglect of social life	0.22	0.06	1.24 (1.11 – 1.39)	<0.01*

†*Controlled for age, body mass index (BMI), smoking and drinking habits, religion, and habitual use of smartphone before sleep; *$p < 0.05$; B, regression coefficient; S.E., standard error; OR, odds ratio; and CI, confidence interval.*

DISCUSSION

The results of the present study showed unsatisfactory quality of sleep in over half of the participants (54.5%) and that those with a smoking habit and a higher level of Internet addiction tended to have poorer sleep quality. In addition, comparison of the scores of Internet addiction between participants with good quality of sleep and those with poor sleep quality revealed significantly lower scores on five out of six of the symptom patterns in the latter, indicating that those with poor sleep quality tended to focus on internet activities, use the internet excessively, have strong anticipation of internet access, exhibit a lack of self-control over the amount of time spent on the internet, and participated in social activities on the internet while neglecting real-world social life. The result was similar with a previous study showing a negative impact of excessive internet use on sleep quality (Mohammadbeigi et al., 2016). Furthermore, the present study also identified the correlations between quality of sleep and five symptom patterns of internet addiction, namely, salience, excessive use, anticipation, lack of control, and neglect of social life. Previous studies have shown that not only does internet addiction adversely affect the quality of sleep in college

students (Lin et al., 2018) but it also impairs sleep quality in children (Chen and Gau, 2016), adolescents as a whole (Chen and Gau, 2016), and adults (Bakken et al., 2009). Internet addiction has been found to contribute to disturbed circadian rhythm (Chen and Gau, 2016) that may negatively influence bedtime and sleep duration, leading to daytime fatigue and impaired work performance.

Additionally, the current study showed that 14% of the recruited female college students were at moderate to severe levels of Internet addiction. The above phenomenon was similar to a report in a previous study which was conducted on 3,616 Taiwanese college students (Lin et al., 2011). Factors contributing to the popularity of participation in social activities on the Internet among college students including the anonymous nature of the social media without requirement for showing one's physical appearance, no limitations of time and space, and low risk offers an ideal way of alleviating loneliness and establishing social networks, thereby elevating the risks of excessive Internet use and Internet addiction (McKenna and Bargh, 2000). Besides, college students tend to entertain themselves through online games and/or shopping as well as chatting on social media which provides pleasure and refuge from daily pressure, mental stress, anxiety, or loneliness (Morahan-Martin and Schumacher, 2003). While poor sleep quality is closely associated with daily life behaviors including Internet over usage (Mohammadbeigi et al., 2016). In terms of overuse, internet behaviors (such as online gaming) could lead to sleep problems such as sleep deprivation (An et al., 2014).

Regarding the correlation between sleep quality and IAT, our results demonstrated significant associations of total IAT score with the total score of PSQI as well as the sub scores on its six items (except habitual sleep efficiency) (**Table 3**). This finding is supported by that of a previous study on the correlation between mood status and sleep quality (Chang et al., 2017). The results of the present study also implicated that an excessive use of Internet could be linked to impaired sleep quality, prolonged sleep latency, shortened sleep duration, sleep disturbances, need for sleep medication, and daytime dysfunction, further highlighting the adverse impact of Internet addiction on different parameters regarding sleep quality. Consistently, logistic regression analysis of the current study demonstrated significant associations between sleep quality and most of the IAT items (**Table 4**). On the other hand, a previous study has shown that subjective perception of sleep quality is related to the individual's sleep attitude (Peach et al., 2018). This may help interpret our findings that a poor sleep attitude as reflected by excessive use of the Internet, lack of control, anticipation of Internet access, and indulgence in online social activities would have a negative impact on an individual's subjective perception of sleep quality.

One of the interesting findings of the present study was the prolonged sleep latency in subjects with moderate to severe Internet addiction. The result was not surprising after taking into account the high prevalence of Internet access through smartphones or tablet computers among Taiwanese college students (Yang et al., 2019) and the stimulation of the central nervous system through participating in games and watching action movies online before sleep which are known contributors to prolonged sleep latency (Higuchi et al., 2005). Another possible explanation is the emission of blue light through the screens that is known to suppress melatonin secretion from the pineal gland, leading to prolongation of sleep latency (Moderie et al., 2017).

Another accompanying finding in the current study was the shortened sleep duration among those with moderate to severe Internet addiction (**Table 3**). A large-scale study investigating the link between Internet use and self-reported sleep duration in up to 130,000 South Korean adolescents between the ages of 13 and 18 has identified a significant negative association between Internet use and sleep duration (Do et al., 2013). Another study on the risk factors associated with short sleep duration that involved twenty thousand Chinese children ranging in ages from five to eleven also reached the conclusion that Internet use is a significant predictor of shortened sleep duration (Li et al., 2010). The negative psychological and physiological impacts of inadequate sleep have been well-documented, including negative emotions (Gujar et al., 2011), anxiety (Alfano et al., 2006), obesity (Wang et al., 2018), and increased risks of participating in hazardous behaviors (e.g., tobacco and/or alcohol consumption, driving while under the influence) (Weaver et al., 2018). On the other hand, a significant association between sleep duration and health responsibility has also been reported (Yang et al., 2019). Excessive Internet users and those with poor self-control over internet use, who were found to have shortened sleep durations in the current study, could have poor health responsibility that may be reinforced through education.

The item of sleep disturbance on PSQI is a measure of interferences during sleep such as the need for going to the toilet, troubled breathing, coughing, feeling hot or cold, having nightmares or pain. A high score on this item may imply a physical impairment or discomfort (Schlarb et al., 2017). The high scorers on the items of salience, excessive use, neglect of work, anticipation, or lack of control in the present study also tended to relate to sleep disturbance from physical factors. Therefore, the finding may suggest a negative impact from Internet use on physical health. As previous investigation has shed light on, the fact that the negative influence of excessive internet use on normal physiological functions of the body including the manifestations of pain and physical discomfort may impair academic and/or work performance (Kelley and Gruber, 2012).

Use of sleep medications is one of the most common and effective ways to tackle sleep problems (Homsey and O'connell, 2012). The identification of a positive correlation between the level of Internet addiction and use of sleep medication in the present study may imply that those with moderate and severe Internet addiction tend to take sleep medication. The finding may be explained by the highly significant link between internet addiction and negative emotions (e.g., depression, anxiety, interpersonal sensitivity, and hostility) (Chou et al., 2017; Kim et al., 2018) as well as the positive association between emotional disturbance and the use of sleep medications (Kodaira and Silva, 2017).

Furthermore, the results of the current study demonstrated a link between Internet use and daytime dysfunction, suggesting a negative impact of Internet overuse on daily activities such as driving (cycling), eating regular meals, or participating in social activities during daytime hours. The significant association of daytime dysfunction with the items of anticipation and neglect of social life in this study, may also imply daytime functional impairment from empty anticipation and neglect of a real-world social life due to inaccessibility to the Internet in daytime when an individual has to participate in normal academic or work activities. As a whole, previous studies have shown that normal Internet use (Mohammadbeigi et al., 2016), avoidance of emotional fluctuations before sleep such as participating in online activities (Higuchi et al., 2005), and maintenance of good bedtime hygiene such as abstinence from excessive tobacco or alcohol use as well as sticking to a regular bedtime (Warren et al., 2017) are all positive contributors to sleep quality.

The logistic regression demonstrated the correlations between sleep quality and internet addiction (**Table 4**). Further review of the subscale of IAT, reveals that both "lack of control" and "neglect of social life" have a greater impact on sleep quality, while "neglect of work" has the least impact on sleep quality. This implies that internet users who lack self-control may suffer a lack of sleep quality due to poor-control behavior of Internet usage (such as delaying bedtime); users who neglect of social life in real-life may lack positive social support which can lead to poor sleep quality (Stafford et al., 2017). A previous study (Bonnefond et al., 2006) also reported that individuals with a low social life such as night-shift workers had poor sleep quality. Definitely, further research is required.

Limitations

The present study had several limitations that have to be taken into account for accurate interpretation of its findings. First, although self-reported sleep parameters such as duration are frequently used (Campbell et al., 2013), the lack of objective evidence to support data accuracy introduced potential bias into the study. Second, the recruitment of students from a single educational institute, which is a medicine and management college, may limit the extrapolation of the findings. Additionally, the present study excluded participants who were pregnant or had children, while future researchers could choose pregnant women and those women who have children as subjects. Third, the choice of the period of study for the current research during the semester could not reflect the participants' status of Internet use and sleep patterns during long holidays. Fourth, this study did not collect the diagnosis of sleep quality among participants, so there is no cut-off point of sleep quality based on clinical diagnosis, which may also limit the generalization of the results in this study. Finally, the cross-sectional design of the current study precluded the establishment of any cause-and-effects relationships among the study parameters. Nevertheless, the present study, which investigated the association between Internet addiction and sleep quality in female college students through analyzing the correlations among the parameters on sleep quality and the symptom patterns of Internet addiction, may provide useful information for educational institutes and related professionals to design suitable programs that can deal with Internet addiction for enhancing sleep quality and academic performance among female college students. Moreover, further research is recommended to recruit students of different genders to explore gender differences in detail.

CONCLUSION

The results of this study demonstrated significant associations of Internet addiction with most parameters of sleep quality (i.e., subjective sleep quality, sleep latency, sleep duration, sleep disturbance, use of sleep medication, and daytime dysfunction), highlighting a poorer quality of sleep in those with moderate and severe Internet addiction than that in normal internet users and those with mild internet dependency. Moreover, Internet addiction was also found as a significant predictor of poor sleep quality. Consequently, preoccupation with the Internet, Internet overuse, anticipation of Internet access, loss of self-control over the time spent on the Internet, and indulgence in online social activities are strongly not recommended among female college students due to all the negative contributors to sleep quality.

DATA AVAILABILITY

All datasets generated for this study are included in the manuscript and/or the **Supplementary Files**.

ETHICS STATEMENT

Ethical approval for the study was obtained from the National Cheng Kung University Human Research Ethics Committee (No. NCKU HREC-E-106-108-2).

AUTHOR CONTRIBUTIONS

P-HL and S-YY designed the survey used in this study, led coding, analysis, and wrote the first draft. Y-CL, K-LC, Y-LL, and P-LH were responsible for the conceptualization of the study, assisted in data analysis, and reviewed this manuscript for contextual content. S-YY and P-LH critically reviewed the manuscript. P-HL and Y-CL assisted in data collection.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnins.2019.00599/full#supplementary-material

REFERENCES

Alfano, C. A., Beidel, D. C., Turner, S. M., and Lewin, D. S. (2006). Preliminary evidence for sleep complaints among children referred for anxiety. *Sleep Med.* 7, 467–473.

An, J., Sun, Y., Wan, Y., Chen, J., Wang, X., and Tao, F. (2014). Associations between problematic internet use and adolescents' physical and psychological symptoms: possible role of sleep quality. *J. Addict. Med.* 8, 282–287. doi: 10.1097/ADM.0000000000000026

Ayar, D., Bektas, M., Bektas, I., Kudubes, A. A., Ok, Y. S., Altan, S. S., et al. (2017). The effect of adolescents' internet addiction on smartphone addiction. *J. Addict. Nurs.* 28, 210–214.

Baker, F. C., and Driver, H. S. (2007). Circadian rhythms, sleep, and the menstrual cycle. *Sleep Med.* 8, 613–622.

Bakken, I. J., Wenzel, H. G., Götestam, K. G., Johansson, A., and Øren, A. (2009). Internet addiction among norwegian adults: a stratified probability sample study. *Scand. J. Psychol.* 50, 121–127. doi: 10.1111/j.1467-9450.2008.00685.x

Bonnefond, A., Härmä, M., Hakola, T., Sallinen, M., Kandolin, I., and Virkkala, J. (2006). Interaction of age with shift-related sleep-wakefulness, sleepiness, performance, and social life. *Exp. Aging Res.* 32, 185–208.

Buysse, D. J., Reynolds, I. I. I. C. F., Monk, T. H., Berman, S. R., and Kupfer, D. J. (1989). The pittsburgh sleep quality index: a new instrument for psychiatric practice and research. *Psychiatry Res.* 28, 193–213.

Campbell, C. M., Bounds, S. C., Kuwabara, H., Edwards, R. R., Campbell, J. N., Haythornthwaite, J. A., et al. (2013). Individual variation in sleep quality and duration is related to cerebral mu opioid receptor binding potential during tonic laboratory pain in healthy subjects. *Pain Med.* 14, 1882–1892. doi: 10.1111/pme.12231

Canan, F., Yildirim, O., Ustunel, T. Y., Sinani, G., Kaleli, A. H., Gunes, C., et al. (2014). The relationship between internet addiction and body mass index in turkish adolescents. *Cyberpsychol. Behav. Soc. Netw.* 17, 40–45.

Chang, B.-W., Liu, F.-C., Lin, C.-H., Yang, M.-L., and Feng, C.-K. (2017). An effect study of mood status on sleep quality: to study the moderating effect of internet used behaviors. *J. Sport Recreat. Res.* 12, 79–91.

Chen, Y. L., and Gau, S. S. F. (2016). Sleep problems and internet addiction among children and adolescents: a longitudinal study. *J. Sleep Res.* 25, 458–465. doi: 10.1111/jsr.12388

Cheng, S. H., Shih, C.-C., Lee, I. H., Hou, Y.-W., Chen, K. C., Chen, K.-T., et al. (2012). A study on the sleep quality of incoming university students. *Psychiatry Res.* 197, 270–274. doi: 10.1016/j.psychres.2011.08.011

Chiu, S.-I., Hong, F.-Y., and Chiu, S.-L. (2013). An analysis on the correlation and gender difference between college students' internet addiction and mobile phone addiction in Taiwan. *ISRN Addict.* 2013:360607.

Chou, W.-P., Lee, K.-H., Ko, C.-H., Liu, T.-L., Hsiao, R. C., Lin, H.-F., et al. (2017). Relationship between psychological inflexibility and experiential avoidance and internet addiction: mediating effects of mental health problems. *Psychiatry Res.* 257, 40–44. doi: 10.1016/j.psychres.2017.07.021

Dhir, A., Chen, S., and Nieminen, M. (2015). Psychometric validation of the chinese compulsive internet use scale (CIUS) with taiwanese high school adolescents. *Psychiatr. Q.* 86, 581–596. doi: 10.1007/s11126-015-9351-9

Do, Y. K., Shin, E., Bautista, M. A., and Foo, K. (2013). The associations between self-reported sleep duration and adolescent health outcomes: what is the role of time spent on internet use? *Sleep Med.* 14, 195–200. doi: 10.1016/j.sleep.2012.09.004

Gujar, N., Yoo, S.-S., Hu, P., and Walker, M. P. (2011). Sleep deprivation amplifies reactivity of brain reward networks, biasing the appraisal of positive emotional experiences. *J. Neurosci.* 31, 4466–4474. doi: 10.1523/JNEUROSCI.3220-10.2011

Higuchi, S., Motohashi, Y., Liu, Y., and Maeda, A. (2005). Effects of playing a computer game using a bright display on presleep physiological variables, sleep latency, slow wave sleep and REM sleep. *J. Sleep Res.* 14, 267–273.

Hill, T. D., Deangelis, R., and Ellison, C. G. (2018). Religious involvement as a social determinant of sleep: an initial review and conceptual model. *Sleep Health* 4, 325–330. doi: 10.1016/j.sleh.2018.04.001

Homsey, M., and O'connell, K. (2012). Use and success of pharmacologic and nonpharmacologic strategies for sleep problems. *J. Am. Acad. Nurse Pract.* 24, 612–623. doi: 10.1111/j.1745-7599.2012.00745.x

Hsieh, K.-Y., Hsiao, R., Yang, Y.-H., Liu, T.-L., and Yen, C.-F. (2018). Predictive effects of sex, age, depression, and problematic behaviors on the incidence and remission of internet addiction in college students: a prospective study. *Int. J. Environ. Res. Public Health* 15:2861. doi: 10.3390/ijerph15122861

Hysing, M., Pallesen, S., Stormark, K. M., Jakobsen, R., Lundervold, A. J., and Sivertsen, B. (2015). Sleep and use of electronic devices in adolescence: results from a large population-based study. *BMJ Open* 5:e006748. doi: 10.1136/bmjopen-2014-006748

Kang, J.-H., and Chen, S.-C. (2009). Effects of an irregular bedtime schedule on sleep quality, daytime sleepiness, and fatigue among university students in Taiwan. *BMC Public Health* 9:248. doi: 10.1186/1471-2458-9-248

Kelley, K. J., and Gruber, E. M. (2012). Problematic Internet use and physical health. *J. Behav. Addict.* 2, 108–112.

Kesintha, A., Rampal, L., Sherina, M., and Kalaiselvam, T. (2018). Prevalence and predictors of poor sleep quality among secondary school students in gombak district, Selangor. *Med. J. Malays.* 73, 31–40.

Kim, Y.-J., Jang, H. M., Lee, Y., Lee, D., and Kim, D.-J. (2018). Effects of internet and smartphone addictions on depression and anxiety based on propensity score matching analysis. *Int. J. Environ. Res. Public Health* 15:859. doi: 10.3390/ijerph15050859

Kodaira, K., and Silva, M. T. (2017). Sleeping pill use in Brazil: a population-based, cross-sectional study. *BMJ Open* 7:e016233. doi: 10.1136/bmjopen-2017-016233

Lee, B. H., and Lee, H. K. (2017). Longitudinal study shows that addictive internet use during adolescence was associated with heavy drinking and smoking cigarettes in early adulthood. *Acta Paediatr.* 106, 497–502. doi: 10.1111/apa.13706

Li, S., Zhu, S., Jin, X., Yan, C., Wu, S., Jiang, F., et al. (2010). Risk factors associated with short sleep duration among chinese school-aged children. *Sleep Med.* 11, 907–916. doi: 10.1016/j.sleep.2010.03.018

Lin, M.-P., Ko, H.-C., and Wu, J. Y.-W. (2011). Prevalence and psychosocial risk factors associated with Internet addiction in a nationally representative sample of college students in Taiwan. *Cyberpsychol. Behav. Soc. Netw.* 14, 741–746. doi: 10.1089/cyber.2010.0574

Lin, P.-H., Lin, C.-Y., Wang, P.-Y., and Yang, S.-Y. (2018). Association between sleeping duration and health-related behaviors in college student. *Soc. Health Behav.* 1, 31–36. doi: 10.3389/fpsyg.2018.02316

Lin, Y.-H., Lu, Y.-C., Liu, K.-L., and Yeh, C.-S. (2015). A study of living pressure, computer using and sleep quality in college students. *Hua Yi J. Soc. Sci. Hum.* 32, 1–9.

Liu, S., Wing, Y. K., Hao, Y., Li, W., Zhang, J., and Zhang, B. (2018). The associations of long-time mobile phone use with sleep disturbances and mental distress in technical college students: a prospective cohort study. *Sleep* 42:zsy213. doi: 10.1093/sleep/zsy213

McKenna, K. Y., and Bargh, J. A. (2000). Plan 9 from cyberspace: the implications of the internet for personality and social psychology. *Pers. Soc. Psychol. Rev.* 4, 57–75.

Moderie, C., Van der Maren, S., and Dumont, M. (2017). Circadian phase, dynamics of subjective sleepiness and sensitivity to blue light in young adults complaining of a delayed sleep schedule. *Sleep Med.* 34, 148–155. doi: 10.1016/j.sleep.2017.03.021

Mohammadbeigi, A., Valizadeh, F., Saadati, M., Sharifimoghadam, S., Ahmadi, A., Mokhtari, M., et al. (2016). Sleep quality in medical students; the impact of over-use of mobile cell-phone and social networks. *J. Res. Health Sci.* 16, 46–50.

Morahan-Martin, J., and Schumacher, P. (2003). Loneliness and social uses of the internet. *Comput. Hum. Behav.* 19, 659–671.

Nadeem, M., Buzdar, M. A., Shakir, M., and Naseer, S. (2018). The association between muslim religiosity and internet addiction among young adult college students. *J. Relig. Health* doi: 10.1007/s10943-018-0697-9 [Epub ahead of print].

Orff, H. J., Meliska, C. J., Martinez, L. F., and Parry, B. L. (2014). The influence of sex and gonadal hormones on sleep disorders. *ChronoPhysiol. Ther.* 4, 15–25.

Peach, H. D., Gaultney, J. F., and Ruggiero, A. R. (2018). Direct and indirect associations of sleep knowledge and attitudes with objective and subjective sleep duration and quality via sleep hygiene. *J. Prim. Prev.* 39, 555–570. doi: 10.1007/s10935-018-0526-7

Saygın, M., Önder Öztürk, T. G., Has, M., Hayri, U. B., Kurt, Y., Yağlı, M. A., et al. (2016). Investigation of sleep quality and sleep disorders in students of medicine. *Turk. Thorac. J.* 17, 132–140. doi: 10.5578/ttj.30513

Schlarb, A. A., Claßen, M., Hellmann, S. M., Vögele, C., and Gulewitsch, M. D. (2017). Sleep and somatic complaints in university students. *J. Pain Res.* 10:1189. doi: 10.2147/JPR.S125421

Stafford, M., Bendayan, R., Tymoszuk, U., and Kuh, D. (2017). Social support from the closest person and sleep quality in later life: evidence from a British birth cohort study. *J. Psychosom. Res.* 98, 1–9. doi: 10.1016/j.jpsychores.2017.04.014

Surani, A. A., Zahid, S., Surani, A., Ali, S., Mubeen, M., and Khan, R. H. (2015). Sleep quality among medical students of karachi, Pakistan. *JPMA* 65, 380–382.

Tan, Y., Chen, Y., Lu, Y., and Li, L. (2016). Exploring associations between problematic internet use, depressive symptoms and sleep disturbance among southern Chinese adolescents. *Int. J. Environ. Res. Public Health* 13:313. doi: 10.3390/ijerph13030313

Tsai, P.-S., Wang, S.-Y., Wang, M.-Y., Su, C.-T., Yang, T.-T., Huang, C.-J., et al. (2005). Psychometric evaluation of the chinese version of the pittsburgh sleep quality index (CPSQI) in primary insomnia and control subjects. *Qual. Life Res.* 14, 1943–1952.

Vargas, P. A., Flores, M., and Robles, E. (2014). Sleep quality and body mass index in college students: the role of sleep disturbances. *J. Am. Coll. Health* 62, 534–541.

Wang, H., Hu, R., Du, H., Fiona, B., Zhong, J., and Yu, M. (2018). The relationship between sleep duration and obesity risk among school students: a cross-sectional study in zhejiang, China. *Nutr. Metab.* 15:48. doi: 10.1186/s12986-018-0285-8

Wang, P.-Y., Chen, K.-L., Yang, S.-Y., and Lin, P.-H. (2019). Relationship of sleep quality, smartphone dependence, and health-related behaviors in female junior college students. *PLoS One* 14:e0214769. doi: 10.1371/journal.pone.0214769

Warren, C. M., Riggs, N. R., and Pentz, M. A. (2017). Longitudinal relationships of sleep and inhibitory control deficits to early adolescent cigarette and alcohol use. *J. Adolesc.* 57, 31–41. doi: 10.1016/j.adolescence.2017.03.003

Weaver, M. D., Barger, L. K., Malone, S. K., Anderson, L. S., and Klerman, E. B. (2018). Dose-dependent associations between sleep duration and unsafe behaviors among us high school students. *JAMA Pediatr.* 172, 1187–1189.

Widyanto, L., and McMurran, M. (2004). The psychometric properties of the internet addiction test. *Cyberpsychol. Behav.* 7, 443–450.

Yang, J., Guo, Y., Du, X., Jiang, Y., Wang, W., Xiao, D., et al. (2018). Association between problematic internet use and sleep disturbance among adolescents: the role of the child's sex. *Int. J. Environ. Res. Public Health* 15:2682.

Yang, S.-Y., Chen, K.-L., Lin, P.-H., and Wang, P.-Y. (2019). Relationships among health-related behaviors, smartphone dependence, and sleep duration in female junior college students. *Soc. Health Behav.* 2:26.

Yang, S.-Y., Lin, C.-Y., Huang, Y.-C., and Chang, J.-H. (2018). Gender differences in the association of smartphone use with the vitality and mental health of adolescent students. *J. Am. Coll. Health* 66, 693–701. doi: 10.1080/07448481.2018.1454930

Young, K. S. (1998). Internet addiction: the emergence of a new clinical disorder. *Cyberpsychol. Behav.* 1, 237–244. doi: 10.1007/s10899-011-9287-4

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Psychosocial Determinants of Insomnia in Adolescents: Roles of Mental Health, Behavioral Health, and Social Environment

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The theoretical explanation of human problems is derived from the complex interplay of psychological, social, economic, political, and physical factors.

Aims: This study examined the roles of behavioral health (i.e., alcohol abuse and suicidality) and social environment (i.e., family support, school connectedness, and favorable neighborhood) and mental health [i.e., depression, anxiety, and attention deficit hyperactivity disorder (ADHD)] in predicting insomnia in adolescents in an ecological perspective.

Methods: Approximately 6445 high school students in Taiwan were administered an anonymous self-report survey. Hierarchical multiple regression was performed to examine how multidimensional social environment, behavioral health, and mental health factors were associated with insomnia in adolescents.

Results: The prevalence rate of insomnia in the sample was 30%. The results indicated that alcohol abuse ($\beta = 0.04$), suicidality ($\beta = 0.06$), depression ($\beta = 0.29$), anxiety ($\beta = 0.14$), and ADHD ($\beta = 0.11$) were positively associated with insomnia ($p < 0.001$), whereas family support ($\beta = -0.06$), school connectedness ($\beta = -0.05$), and favorable neighborhood ($\beta = -0.10$) were negatively associated with insomnia ($p < 0.001$). Sex did not predict insomnia, but age was positively associated with insomnia ($\beta = 0.09$, $p < 0.001$). Among all predictors of insomnia in the study, mental health factors, especially depression, play a major role on insomnia among adolescents, and is as much important as social environment factors.

Conclusion: This study demonstrated how both psychosocial variables (social environment and behavioral health) and psychological symptoms were associated with insomnia in adolescents when the demographic variables (sex and age) were controlled and provided valuable information and evidence for clinicians, social workers, and health professionals who provide support to adolescents with insomnia. Applying an ecological approach in practice can aid in understanding at individual, family, school, and

community levels and in identifying the strengths and weaknesses of their interactions with each other.

Implications: This perspective enables practitioners in effectively treating problems and addressing the needs of the various levels, including the individual, family, school, and the broader community. Thus, prevention and intervention of insomnia in adolescents should focus on multidimensional risk and protective factors, including mental health, behavioral health, and social environment, in the context of an ecological system.

Keywords: insomnia, suicidality, alcohol abuse, family support, school connectedness, favorable neighborhood, mental health, adolescent

INTRODUCTION

Insomnia is a subjective complaint, defined as difficulty in falling asleep, trouble in staying asleep, or having poor sleep quality (Ohayon, 2002). In Taiwan, >25% (n = 36,743) of adults and 18.7% adolescents (aged 12–18 years) experienced insomnia (Kao et al., 2008; Huang et al., 2010). The most common insomnia type was the difficulty in initiating sleep, followed by early morning awakening and difficulty in maintaining sleep (Kao et al., 2008). In the United States, the age-adjusted prevalence of insomnia was 18.8% (Cunningham et al., 2015) and was 19.3% among young children and preadolescents (Calhoun et al., 2014).

Why study insomnia in adolescents? Insufficient and unsatisfactory sleep in adolescents is associated with adverse outcomes across various areas of youth development, including physical health (e.g., inflammation), cognitive and behavioral function, school performance, delinquency, substance use, depression, diminished quality of life, and even suicide ideation and self-harm behavior (Roberts et al., 2001; Sadeh et al., 2003; Curcio et al., 2006; Clinkinbeard et al., 2011; Mueller et al., 2011; Wong et al., 2011; Pasch et al., 2012; Park et al., 2016; Wang et al., 2017). Moreover, sleep is critical for all areas of adolescent development. However, sleep disruption and insufficient sleep are frequent among youth (Calhoun et al., 2014). Therefore, in addition to previous studies focusing on physical conditions such as chronic painful physical condition as a major contributive factor for insomnia (Ohayon, 2005), it is important for the present study to identify psychological, social, behavioral, and contextual barriers and aids to induce good sleep.

Considering the person-in-environment perspective, it is important to understand an individual and individual behavior in light of the environment contexts in which that person lives and acts. Thus, in addition to mental health [i.e., depression, anxiety, and attention deficit hyperactivity disorder (ADHD)], the current study also examined the roles of behavioral health (i.e., alcohol abuse and suicidality) and social environment (i.e., family support, school connectedness, and favorable neighborhood) simultaneously in predicting insomnia in adolescents. First, regarding behavioral health, alcohol abuse and suicidality are potential barriers to good sleep and risk factors for insomnia. Concerning alcohol abuse, studies have found that chronic alcoholic exposure can cause sleep disruptions, which is manifested by increasing sleep-onset latency and wakefulness (Thakkar et al., 2015). In addition, alcohol often interacts with sleep deprivation and sleep restriction to exacerbate daytime sleepiness and alcohol-induced performance impairments (Roehrs and Roth, 2001). Regarding suicidality, a meta-analysis concluded that sleep disturbance was significantly associated with an increased relative risk of suicidal ideation, suicide attempt, and suicide (Pigeon et al., 2012). Similarly, a longitudinal study identified variability in sleep timing and insomnia as warning signs of suicide ideation (Bernert et al., 2017). However, little research examined whether higher levels of suicidality was associated with higher levels of sleep problems.

Second, regarding psychosocial and contextual factors in the ecological system (Bronfenbrenner, 1979), family support, school connectedness, and favorable neighborhood are potential aids to good sleep and preventive factors of insomnia. Concerning family support, having strained family relationships was associated with more troubled sleep, whereas supportive family relationships are associated with less disturbed sleep, particularly in individuals who are in frequent contact with the family members (e.g., adolescents) (Ailshire and Burgard, 2012). Sleep troubles are most evident when family relationships are highly strained and provide inadequate emotional support. In the context of family stress, Tsai et al. (2018) reported that parental support was associated with longer sleep duration, less sleep variability, and less time spent awake during the night. It suggested that cohesive family relationships and support provide a sense of stability and security that is necessary for healthy sleep. Regarding the school-level predictors of insomnia, most of the research focuses on the effects of insomnia on school performance or the link between academic stress and insomnia (Yan et al., 2018). However, not much research has explored the relationship between school connectedness and insomnia among adolescents. In a sample of Chinese male adolescents, although sleep problems at the beginning of the school year predicted lower levels of school connectedness at the end of the school year, but school connectedness at the beginning of the school year did not predict sleep problems at the end of the school year (Bao et al., 2018). In a sample of Latino and Asian adolescents, a sense of school belongingness buffered the negative effect of overt discrimination on sleep (Huynh and Gillen-O'Neel, 2016), which suggested that school belongingness represents a positive support for adolescents that induce good sleep. Regarding community-level predictors

of insomnia, adverse neighborhood and social environment (e.g., high disorder, low safety and social cohesion, violence, and noise) were associated with a higher prevalence of short sleep and insomnia (DeSantis et al., 2013; Simonelli et al., 2017). Moreover, the results of a global analysis of six countries (n = 39,590) indicated that perceived neighborhood safety is negatively associated with insomnia symptoms and poor sleep quality in the past 30 days (Hill et al., 2016). Therefore, favorable neighborhood is a potential preventive factor of insomnia.

Third, regarding mental health, depression, anxiety, and ADHD are potential barriers to good sleep and risk factors for insomnia. Concerning depression, the relationship between insomnia and depression was found to be reciprocal (Roberts and Duong, 2013; Lovato and Gradisar, 2014). Individuals with insomnia have a twofold risk of depression compared with those with no sleep difficulties (Baglioni et al., 2011). By contrast, adolescents with depression experienced significantly more wakefulness in bed, lighter sleep, and more subjective sleep disturbance (Lovato and Gradisar, 2014). Depressive symptoms in adolescents significantly predicted sleep problem development and persistence at a 4-year follow-up (Patten et al., 2000). Adolescents who reported depressive symptoms were 50% more likely to develop sleep problems than those who did not report any symptoms. Regarding anxiety, a systematic review has reported a one-way relationship where anxiety predicted excessive daytime sleepiness (Alvaro et al., 2013). Another study in youth found that anxiety preceded insomnia 73% of the time after adjustments for gender, race, and ethnicity (Johnson et al., 2006). Similarly, an epidemiological study in India revealed that anxiety was independently associated with insomnia after adjustments for other variables (Khan et al., 2018). Regarding ADHD, a study in the Netherlands showed that 43% of patients with ADHD reported significant insomnia (odds ratio = 2.66) and 41% reported short sleep duration (Wynchank et al., 2018). Another study in Ankara, Istanbul found that probability of insomnia was higher (2.7-fold) among those with probable ADHD, and both inattentiveness and hyperactivity dimensions of ADHD was related to insomnia severity (Evren et al., 2019). A clinical review paper indicated high rates of parental reports of sleep disturbances in children with ADHD (Cohen-Zion and Ancoli-Israel, 2004). Notably, children with ADHD have a fivefold increase in sleep problems than children without ADHD.

Therefore, this study expands on the previous research by simultaneously examining multidimensional psychosocial determinants, such as behavioral health (i.e., alcohol abuse and suicidality), social environment (i.e., family support, school connectedness, and favorable neighborhood), and mental health (i.e., depression, anxiety, and ADHD) to determine their association with insomnia in adolescents in the context of an ecological system. Concordant with previous research, we hypothesized that alcohol abuse, suicidality, depression, anxiety, and ADHD would be the risk factors for insomnia in adolescents, after control for sex and age. By contrast, family support, school connectedness, and conducive neighborhood would be the preventive factors associated with insomnia.

MATERIALS AND METHODS

Participants

The participants in this study were enrolled from the 2009 Project for the Health of Children and Adolescents in Southern Taiwan, a research program studying the mental health status of children and adolescents living in four counties and three metropolitan areas in southern Taiwan (Yen et al., 2010a). In 2009, there were 254,130 students in 205 junior high schools and 202,883 students in 143 senior high/vocational schools in this area. On the basis of the definitions of urban and rural districts in the Taiwan-Fukien Demographic Fact Book (Ministry of the Interior, 2002), a stratified random sampling strategy was used to ensure that there was proportional representation of districts and schools. Two-stage random cluster sampling was used to select schools and classes for the study. Five junior high schools and five senior high or vocational schools were randomly selected from urban districts. Similarly, five junior high schools and four senior high or vocational schools were randomly selected from the rural districts. The classes were randomly selected from these schools. All students in the selected classes were invited to participate in the study, except the students with special needs. Subsequently, 6703 students from grades 7 to 12 participated in the study.

Procedure

This study was approved by the Institutional Review Board (IRB) of Kaohsiung Medical University before sampling and data collection. The research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context. And, the data were recorded in a manner that individuals cannot be identified in the anonymous survey. The waiver of written parental consent form did not adversely affect the rights and welfare of the subjects and was approved by IRB. The passive parental consent was used. Prior to the administration of the survey, parents/guardians of all student participants received written notice letter that their child would be recruited to participate in the study and explaining the study purpose and procedure, emphasizing the voluntary and confidential nature of the study. Parents were given the opportunity to exclude their daughter/son from participation in the study and asked to respond within 3 days. Students took the letter home for their parents or guardians, who were given a choice to call the researchers, write in the school communications book, or ask their children to directly, all convey to their refusal for their children to join the study. In addition, the students were given the liberty to refuse participation in this study by returning blank questionnaires along with those from other students.

Measures

Based on the ecological system theory, we included three layers of social environment as predictors in the study: family support, school connectedness, and favorable neighborhood. We assessed the students' experiences with insomnia, mental health (i.e., depression, anxiety, and ADHD), behavioral health (i.e., alcohol use and suicidality), and social environment (i.e., family support,

school connectedness, and favorable neighborhood) by using the self-reported surveys. A pilot study (n = 76) was conducted to ensure adequate reliability of all research instruments by performing a 2-week test–retest reliability.

Insomnia

The 8-item Athens Insomnia Scale (AIS-8) was used to assess the severity of subjective insomnia over the preceding month (Soldatos et al., 2000). The items of the AIS-8 correspond to the taxonomies for the diagnosis of insomnia per the International Classification of Diseases, Tenth Edition. The first five items assess difficulty with sleep induction, awakening during the night, early morning awakening, total sleep time, and overall quality of sleep. The last three items assess the next-day consequences of any insomnia, including problems with a sense of well-being, functioning, and daytime sleepiness. The Taiwanese version of the AIS-8 scale has been validated in previous study (Chung et al., 2011; Sun et al., 2011). Each item of the AIS-8 was rated on a four-point rating scale from 0 to 3 with a higher score indicating severe insomnia. The mean score was calculated. The Cronbach's alpha in the present study was 0.69, and the 2-week test–retest reliability was 0.72 ($p < 0.001$).

Depression

The 20-item Mandarin-Chinese version of the Center for Epidemiological Studies-Depression (CES-D) Scale was used to assess the frequency of depressive symptoms in the previous week (Radloff, 1977; Chien and Cheng, 1985). Each item of the CES-D was rated on a 4-point rating scale from 0 to 3. A higher score indicated severe depression. The mean score was calculated. The Cronbach's alpha for the CES-D was 0.89, and the 2-week test–retest reliability was 0.78.

Anxiety

We used the Taiwanese Version of the Multidimensional Anxiety Scale for Children (MASC-T) to assess the participants' self-reported anxiety symptoms (March, 1997; Yen et al., 2010b). The MASC-T consisted of 39 items answered on a 4-point Likert scale from 0 to 3. A higher score represented a severe level of anxiety. The mean score was calculated. The Cronbach's alpha for the MASC-T in the present study was 0.89.

ADHD

An 18-item self-report ADHD scale was modified from the Vanderbilt ADHD Diagnostic Parent Rating Scale (Wolraich et al., 2003) and represented the 18 diagnostic symptoms of ADHD from the DSM-IV, Text Revision (American Psychiatric and Association, 2000). Items 1–9 measure inattention symptoms, and items 10–18 measure hyperactivity and impulsivity symptoms. Taiwanese version of ADHD scale has been validated in previous study (Gau et al., 2008). Participants rated their symptoms on a 4-point Likert scale from 0 to 3 with a higher score indicating symptom severity. The mean score was calculated. The Cronbach's alpha was 0.88.

Alcohol Abuse

The 5-item alcohol abuse scale was adapted from the CRAFFT substance abuse screening test to assess problematic alcohol use in adolescents (Knight et al., 2002). We removed one item "CAR" to increase the reliability. The "yes" answer was scored as 1 and "no" as 0. A higher total score on the scale represented a severe level of alcohol abuse. The Cronbach's alpha for the alcohol abuse scale was 0.65.

Suicidality

The 5-item questionnaire from the epidemiological version of the Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS-E; Puig-Antich and Chambers, 1978) was used to assess suicidal ideation and attempt in the preceding year. Questions were as follows: (1) "Has there ever been a period of 2 weeks or longer when you thought a lot about death, including thoughts of your death, somebody else's death, or death in general?" (2) "Has there ever been a period of 2 weeks or longer when you had a desire to die?" (3) "Have you ever thought of attempting suicide?" (4) "Have you had a suicidal plan?" (5) "Have you ever attempted suicide?" Each question elicited a "yes" or "no" answer. In a previous study in Taiwan, the Cohen's kappa coefficient of agreement (j) between participants' self-reported suicide attempts and their parents' reports was 0.54 ($p < 0.001$) (Tang et al., 2009). The Cronbach's alpha in this study was 0.79.

Family Support

The 5-item Chinese version of the Family APGAR Index (Smilkstein, 1978; Chen et al., 1980) was applied to measure participants' satisfaction with aspects of family support on a 4-point rating scale from 0 to 3. A higher score represented a higher level of family support. The mean score was calculated. The Cronbach's alpha in the present study was 0.85.

School Connectedness

The level of connectedness to school was assessed based on five statements: "I enjoy my school life," "I get along well with my teachers," "I get along well with my schoolmates," "I feel that I am popular," and "I feel no interest to interact with friends or schoolmates (revise coded)." The participants scored the items on a 4-point Likert scale from 0 to 3, with a higher score indicating more agreement with the statements. To make the interpretation easier, we reverse-coded these items and calculated the sum score. After recoding, a higher score indicating a higher level of school connectedness. The mean score was calculated. The Cronbach's alpha was 0.68.

Favorable Neighborhood

The 8-item favorable living environment scale was adapted from the Taiwanese Quality of Life Questionnaire for Adolescents (Fuh et al., 2005) to assess experiences in the preceding 2 weeks. A sample question was as follows: "Do you feel safe and protected in your home?" The participants reported their experiences on a 5-point rating scale from 0 to 4. A higher score indicated better quality of life over the preceding 2 weeks. The mean score was calculated. The Cronbach's alpha in this study was 0.89.

Analysis Plan

Statistical analysis was performed using the SPSS Statistical Package for Windows, version 24. First, descriptive statistics

were used to assess the distribution of adolescents' insomnia, behavioral health (i.e., alcohol abuse and suicidality), social environment (i.e., family support, school connectedness, and favorable neighborhood), and mental health (i.e., depression, anxiety, and ADHD) based on the ecological system theory. Second, we conducted correlational analyses using the Pearson coefficient of correlation to illustrate interrelationships between each of the variables. Third, we performed hierarchical regression to examine the effects of behavioral health, social environment, and mental health on insomnia in adolescents, after control for age and sex.

RESULTS

Descriptive Statistics and Correlations

Overall, 6445 participants completed the research questionnaires without withdrawal, of which 52% were girls and 48% were boys. **Table 1** presents the correlation coefficients of all study variables and the descriptive statistics of the means and standard deviations of the variables. The prevalence rate of insomnia in the sample was 30%, based on the optimal cut-offs for AIS-8 (Chung et al., 2011).

Effects of Psychosocial Determinants on Insomnia

Prior to conducing a hierarchical multiple regression, the relevant assumptions of this statistical analysis were tested. Firstly, a sample size of 6445 was deemed adequate given 10 independent variables to be included in the analysis (Tabachnick et al., 2007). The assumption of singularity was also met as the independent variables were not a combination of other independent variables. An examination of correlations (**Table 1**) revealed that no independent variables were highly correlated, with the exception of depression and anxiety ($r = 0.52$). As the collinearity statistics (i.e., Tolerance and VIF) were all within accepted limits, the result indicated that multicollinearity was not a concern (Hair et al., 1998). The residual plots, the normal probability plot, and scatter plots indicated that the assumptions of normality, linearity, and homoscedasticity were all satisfied (Hair et al., 1998; Pallant, 2013; **Supplementary Appendix 1**). And, the value of Durbin–Watson test statistic was 2 that indicated the residuals were uncorrelated (Durbin and Watson, 1951). Hierarchical regression analyses were used to examine whether adolescents' two behavioral health and three social environment factors, and three mental health factors were significant contributors to insomnia, after control for sex and age. **Table 2** summarizes the results from the hierarchical regression. The demographic variables (sex and age) were entered into the regression model of insomnia in the first step (Model 1). Behavioral health and social environment variables (i.e., alcohol abuse, suicidality, family support, school connectedness, and favorable neighborhood) were entered into the regression model in the second step (Model 2). Mental health variables (i.e., depression, anxiety, and ADHD) were entered in the third and final step (Model 3).

The results showed that adolescents' sex and age significantly contributed to the regression model, $F(2,6388) = 61.18$, $p < 0.001$ and accounted for 2% of the variance in insomnia. Introducing two behavioral health and three social environmental variables significantly explained an additional 22% of the variance in insomnia and this change in R^2 was significant, $F(5,6383) = 371.98$, $p < 0.001$. Finally, the addition of three mental health variables to the regression model explained an additional 12% of the variance in insomnia and this change in R^2 was also significant, $F(3,6380) = 403.69$, $p < 0.001$ ($\Delta R^2 = 0.12$, $p < 0.001$). Taken together, in the final model, these demographic, behavioral health variables, social environment variables, and mental health variables significantly explained 36% of the variance in insomnia. The sum of square was 345.71 and the sum of square error was 610.86. A Mallow's *Cp* value ($Cp = 11$) that was close to the number of predictors plus the constant indicated that the model produced relatively precise and unbiased estimates. The regression coefficients indicated that alcohol abuse ($\beta = 0.04$), suicidality ($\beta = 0.06$), depression ($\beta = 0.29$), anxiety ($\beta = 0.14$), and ADHD ($\beta = 0.11$) were positively associated with insomnia ($p < 0.001$), whereas family support ($\beta = -0.06$), school connectedness ($\beta = -0.05$), and favorable neighborhood ($\beta = -0.10$) were negatively associated with insomnia ($p < 0.001$). Therefore, adolescents who reported higher levels of alcohol abuse, suicidality, depression, anxiety, and ADHD were more likely to have insomnia. In contrast, adolescents who perceived higher levels of family support, school connectedness, and favorable neighborhood were less likely to have insomnia. Sex did not predict insomnia. Age was positively associated with insomnia ($\beta = 0.09$, $p < 0.001$). Older adolescents reported more insomnia than younger adolescents. Among all predictors of insomnia in the study, mental health factors, especially depression, play a major role on insomnia among adolescents, and is as much important as social environment factors. When applying stepwise elimination approach, depression was the best predictor that accounted for the most of the variance in insomnia [$\Delta R^2 = 0.30$, $p < 0.001$; $F(1,6389) = 2775.41$, $p < 0.001$], followed by ADHD and favorable neighborhood, and school connectedness accounted for the least of the variance in insomnia.

DISCUSSION

The present study extends the previous research regarding the impact of behavioral and mental health and social environment on insomnia in adolescents. This study addressed the increasing problems of insomnia in adolescents and added to the fund of knowledge by analyzing how multidimensional factors contribute to insomnia in adolescents at individual, family, school, and community levels in the ecological system. The results supported our hypotheses. First, we found empirical support that adolescent alcohol abuse and suicidality were positively associated with insomnia, after control for age, sex, and other factors. Second, we revealed that family support, school connectedness, and favorable neighborhood were negatively associated with adolescent insomnia, after control for demographics and other covariates. Third, we found that mental health problems such as depression, anxiety, and ADHD were positively associated

TABLE 1 | Bivariate correlations, means, and standard deviations for variables in the models.

	1	2	3	4	5	6	7	8	9	10	11
1. Insomnia	–										
2. Sex	−0.05**	–									
3. Age	0.13**	−0.5**	–								
4. Alcohol abuse	0.15**	0.05**	0.06**	–							
5. Suicidality	0.33**	−0.09**	0.01	0.21**	–						
6. Family support	−0.28**	−0.10**	−0.06**	−0.15**	−0.25**	–					
7. SC	−0.32**	−0.03*	0.05**	−0.08**	−0.21**	0.28**	–				
8. FN	−0.36**	0.08**	−0.11**	−0.11**	−0.25**	0.45**	0.34**	–			
9. Depression	0.55**	−0.11**	0.08**	0.17**	0.48**	−0.37**	−0.50**	−0.43**	–		
10. Anxiety	0.37**	−0.21**	−0.03*	−0.01	0.26**	0.02	−0.24**	−0.19**	0.52**	–	
11. ADHD	0.38**	0.06**	0.09**	0.15**	0.24**	−0.24**	−0.26**	−0.27**	0.47**	0.32**	–
Mean	0.78	–	14.78	0.35	0.71	1.81	2.09	2.50	0.79	0.99	0.91
SD	0.39	–	1.81	0.81	1.27	0.70	0.47	0.74	0.49	0.40	0.44

*$p < 0.05$. **$p < 0.01$. SC, school connectedness; FN, favorable neighborhood; SD, standard deviation. Codes for sex are 1 = male, 0 = female.

TABLE 2 | Summary of hierarchical regression analysis for variables predicting insomnia (n = 6,445).

	Model 1			Model 2			Model 3			Model 3
Predictor variables	***B***	***SE***	β	***B***	***SE***	β	***B***	***SE***	β	**95% CI**
Step 1: Demographic										
Child sex	−0.03	0.01	−0.04**	−0.02	0.01	−0.02*	0.01	0.01	0.02	−0.004–0.028
Child age	0.03	0.01	0.13***	0.02	0.01	0.11***	0.02	0.01	0.09***	0.015–0.023
Step 2: Behavioral health and social environment										
Alcohol abuse				0.02	0.01	0.05***	0.02	0.01	0.04**	0.007–0.027
Suicidality				0.06	0.01	0.21***	0.02	0.01	0.06***	0.012–0.026
Family support				−0.05	0.01	−0.09***	−0.04	0.01	−0.06***	−0.048 to −0.022
School connectedness				−0.16	0.01	−0.20***	−0.04	0.01	−0.05***	−0.060 to −0.022
Favorable neighborhood				−0.10	0.01	−0.18***	−0.05	0.01	−0.10***	−0.065 to −0.040
Step 3: Mental health										
Depression							0.23	0.01	0.29***	0.204–0.253
Anxiety							0.14	0.01	0.14***	0.115–0.162
ADHD							0.10	0.01	0.11***	0.080–0.121
Fit test										
Adjusted R^2			0.02			0.24			0.36	
R^2 change			0.02			0.22			0.12	

*Codes for sex are 1 = male, 0 = female. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.*

with insomnia when controlling the demographics and other covariates. Both the behavioral health and social environment variables and the mental health variables explained the significant variance in the model.

Behavioral and Mental Health and Insomnia

Regarding behavioral health problems, the study confirmed the relationship between alcohol abuse and insomnia among adolescents in Taiwan – concordant with previous research on adult samples (Chaudhary et al., 2015). Adolescents with alcohol abuse issues are at a higher risk of a chronic predicament of insomnia. The correlation between alcohol abuse and insomnia was also found in a Polish study sample that indicated >60% of alcohol-dependent patients screened positive for insomnia (Zhabenko et al., 2012), and insomnia was also found to be prevalent in 75% of alcohol-dependent adults in a US sample (Chaudhary et al., 2015). On the other hand, sleep disturbances may place adolescents without alcohol abuse issues at a high risk of alcohol abuse (Hasler et al., 2014). Furthermore, concordant with a previous research of an extensive school-based survey and a longitudinal study in the United States (Roberts et al., 2001; Wong et al., 2011), this study on a Taiwanese sample confirmed that suicidality was associated with insomnia among the adolescents, after accounting for depression, anxiety, PTSD, and alcohol abuse. Regarding mental health problems, most studies found strong relationships with insomnia in adults or older adults (Cho et al., 2008). For example, a Swedish study of a general population sample found that depression at its baseline is

related to subsequent symptoms of insomnia (Jansson-Fröjmark and Lindblom, 2008). In addition, a prospective study in the United Kingdom on an adult sample revealed that depression predicted the incidence of insomnia at 1-year follow-up (Morphy et al., 2007). This study conducted in Taiwan showed that depression, anxiety, and ADHD significantly affected insomnia in adolescents, after control for the effects of the social environment and behavioral health.

Social Environment and Insomnia

Considering that behavioral and mental health problems were the risk factors for insomnia, we examined the potential preventive factors in the three social environment levels that were related to low insomnia levels. This relationship has not been explored much previously. We hypothesized three preventive factors in the context of family, school, and community to represent the social environment in the ecological system. The results supported the hypotheses that higher family support, school connectedness, and a conducive neighborhood contributed to low risk of insomnia among adolescents. Based on the stress-buffering model, social support protected individuals from the negative psychological consequences of a wide range of stressful events that can help reduce insomnia (Cohen and Wills, 1985; Cohen et al., 2000). Family support and school connectedness are two essential types of social support for adolescents. Adolescents perceived a high level of social support when they felt that they were cared for, loved, held in high esteem, and were members of a network of mutual obligations. These perceptions enabled the adolescents to cope and adapt in life (Cobb, 1976), and consequently reduced sleep problems. Concordant with a previous US study on an adult sample (Ailshire and Burgard, 2012), we confirmed that perceived family support was associated with less insomnia in adolescents. The relationship between school connectedness and insomnia among the adolescents has not been researched much, but previous research suggested that school belongingness/connectedness may be a positive support for the adolescents (Huynh and Gillen-O'Neel, 2016). Our results support the hypothesis that adolescents who perceived higher school connectedness had fewer sleep problems, such as insomnia. Finally, our study on Taiwanese adolescents found that favorable neighborhood was associated with less insomnia, which was concordant with a previous research in the United States on adult samples that found higher prevalence of insomnia related to adverse neighborhood (Hill et al., 2009; DeSantis et al., 2013; Simonelli et al., 2017).

Strengths and Limitations

A strength of our study is the use of an ecological perspective to examine the roles of mental health and multidimensional psychosocial determinants, such as behavioral health (i.e., alcohol abuse and suicidality) and social environment (i.e., family support, school connectedness, and favorable neighborhood), in insomnia in adolescents. Holistic thinking can provide a paradigm to understand how various systems and their interactions can contribute to an individual's problem and behavior. Another strength is the large size of the study sample. By contrast, a limitation of the study is its cross-sectional design that can only draw conclusions regarding the correlation between the study variables and not interpret the cause-and-effect. Moreover, some of the variables may have a reciprocal relationship with insomnia. For example, depression predicts insomnia, whereas insomnia also predicts depression. Future research may be warranted to examine the reciprocal relationships between the psychosocial variables and insomnia and identify patterns of a negative cycle.

Implications

The study provides valuable information and evidence for clinicians, social workers, and health professionals providing support to adolescents with insomnia. Applying an ecological approach in practice aids in understanding the issues at individual, family, school, and community levels and identify the strengths and weaknesses of the interactions between them. This perspective allows the practitioner to effectively treat problems and address the needs of the various levels, including the individual, family, school, and the broader community. The prevention and intervention of insomnia in the adolescents should focus on multidimensional risks and preventive factors, including mental health, behavioral health, and social environment in the context of an ecological system.

DATA AVAILABILITY

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

ETHICS STATEMENT

This study was approved by the IRB of Kaohsiung Medical University before sampling and data collection. Before conducting the study, we prepared a leaflet explaining the study purpose and procedure, emphasizing the voluntary and confidential nature of the study. Students took the leaflets home for their parents or guardians, who were given a choice to call the researchers, write in the school communications book, or ask their children to directly, all convey to their refusal for their children to join the study. In addition, the students were given the liberty to refuse participation in this study by returning blank questionnaires along with those from other students.

AUTHOR CONTRIBUTIONS

Y-PH: conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing – original draft preparation, review and editing, and visualization. W-HL and C-FY: conceptualization, validation, investigation, resources, data curation, review and editing, supervision, project administration, and funding acquisition.

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SUPPLEMENTARY MATERIAL

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REFERENCES

Ailshire, J. A., and Burgard, S. A. (2012). Family relationships and troubled sleep among US adults: examining the influences of contact frequency and relationship quality. *J. Health Soc. Behav.* 53, 248–262. doi: 10.1177/0022146512446642

Alvaro, P. K., Roberts, R. M., and Harris, J. K. (2013). A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. *Sleep* 36, 1059–1068. doi: 10.5665/sleep.2810

American Psychiatric and Association (2000). *Diagnostic and Statistical Manual of Mental Disorders,* 4th Edn. Washington DC: American Psychiatric Association.

Baglioni, C., Battagliese, G., Feige, B., Spiegelhalder, K., Nissen, C., Voderholzer, U., et al. (2011). Insomnia as a predictor of depression: a meta-analytic evaluation of longitudinal epidemiological studies. *J. Affect. Disord.* 135, 10–19. doi: 10.1016/j.jad.2011.01.011

Bao, Z., Chen, C., Zhang, W., Jiang, Y., Zhu, J., and Lai, X. (2018). School connectedness and chinese adolescents' sleep problems: a cross-lagged panel analysis. *J. Sch. Health* 88, 315–321. doi: 10.1111/josh.12608

Bernert, R. A., Hom, M. A., Iwata, N. G., and Joiner, T. E. (2017). Objectively assessed sleep variability as an acute warning sign of suicidal ideation in a longitudinal evaluation of young adults at high suicide risk. *J. Clin. Psychiatry* 78, e678–e687. doi: 10.4088/JCP.16m11193

Bronfenbrenner, U. (1979). *The Ecology Of Human Development*. Cambridge, MA: Harvard university press.

Calhoun, S. L., Fernandez-Mendoza, J., Vgontzas, A. N., Liao, D., and Bixler, E. O. (2014). Prevalence of insomnia symptoms in a general population sample of young children and preadolescents: gender effects. *Sleep Med.* 15, 91–95. doi: 10.1016/j.sleep.2013.08.787

Chaudhary, N. S., Kampman, K. M., Kranzler, H. R., Grandner, M. A., Debbarma, S., and Chakravorty, S. (2015). Insomnia in alcohol dependent subjects is associated with greater psychosocial problem severity. *Addict. Behav.* 50, 165–172. doi: 10.1016/j.addbeh.2015.06.021

Chen, Y. C., Hsu, C. C., Hsu, S. H., and Lin, C. C. (1980). A preliminary study of family APGAR index. *Gaoxiong Yi Xue Ke Xue Za Zhi* 21, 210–217.

Chien, C. P., and Cheng, T. A. (1985). Depression in taiwan: epidemiological survey utilizing CES-D. *Seishin Shinkeigaku Zasshi* 87, 335–338.

Cho, H. J., Lavretsky, H., Olmstead, R., Levin, M. J., Oxman, M. N., and Irwin, M. R. (2008). Sleep disturbance and depression recurrence in community-dwelling older adults: a prospective study. *Am. J. Psychiatry* 165, 1543–1550. doi: 10.1176/appi.ajp.2008.07121882

Chung, K. F., Kan, K. K. K., and Yeung, W. F. (2011). Assessing insomnia in adolescents: comparison of insomnia severity index, athens insomnia scale and sleep quality index. *Sleep Med.* 12, 463–470. doi: 10.1016/j.sleep.2010.09.019

Clinkinbeard, S. S., Simi, P., Evans, M. K., and Anderson, A. L. (2011). Sleep and delinquency: does the amount of sleep matter? *J. Youth Adolesc.* 40, 916–930. doi: 10.1007/s10964-010-9594-6

Cobb, S. (1976). Social support as a moderator of life stress. *Psychosomatic Med.* 38, 300–314. doi: 10.1097/00006842-197609000-00003

Cohen, S., Gottlieb, B. H., and Underwood, L. G. (2000). "Social relationships and health," in *Social Support Measurement And Intervention: A Guide For Health And Social Scientists*, eds S. Cohen, L. G. Underwood, and B. H. Gottlieb (New York, NY: Oxford University Press), 3–25.

Cohen, S., and Wills, T. A. (1985). Stress, social support, and the buffering hypothesis. *Psychol. Bull.* 98, 310–357. doi: 10.1037/0033-2909.98.2.310

Cohen-Zion, M., and Ancoli-Israel, S. (2004). Sleep in children with attention-deficit hyperactivity disorder (ADHD): a review of naturalistic and stimulant intervention studies. *Sleep Med. Rev.* 8, 379–402. doi: 10.1016/j.smrv.2004.06.002

Cunningham, T. J., Ford, E. S., Chapman, D. P., Liu, Y., and Croft, J. B. (2015). Independent and joint associations of race/ethnicity and educational attainment with sleep-related symptoms in a population-based US sample. *Prev. Med.* 77, 99–105. doi: 10.1016/j.ypmed.2015.05.008

Curcio, G., Ferrara, M., and De Gennaro, L. (2006). Sleep loss, learning capacity and academic performance. *Sleep Med. Rev.* 10, 323–337. doi: 10.1016/j.smrv.2005.11.001

DeSantis, A. S., Diez Roux, A. V., Moore, K., Baron, K. G., Mujahid, M. S., and Nieto, F. J. (2013). Associations of neighborhood characteristics with sleep timing and quality: the multi-ethnic study of atherosclerosis. *Sleep* 36, 1543–1551. doi: 10.5665/sleep.3054

Durbin, J., and Watson, G. S. (1951). Testing for serial correlation in least squares regression. II. *Biometrika* 38, 159–177.

Evren, B., Evren, C., Dalbudak, E., Topcu, M., and Kutlu, N. (2019). The impact of depression, anxiety, neuroticism, and severity of Internet addiction symptoms on the relationship between probable ADHD and severity of insomnia among young adults. *Psychiatry Res.* 271, 726–731. doi: 10.1016/j.psychres.2018.12.010

Fuh, J. L., Wang, S. J., Lu, S. R., and Juang, K. D. (2005). Assessing quality of life for adolescents in taiwan. *Psychiatry Clin. Neurosci.* 59, 11–18. doi: 10.1111/j.1323-1316.2005.01306.x

Gau, S. S. F., Shang, C. Y., Liu, S. K., Lin, C. H., Swanson, J. M., Liu, Y. C., et al. (2008). Psychometric properties of the chinese version of the swanson, nolan, and pelham, version IV scale–parent form. *Int. J. Methods Psychiatr. Res.* 17, 35–44. doi: 10.1002/mpr.237

Hair, J. F., Anderson, R. E., Tatham, R. L., and Black, W. C. (1998). *Multivariate Data Analysis*. Jersey City, NJ: Englewood Cliff.

Hasler, B. P., Martin, C. S., Wood, D. S., Rosario, B., and Clark, D. B. (2014). A longitudinal study of insomnia and other sleep complaints in adolescents with and without alcohol use disorders. *Alcoholism* 38, 2225–2233. doi: 10.1111/acer.12474

Hill, T. D., Burdette, A. M., and Hale, L. (2009). Neighborhood disorder, sleep quality, and psychological distress: testing a model of structural amplification. *Health Place* 15, 1006–1013. doi: 10.1016/j.healthplace.2009.04.001

Hill, T. D., Trinh, H. N., Wen, M., and Hale, L. (2016). Perceived neighborhood safety and sleep quality: a global analysis of six countries. *Sleep Med.* 18, 56–60. doi: 10.1016/j.sleep.2014.12.003

Huang, Y. S., Wang, C. H., and Guilleminault, C. (2010). An epidemiologic study of sleep problems among adolescents in north taiwan. *Sleep Med.* 11, 1035–1042. doi: 10.1016/j.sleep.2010.04.009

Huynh, V. W., and Gillen-O'Neel, C. (2016). Discrimination and sleep: the protective role of school belonging. *Youth Soc.* 48, 649–672. doi: 10.1177/0044118x13506720

Jansson-Fröjmark, M., and Lindblom, K. (2008). A bidirectional relationship between anxiety and depression, and insomnia? a prospective study in the general population. *J. Psychos. Res.* 64, 443–449. doi: 10.1016/j.jpsychores.2007.10.016

Johnson, E. O., Roth, T., and Breslau, N. (2006). The association of insomnia with anxiety disorders and depression: exploration of the direction of risk. *J. Psychiatr. Res.* 40, 700–708. doi: 10.1016/j.jpsychires.2006.07.008

Kao, C. C., Huang, C. J., Wang, M. Y., and Tsai, P. S. (2008). Insomnia: prevalence and its impact on excessive daytime sleepiness and psychological well-being in the adult taiwanese population. *Q. Life Res.* 17, 1073–1080. doi: 10.1007/s11136-008-9383-9

Khan, I. W., Juyal, R., Shikha, D., and Gupta, R. (2018). Generalized anxiety disorder but not depression is associated with insomnia: a population based study. *Sleep Science* 11, 166–173. doi: 10.5935/1984-0063.20180031

Knight, J. R., Sherritt, L., Shrier, L. A., Harris, S. K., and Chang, G. (2002). Validity of the CRAFFT substance abuse screening test among adolescent clinic patients. *Arch. Pediatr. Adolesc. Med.* 156, 607–614.

Lovato, N., and Gradisar, M. (2014). A meta-analysis and model of the relationship between sleep and depression in adolescents: recommendations for future

research and clinical practice. *Sleep Med. Rev.* 18, 521–529. doi: 10.1016/j.smrv.2014.03.006

March, J. S. (1997). *Multidimensional Anxiety Scale For Children*. North Tonawanda, NY: Multi-Health Systems Inc.

Ministry of the Interior (2002). *2001 Taiwan-Fukien Demographic Fact Book: Republic of China*. Taiwan: Executive Yuan, Taipei.

Morphy, H., Dunn, K. M., Lewis, M., Boardman, H. F., and Croft, P. R. (2007). Epidemiology of insomnia: a longitudinal study in a UK population. *Sleep* 30, 274–280.

Mueller, C. E., Bridges, S. K., and Goddard, M. S. (2011). Sleep and parent-family connectedness: links, relationships and implications for adolescent depression. *J. Fam. Stud.* 17, 9–23. doi: 10.5172/jfs.2011.17.1.9

Ohayon, M. M. (2002). Epidemiology of insomnia: what we know and what we still need to learn. *Sleep Med. Rev.* 6, 97–111. doi: 10.1053/smrv.2002.0186

Ohayon, M. M. (2005). Relationship between chronic painful physical condition and insomnia. *J. Psychiatr. Res.* 39, 151–159. doi: 10.1016/j.jpsychires.2004.07.001

Pallant, J. (2013). *Assessing Normality. SPSS Survival Manual*. New York, NY: McGraw-Hill Education.

Park, H., Tsai, K. M., Dahl, R. E., Irwin, M. R., McCreath, H., Seeman, T. E., et al. (2016). Sleep and inflammation during adolescence. *Psychos. Med.* 78, 677–685. doi: 10.1097/PSY.0000000000000340

Pasch, K. E., Latimer, L. A., Cance, J. D., Moe, S. G., and Lytle, L. A. (2012). Longitudinal bi-directional relationships between sleep and youth substance use. *J. Youth Adolesc.* 41, 1184–1196. doi: 10.1007/s10964-012-9784-5

Patten, C. A., Choi, W. S., Gillin, J. C., and Pierce, J. P. (2000). Depressive symptoms and cigarette smoking predict development and persistence of sleep problems in US adolescents. *Pediatrics* 106, e23–e23. doi: 10.1542/peds.106.2.e23

Pigeon, W. R., Pinquart, M., and Conner, K. (2012). Meta-analysis of sleep disturbance and suicidal thoughts and behaviors. *J. Clin. Psychiatry* 73, e1160–e1167. doi: 10.4088/JCP.11r07586

Puig-Antich, J., and Chambers, W. (1978). *The Schedule For Affective Disorders And Schizophrenia For School Age Children (Kiddie-SADS)*. New York, NY: New York State Psychiatric Institute.

Radloff, L. S. (1977). The CES-D scale: a self-report depression scale for research in the general population. *Appl. Psychol. Measure.* 1, 385–401. doi: 10.1177/014662167700100306

Roberts, R. E., and Duong, H. T. (2013). Depression and insomnia among adolescents: a prospective perspective. *J. Affect. Disord.* 148, 66–71. doi: 10.1016/j.jad.2012.11.049

Roberts, R. E., Roberts, C. R., and Chen, I. G. (2001). Functioning of adolescents with symptoms of disturbed sleep. *J. Youth Adolesc.* 30, 1–18. doi: 10.1023/a%3A1005230820074

Roehrs, T., and Roth, T. (2001). Sleep, sleepiness, and alcohol use. *Alcohol. Res. Health* 25, 101–101.

Sadeh, A., Gruber, R., and Raviv, A. (2003). The effects of sleep restriction and extension on school-age children: what a difference an hour makes. *Child Dev.* 74, 444–455. doi: 10.1111/1467-8624.7402008

Simonelli, G., Dudley, K. A., Weng, J., Gallo, L. C., Perreira, K., Shah, N. A., et al. (2017). Neighborhood factors as predictors of poor sleep in the sueno ancillary study of the hispanic community health study/study of latinos. *Sleep* 40, 1–8. doi: 10.1093/sleep/zsw025

Smilkstein, G. (1978). The family APGAR: a proposal for a family function test and its use by physicians. *J. Fam. Practice* 6, 1231–1239.

Soldatos, C. R., Dikeos, D. G., and Paparrigopoulos, T. J. (2000). Athens insomnia scale: validation of an instrument based on ICD-10 criteria. *J. Psychos. Res.* 48, 555–560. doi: 10.1016/s0022-3999(00)00095-7

Sun, J. L., Chiou, J. F., and Lin, C. C. (2011). Validation of the taiwanese version of the athens insomnia scale and assessment of insomnia in taiwanese cancer patients. *J. Pain Symptom Manag.* 41, 904–914. doi: 10.1016/j.jpainsymman.2010.07.021

Tabachnick, B. G., Fidell, L. S., and Ullman, J. B. (2007). *Using Multivariate Statistics*. Boston, MA: Pearson.

Tang, T. C., Ko, C. H., Yen, J. Y., Lin, H. C., Liu, S. C., Huang, C. F., et al. (2009). Suicide and its association with individual, family, peer and school factors in a population of 10,233 adolescents in southern Taiwan. *Suicide Life Threaten. Behav.* 39, 91–102. doi: 10.1521/suli.2009.39.1.91

Thakkar, M. M., Sharma, R., and Sahota, P. (2015). Alcohol disrupts sleep homeostasis. *Alcoholism* 49, 299–310. doi: 10.1016/j.alcohol.2014.07.019

Tsai, K. M., Dahl, R. E., Irwin, M. R., Bower, J. E., McCreath, H., Seeman, T. E., et al. (2018). The roles of parental support and family stress in adolescent sleep. *Child Dev.* 89, 1577–1588. doi: 10.1111/cdev.12917

Wang, C. C., Liu, T. L., Hsiao, R. C., Wu, Y. Y., Hu, H. F., and Yen, C. F. (2017). The relationships of insomnia and short and long nocturnal sleep durations with quality of life and the moderating effects of sex and age in taiwanese adolescents. *Neuropsychiatry* 7, 217–223.

Wolraich, M. L., Lambert, W., Doffing, M. A., Bickman, L., Simmons, T., and Worley, K. (2003). Psychometric properties of the vanderbilt ADHD diagnostic parent rating scale in a referred population. *J. Pediatr. Psychol.* 28, 559–568. doi: 10.1093/jpepsy/jsg046

Wong, M. M., Brower, K. J., and Zucker, R. A. (2011). Sleep problems, suicidal ideation, and self-harm behaviors in adolescence. *J. Psychiatr. Res.* 45, 505–511. doi: 10.1016/j.jpsychires.2010.09.005

Wynchank, D., ten Have, M., Bijlenga, D., Penninx, B. W., Beekman, A. T., Lamers, F., et al. (2018). The association between insomnia and sleep duration in adults with attention-deficit hyperactivity disorder: results from a general population study. *J. Clin. Sleep Med.* 14, 349–357. doi: 10.5664/jcsm.6976

Yan, Y. W., Lin, R. M., Su, Y. K., and Liu, M. Y. (2018). The relationship between adolescent academic stress and sleep quality: a multiple mediation model. *Soc. Behav. Pers.* 46, 63–77. doi: 10.2224/sbp.6530

Yen, C. F., Ko, C. H., Wu, Y. Y., Yen, J. Y., Hsu, F. C., and Yang, P. (2010a). Normative data on anxiety symptoms on the multidimensional anxiety scale for children in taiwanese children and adolescents: differences in sex, age, and residence and comparison with an american sample. *Child Psychiatry Hum. Dev.* 41, 614–623. doi: 10.1007/s10578-010-0191-4

Yen, C. F., Yang, P., Wu, Y. Y., Hsu, F. C., and Cheng, C. P. (2010b). Factor structure, reliability and validity of the taiwanese version of the multidimensional anxiety scale for children. *Child Psychiatry Hum. Dev.* 41, 342–352. doi: 10.1007/s10578-010-0172-7

Zhabenko, N., Wojnar, M., and Brower, K. J. (2012). Prevalence and correlates of insomnia in a Polish sample of alcohol-dependent patients. *Alcoholism* 36, 1600–1607. doi: 10.1111/j.1530-0277.2012.01771.x

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frontiers in Neuroscience

BRIEF RESEARCH REPORT
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The Relationship Between Sleep Duration and Participation in Home, School, and Community Activities Among School-Aged Children

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Sleep duration has important implications for children's participation in daily activities; however, past attempts to examine this relationship has been limited to specific types of physical or educational activities. The present study aimed to investigate the relationship between sleep duration and participation in various daily activities among school-aged children. A school-based sample of 391 children aged 5–12 years (boys: 52.4%) participated in this cross-sectional survey. Sleep duration was quantified using parental reports of their children's bedtime and wake-up time on weekdays and weekends. The parent-reported Participation and Environment Measure for Children and Youth was used to measure their children's participation frequency and involvement in 25 home, school, and community activities. The results of hierarchical regression analyses showed that, when the demographic variables were controlled for, weekday sleep duration was positively related to homework involvement and negatively related to the frequency of TV viewing; however, it was unrelated to participation in school and community activities. Conversely, weekend sleep duration was positively related to overall participation in school activities, and participation frequency and involvement in some home and community activities. Furthermore, sleep duration was approximately an hour shorter on weekdays than on weekends. These results suggest that weekend sleep duration has stronger positive implications for children's participation in daily activities than does weekday sleep duration. Interventions aiming to promote children's activity participation may either prolong children's weekend sleep duration or address their shorter weekday sleep duration.

Keywords: participation, sleep, Participation and Environment Measure, PEM-CY, weekday sleep duration, weekend sleep duration

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INTRODUCTION

Adequate sleep plays an important role in healthy child development, and it is also required for the maintenance of physical and mental health. According to the National Sleep Foundation (Hirshkowitz et al., 2015), school-aged children (6–13 years) are recommended to sleep for a duration of 9–11 h per night. However, when compared to earlier times, children in modern societies do not get enough sleep; this is especially true for children who live in Asian and

North American countries (Matricciani et al., 2012). Insufficient sleep has adverse effects on the cognition, emotional regulation, energy balance, and metabolism of children (St-Onge, 2013; Chaput et al., 2016; Bolinger et al., 2018). These effects have long-term consequences for children's development (Chaput et al., 2016), academic performance (Curcio et al., 2006), health (Smaldone et al., 2007; Medic et al., 2017), and quality of life (Magee et al., 2017). Therefore, understanding the effects of insufficient sleep on children has important implications for the foundation of health guidelines and the development of intervention strategies that can alleviate the adverse effects of insufficient sleep.

Insufficient sleep among school-aged children may lead to low levels of participation in daily activities or a lack of balanced engagement in a variety of daily activities (Ortega et al., 2011; Engle-Friedman, 2014). However, the existing literature on the relationship between sleep duration and activity participation is primarily limited to specific types of physical or educational activities that have been examined across disparate studies (Li et al., 2014; Jiang et al., 2015; Khan et al., 2015; Lin et al., 2018). Furthermore, these studies did not examine the relationships between sleep duration and the levels of children's involvement in activities; instead, the participation duration or frequency has been operationalized in most of the studies. The construct of participation has been refined in recent years (Coster et al., 2011b; Kang et al., 2014; Imms et al., 2016b), and it includes two key dimensions: attendance and involvement. Attendance is defined as "being there" reflected by the time spent on or frequency of engaging in activities. Involvement is conceptualized as "the experience of participation" which may include elements of motivation, persistence, social connection, and level of affect (Chien et al., 2014; Imms et al., 2016b). According to this bi-dimensional framework of activity participation, attendance is a necessary but insufficient requirement for high levels of involvement in activities (Imms et al., 2016b). For example, a child may attend soccer practice but may spend a majority of the time passively running around the field and watching for his/her teammates' play the sport. Therefore, it is important to examine the relationship between sleep duration and both dimensions of activity participation, namely, attendance and involvement.

The objective of the present study was to examine the relationship between sleep duration (during weekdays and the weekend) and two dimensions of activity participation (frequency and involvement) among school-aged children. The activities to be examined in this study pertained to a variety of activities in which children took part at home, at school, and in the community.

MATERIALS AND METHODS

Participants

Participants were recruited from four mainstream primary schools using convenience sampling. First, invitations to participate in this study were sent to all the schools in Hong Kong. Those schools that were first to accept the invitation in each of the four major geographical regions (i.e., Hong Kong Island, Kowloon, New Territory East, and New Territory West) were included in the study. Children who met the following criteria were included in the study sample: (1) between the ages of 5 and 12 years; (2) no history of diagnoses of diseases or disabilities that might interfere with their ability to participate in activities (i.e., as per parent-reports); and (3) parents can read Chinese.

Procedure

A cross-sectional school-based survey was conducted between 2017 and 2018. An assessment packet that consisted of printed invitation letters, consent forms, and survey questionnaires were distributed to all the children in the four participating schools. Children were instructed to give the packets to their parents. Parents who were willing to participate in the research study were asked to provide written consent, complete the questionnaires, and return them by post using the prepaid envelopes that were included in the assessment packet. Ethical approval for the present study was granted by the ethical review committee of the Hong Kong Polytechnic University.

Measures

Activity Participation

The Participation and Environment Measure for Children and Youth (PEM-CY) (Coster et al., 2011b) is a well-developed parent-reported measure of children's participation in a range of daily activities. The PEM-CY consists of 25 items that measures children's participation in a board range of activities at home (10 items), at school (5 items), and in the community (10 items). In each type of activity, there are a few illustrative examples. For example, in the activity of indoor play and games, the examples include playing with toys, puzzles, or board games, playing kitchen, or dress-up. Parents are asked to think about all of the examples that belong to the activity category when answering following questions. First, parents report how often your child has participated in one or more activities of this type over the last 4 months (0 = never; 7 = daily) and, secondly, how involved your child is when participating in one or two activities of this type that he or she does most often (1 = minimally involved; 5 = very involved). Two types of composite participation scores (namely frequency and involvement) can be generated by averaging the individual item scores that have been recorded for each of the three domains of activities (i.e., home, school, and community settings). The PEM-CY has demonstrated fair to high internal consistency (Cronbach's α = 0.55–0.86) and satisfactory test–retest reliability (intraclass correlation coefficients = 0.70-0.84) (Coster et al., 2011a; Chien et al., 2019).

Sleep Duration

Children's sleep schedules were assessed using a questionnaire that was designed for the purpose of the present study. Parents were asked to indicate the time at which their children typically went to bed at night and woke up in the morning on weekdays and weekends. Sleep duration was calculated as the time that had lapsed between bedtime and wake-up time on weekdays and weekends. The test–retest reliability of this indicator across a 1-month interval was found to be satisfactory (intraclass

correlation coefficient = 0.79 for weekdays and 0.81 for weekends) in a subset of 55 children of the study sample.

Demographic Characteristics

A demographic questionnaire was used to obtain information about children's gender, age, and the presence of any diagnoses/disabilities, as well as the respondent's relationship with his/her child, age, education, occupation, monthly household income, and district of residence.

Data Analysis

Means and standard deviations were computed for continuous variables, and percentages were computed for categorical variables. One-way analyses of variance and (independent-samples and paired) *t*-tests were used to examine group differences.

To examine the relationship between sleep duration and activity participation, hierarchical multiple linear regression analyses were conducted. Each of the two composite participation scores for the three domains of activities (i.e., home, school, and community) served as the dependent variable. Since the age, gender, and household income of children have been found to strongly influence activity participation (Brown et al., 2011; Anaby et al., 2014; Imms et al., 2016a), these variables were included as control variables in the first block of the models. In the second block of the models, sleep duration served as the independent variable. Separate analyses were conducted for sleep duration on weekdays and weekends, as different sleep patterns have been reported for these two parts of the week (Wing et al., 2009). The significance level at which the results of these analyses were tested was specified at 0.05.

Furthermore, hierarchical regression analyses were repeated for each PEM-CY item. For these item-level analyses, Bonferroni corrections (Bland and Altman, 1995) were applied to adjust *p*-values to 0.005, 0.010, and 0.005 for participation in home, school, and community activities, respectively.

In addition, variance inflation factors and residual analyses were performed to search for violations of necessary assumptions (e.g., multicollinearity, homescedasticity, normality, and linearity) for the multiple regression analysis (Tabachnik and Fiddel, 2007). We found that the variation inflation factors of all control and independent variables were found to be less than 3, indicating that no multicollinearity was present (Pallant, 2007). The residuals of the children's participation in each domain of activities or individual activity appeared to be linear, normally distributed, and homoscedastic when the normality probability plots and scatterplots were examined.

RESULTS

Demographics, Sleep Duration, and Activity Participation

A total of 517 parents/caregivers (response rate: 34.9%) completed the research questionnaires; of these, 396 (76.6%) were mothers. Further, 82 children had known diagnoses/disabilities and were therefore excluded from the sample. Additionally, 88 children were sibling pairs that represented the same family. Since they tended to coparticipate in activities and have similar sleep schedules, we randomly excluded the data of one child from each family. The final sample included 391 children: 205 boys (52.4%) and 186 girls (47.6%). Their mean age was 8.9 years (SD = 1.8), and 272 (69.6%) children's families had monthly incomes that were equal to or higher than the median.

Sleep duration and activity participation as a function of age, gender, and household income are shown in **Table 1**. The mean sleep duration on a typical weeknight was 9.02 h, and 58.8% of the children slept for a duration that was lower than the recommended duration for children aged 6–13 years: 9–11 h per night (Hirshkowitz et al., 2015). No significant differences emerged between the groups that differed on gender and household income; however, younger children slept for a longer duration than their older counterparts ($p < 0.001$). In contrast, children slept for a significantly longer duration ($p < 0.001$) on weekend nights (M = 10.01 h) than on weeknights. There were 17.4% of children who slept for less than 9 h on weekend nights. Age, gender, and household income did not have a significant effect on weekend sleep duration.

With regard to activity participation, the average frequency scores were 5.53, 4.36, and 2.57 for the home, school, and community activities, respectively. These values indicate that, on average, children engaged in home, school, and community activities few times a week, once a week, and once a month, respectively. The average involvement scores revealed that parents perceived their children's involvement in home (M = 3.84), school (M = 3.67), and community (M = 2.78) activities to be of a moderate level. There were no significant age and gender differences in children's activity participation; however, older children participated more frequently and were more involved in school activities than their younger counterparts ($p < 0.001$; see **Table 1**). Additionally, children from high-income families participated more frequently in community activities and were more involved in home and community activities than children from low-income families ($p \leq 0.021$).

Relationships Between Sleep Duration and Participation in Home Activities

Table 2 shows the relationships that emerged between participation in home activities and sleep duration. With regard to participation frequency, weekday sleep duration was found to be negatively related to watching TV, videos, and DVDs ($\beta = -0.149$, $p = 0.004$). On the other hand, with regard to participation involvement, weekday sleep duration was positively related to doing homework ($\beta = 0.184$, $p = 0.001$). Furthermore, children who slept for longer duration on weekends tended to be more involved in home activities as a whole ($\beta = 0.119$, $p = 0.022$) and specifically in tasks that were involved in preparing school materials at home ($\beta = 0.177$, $p = 0.001$).

Relationships Between Sleep Duration and Participation in School Activities

Table 3 shows the relationships that emerged between participation in school activities and sleep duration. Weekday

TABLE 1 | Sleep duration and activity participation as a function of age, gender, and household income.

	Age (in years)				Gender			Household monthly income		
	5.5–7.5 (*n* = 126)	**7.6–9.5 (*n* = 114)**	**9.6–12.5 (*n* = 151)**	***p***	**Boys (*n* = 205)**	**Girls (*n* = 186)**	***p***	**<median (*n* = 118)**	**≥median (*n* = 272)**	***p***
Weekday sleep duration	9.31 (0.68)	8.99 (0.69)	8.81 (0.77)	< 0.001	9.06 (7.32)	8.99 (0.76)	0.321	9.03 (0.80)	9.02 (0.72)	0.871
Weekend sleep duration	10.14 (0.87)	10.05 (1.06)	10.02 (1.04)	0.620	10.00 (1.00)	10.14 (0.98)	0.127	10.18 (1.17)	10.02 (0.90)	0.127
Home participation										
Frequency	5.46 (0.69)	5.50 (0.64)	5.61 (0.64)	0.139	5.53 (0.64)	5.53 (0.69)	0.986	5.50 (0.74)	5.55 (0.63)	0.487
Involvement	3.89 (0.60)	3.76 (0.61)	3.85 (0.61)	0.274	3.85 (0.62)	3.83 (0.59)	0.754	3.73 (0.64)	3.89 (0.59)	0.021
School participation										
Frequency	3.97 (1.17)	4.21 (1.13)	4.83 (0.92)	< 0.001	4.31 (1.17)	4.42 (1.09)	0.343	4.24 (1.17)	4.42 (1.11)	0.154
Involvement	3.40 (1.02)	3.63 (0.98)	3.92 (0.90)	< 0.001	3.64 (1.03)	3.69 (0.94)	0.630	3.54 (1.05)	3.71 (0.96)	0.120
Community participation										
Frequency	2.68 (0.74)	2.45 (0.77)	2.57 (0.88)	0.093	2.60 (0.81)	2.54 (0.80)	0.509	2.33 (0.76)	2.66 (0.80)	< 0.001
Involvement	2.89 (0.75)	2.66 (0.92)	2.78 (0.91)	0.146	2.79 (0.86)	2.77 (0.87)	0.823	2.52 (0.97)	2.87 (0.80)	0.001

TABLE 2 | Relationships, indicated by regression coefficients, between sleep duration and participation in home activities.

	Weekday sleep duration			Weekend sleep duration		
Dependent variable	**β**	**95% CI**	***p***	**β**	**95% CI**	***p***
Participation frequency						
Composite frequency score	0.025	−0.081, 0.131	0.640	0.069	−0.031, 0.171	0.176
Computer and video games	−0.023	−0.127, 0.082	0.673	−0.053	−0.153, 0.046	0.291
Indoor play and games	0.094	−0.002, 0.191	0.056	−0.004	−0.097, 0.088	0.924
Arts, crafts, music, and hobbies	−0.023	−0.131, 0.085	0.674	0.087	−0.014, 0.189	0.094
Watching TV, videos, and DVDs	**−0.149**	**−0.254, −0.042**	**0.004**	−0.070	−0.171, 0.031	0.176
Getting together with other people	−0.025	−0.132, 0.082	0.641	−0.036	−0.138, 0.064	0.476
Socializing using technology	−0.017	−0.117, 0.082	0.725	0.029	−0.065, 0.124	0.543
Household chores	0.131	0.025, 0.237	0.015	0.104	0.003, 0.206	0.042
Personal care management	−0.014	−0.120, 0.093	0.800	0.121	0.020, 0.222	0.019
School preparation (not homework)	0.046	−0.058, 0.151	0.383	0.078	−0.021, 0.178	0.124
Homework	0.019	−0.087, 0.126	0.721	0.095	−0.006, 0.197	0.065
Participation involvement						
Composite involvement score	0.072	−0.036, 0.180	0.191	**0.119**	**0.017, 0.222**	**0.022**
Computer and video games	−0.125	−0.230, −0.019	0.020	−0.064	−0.164, 0.037	0.216
Indoor play and games	0.013	−0.089, 0.117	0.796	0.017	−0.081, 0.115	0.733
Arts, crafts, music, and hobbies	0.037	−0.071, 0.144	0.504	0.065	−0.036, 0.168	0.210
Watching TV, videos, and DVDs	−0.105	−0.003, 0.388	0.053	0.014	−0.087, 0.116	0.782
Getting together with other people	0.089	−0.017, 0.196	0.100	0.061	−0.040, 0.163	0.236
Socializing using technology	−0.005	−0.109, 0.099	0.921	0.038	−0.060, 0.137	0.449
Household chores	0.053	−0.055, 0.161	0.336	0.100	−0.001, 0.203	0.053
Personal care management	0.055	−0.053, 0.163	0.320	0.082	−0.021, 0.184	0.119
School preparation (not homework)	0.122	0.014, 0.229	0.026	**0.177**	**0.007, 0.279**	**0.001**
Homework	**0.184**	**0.077, 0.291**	**0.001**	0.119	−0.017, 0.222	0.022

All models were adjusted for children's age, gender, and household income. Statistically significant results are presented in boldface; $p < 0.050$ and $p < 0.005$ were the levels of significance that were used to test the composite scores and individual item scores, respectively.

sleep duration was unrelated to participation frequency and involvement in school activities. In contrast, weekend sleep duration was positively related to both the frequency of participation (β = 0.109, $p = 0.024$) and involvement (β = 0.115, $p = 0.023$) in school activities (i.e., composite scale score). Specifically, children who slept for longer duration on weekends tended to participate more frequently (β = 0.154, $p = 0.002$) and be more involved (β = 0.152, $p = 0.002$) in prosocial activities at school by playing roles such as a class leader, discipline leader, or student mentor.

TABLE 3 | Relationships, indicated by regression coefficients, between sleep duration and participation in school activities.

	Weekday sleep duration			Weekend sleep duration		
Dependent variable	**β**	**95% CI**	***p***	**β**	**95% CI**	***p***
Participation frequency						
Composite frequency score	0.036	−0.064, 0.136	0.479	**0.109**	**0.014, 0.203**	**0.024**
Classroom activities	0.073	−0.033, 0.180	0.176	0.026	−0.076, 0.128	0.613
Field trips and school events	0.122	0.016, 0.228	0.023	0.046	−0.056, 0.147	0.375
School-sponsored teams, clubs and organizations	−0.053	−0.156, 0.049	0.308	0.018	−0.079, 0.116	0.714
Getting together with peers outside of class	0.073	−0.034, 0.180	0.184	0.052	−0.050, 0.155	0.316
Special roles at school	< 0.001	−0.102, 0.103	0.999	**0.154**	**0.057, 0.251**	**0.002**
Participation involvement						
Composite involvement score	−0.013	−0.118, 0.091	0.804	**0.115**	**0.015, 0.214**	**0.023**
Classroom activities	0.054	−0.053, 0.163	0.321	0.121	0.017, 0.223	0.021
Field trips and school events	−0.049	−0.157, 0.059	0.370	0.044	−0.058, 0.147	0.393
School-sponsored teams, clubs and organizations	−0.021	−0.127, 0.084	0.690	0.039	−0.061, 0.139	0.447
Getting together with peers outside of class	0.017	−0.092, 0.126	0.765	0.006	−0.098, 0.110	0.910
Special roles at school	0.021	−0.086, 0.127	0.704	**0.152**	**0.052, 0.252**	**0.002**

All models were adjusted for children's age, gender, and household income. Statistically significant results are presented in boldface; $p < 0.050$ and $p < 0.010$ were the levels of significance that were used to test the composite scores and individual item scores, respectively.

TABLE 4 | Relationships, indicated by regression coefficients, between sleep duration and participation in community activities.

	Weekday sleep duration			Weekend sleep duration		
Dependent variable	**β**	**95% CI**	***p***	**β**	**95% CI**	***p***
Participation frequency						
Composite frequency score	0.084	−0.024, 0.207	0.122	0.099	−0.002, 0.201	0.057
Neighborhood outings	0.021	−0.008, 0.124	0.690	0.051	−0.046, 0.150	0.299
Community events	−0.041	−0.150, 0.067	0.451	0.090	−0.012, 0.193	0.083
Organized physical activities	0.075	−0.031, 0.181	0.165	0.088	−0.012, 0.189	0.084
Unstructured physical activities	0.069	−0.038, 0.175	0.208	−0.002	−0.104, 0.100	0.977
Classes and lessons (not school-sponsored)	−0.001	−0.106, 0.103	0.983	**0.149**	**0.050, 0.247**	**0.003**
Organizations, groups, clubs, and volunteer or leadership activities	0.003	−0.103, 0.111	0.947	−0.003	−0.105, 0.098	0.950
Religious or spiritual gatherings and activities	0.088	−0.020, 0.196	0.109	−0.015	−0.118, 0.088	0.775
Getting together with other children in the community	0.082	−0.024, 0.187	0.128	0.029	−0.071, 0.129	0.571
Working for pay	0.101	−0.007, 0.210	0.069	−0.021	−0.125, 0.083	0.687
Overnight visits or trips	0.102	−0.006, 0.210	0.066	0.048	−0.056, 0.151	0.362
Participation involvement						
Composite involvement score	0.044	−0.067, 0.155	0.431	0.043	−0.063, 0.148	0.428
Neighborhood outings	−0.033	−0.141, 0.075	0.549	0.005	−0.097, 0.108	0.919
Community events	−0.067	−0.177, 0.043	0.234	0.052	−0.052, 0.157	0.327
Organized physical activities	0.120	0.011, 0.228	0.031	0.089	−0.014, 0.192	0.090
Unstructured physical activities	0.058	−0.049, 0.167	0.288	−0.018	−0.121, 0.084	0.726
Classes and lessons (not school-sponsored)	0.038	−0.069, 0.145	0.482	0.077	−0.024, 0.179	0.135
Organizations, groups, clubs, and volunteer or leadership activities	−0.009	−0.119, 0.100	0.863	−0.004	−0.108, 0.100	0.935
Religious or spiritual gatherings and activities	0.009	−0.019, 0.203	0.103	−0.053	−0.159, 0.053	0.323
Getting together with other children in the community	−0.016	−0.124, 0.092	0.775	0.016	−0.087, 0.119	0.759
Working for pay	0.079	−0.030, 0.189	0.157	−0.004	−0.109, 0.101	0.936
Overnight visits or trips	0.045	−0.065, 0.157	0.421	0.064	−0.040, 0.170	0.228

All models were adjusted for children's age, gender, and household income. Statistically significant results are presented in boldface; $p < 0.050$ and $p < 0.005$ were the levels of significance that were used to test the composite scores and individual item scores, respectively.

Relationships Between Sleep Duration and Participation in Community Activities

Table 4 shows the relationships that emerged between participation in community activities and sleep duration. Weekday sleep duration was unrelated to both participation frequency and involvement in community activities. Similarly, weekend sleep duration was also unrelated to the level of involvement in community activities; however, it was positively

related to the frequency of participation in community-based classes and lessons (β = 0.149, $p = 0.003$).

DISCUSSION

Activity participation offers children opportunities to learn new skills, develop physical abilities, make friends, and establish their sense of purpose (Law, 2002; Hoogsteen and Woodgate, 2010; Chien and Rodger, 2011), and it has been recognized as an important contributor to health and quality of life (Colver, 2009; Holder et al., 2009; Berg et al., 2018). To our knowledge, the present study is the first to investigate the relationships between sleep duration and the frequency and involvement with which school-aged children participate in a wide range of activities. Overall, our results show that children slept for longer duration of time on weekend nights than on weeknights. Furthermore, longer weekend sleep duration was related to a higher frequency and greater involvement in home, school, and community activities. However, weekday sleep duration was negatively related to the frequency of watching TV and positively related to the involvement in doing homework; it was unrelated to school and community activities. These findings highlight the influence of weekday and weekend sleep duration on children's different activity participation patterns.

Previous studies have reported that children sleeping less were likely to have a sedentary and inactive lifestyle coupled with more time spent on watching TV and homework completion (Li et al., 2014; Jiang et al., 2015; Lin et al., 2018). Reciprocally, more time spent on TV viewing and finishing homework may delay children's bedtime and shorten their sleep duration (Li et al., 2007; Calamaro et al., 2009). Similar relationships between weekday sleep duration and the frequency of TV viewing was also observed in the present study, although the cross-sectional research design of this study did not allow us to determinate the direction of the relationships. However, with regard to homework, we found that short sleep duration was associated with low involvement but not high frequency. Thus, we speculated that short sleep duration might lead to tiredness or poor concentration during the daytime (O'Brien, 2009; St-Onge, 2013; Bolinger et al., 2018). This in turn might cause children to be less involved in homework activities and subsequently prolong the time that is required to finish their homework. Because previous studies have focused exclusively on the time that was spent on homework (Li et al., 2014; Jiang et al., 2015), the present findings on the relationship between sleep duration and involvement in doing one's homework make a noteworthy contribution to the existing literature.

Interestingly, we did not find a relationship between weekday sleep duration and participation in school or community activities. However, it is noted that we controlled for age, gender, and household income when examining the relationships between sleep duration and activity participation. Significant age differences emerged for school participation; similarly, significant differences in participation in community activities emerged between the groups that differed in household income (see **Table 1**). It is thus possible that the impact of short sleep duration on participation in school and community activities might be largely explained by the demographic variables. To test this possibility, we conducted the additional regression analyses by entering weekday sleep duration first and demographic variables subsequently. Significant relationships between weekday sleep duration and participation in some school and community activities attenuated when the demographic variables were entered into the models (results are not shown). In particular, children's age and/or household income became the strongest factors of nearly half the number of school and community activities in those models. This result is in accordance with past findings that children's activity participation involves a dynamic interdependence between personal, familial, and environmental factors (Law et al., 2007; Verdonschot et al., 2009; Anaby et al., 2014; Chien et al., 2017; Cho et al., 2018). Accordingly, weekday sleep duration may play a less important role than other personal and environmental factors in children's participation in school and community activities.

In contradistinction to the findings that emerged for weekday sleep duration, weekend sleep duration was positively related to participation in not only home activities but also in school and community activities. One possible explanation for the relationships that emerged for weekend sleep duration but not for weekday sleep duration may pertain to the benefits of weekend sleep extension (also known as weekend catch-up sleep). In the present study, the average duration of sleep was approximately an hour (1.04 h) longer on weekends than on weekdays. Particularly, 94.3% of 230 children who slept for shorter duration (i.e., ≤9 h) during the week were found to sleep, on average, 1.38 h ($SD = 0.97$) longer on weekends. Similarly, the longer duration of sleep on weekends than on weekdays ($M = 0.55$; $SD = 1.08$) was also found in 67.7% of 161 children who slept for more than 9 h during the week. This trend is consistent with past findings that elementary-school children ($N = 5159$) slept for longer duration on weekends to compensate for the insufficient sleep that they got throughout the week (Wing et al., 2009). Studies have shown that weekend catch-up sleep can restore the cognitive impairments that were caused by sleep restrictions that one got on weeknights (Kuula et al., 2015; Agostini et al., 2017). Children who slept for longer duration on weekends might have better attention and concentration and, therefore, might demonstrate a higher frequency of participation or greater involvement in activities such as preparing school materials at home, playing special roles at school, and attending extracurricular classes in the community. In the short term, weekend catch-up sleep may serve as a buffer against insufficient sleep on weekdays and may enhance participation in daily activities. Nonetheless, oversleeping on weekends may not be a suitable long-term solution. Specifically, a growing body of research suggests that children who sleep for longer duration on weekends tend to skip breakfast, develop irregular cortisol circadian rhythm, and have impaired executive functions; these in turn result in poor academic performance, depression, and weight gain (overweight/obesity) (Kuula et al., 2015; Becker et al., 2017; Sun et al., 2019).

There are several limitations that must be considered when the findings of the present study are interpreted. First, the present study used a well-developed and validated parent-reported

questionnaire (i.e., the PEM-CY) to assess children's activity participation. However, parents' interpretations of their child's participation may differ from those of the children. Furthermore, the PEM-CY did not obtain parents' report on their children's participation duration for each activity, and it is possible that children's sleep duration might be affected more by the activities in which they do not participate often but spend many hours each time they participate. Second, children's sleep duration was defined as the span of time between bedtime and wake-up time, both of which were reported by parents; therefore, the sleep duration that was computed may be overestimated. In addition, we did not collect either information on daytime naps or sleep quality in this study. Future studies that use objective actigraphic measures of sleep duration and comprehensive measures of sleep parameters are needed. Third, factors such as commuting time, seasonal effects, and environmental barriers that may impact children's activity participation and sleep behaviors were not taken into account in the present study. Future studies to include these factors may provide us a more comprehensive picture to address the concerns proposed in the present study. Finally, the present study entailed a cross-sectional survey design and, therefore, the causality of the observed relationships must be tested in future prospective and experimental studies.

CONCLUSION

Weekday sleep duration was associated with school-aged children's participation in some home activities but not school or community activities. In contrast, weekend sleep duration was associated with participation frequency and involvement in home, school, and community activities. Our findings also showed that the duration of sleep was approximately an hour longer on weekends than on weekdays, thereby indicating the phenomenon of weekend catch-up sleep that is common among school-aged children. Therefore, interventions that aim to promote children's participation in daily activities may need to incorporate strategies that ensure the adequate sleep children get on both weeknights and weekend nights. Increasing the awareness of the associations between sleep duration and activity participation could be also the focus of future health promotion programs for school-aged children and their parents.

DATA AVAILABILITY

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

AUTHOR CONTRIBUTIONS

C-WC conceived and designed the study, supervised the data collection, carried out the initial analyses, and drafted the initial manuscript. PC reviewed the relevant literature, carried out parts of the analyses, and critically reviewed the manuscript for important intellectual content. C-YC co-designed the study, reviewed the relevant literature, and critically reviewed the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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REFERENCES

Agostini, A., Carskadon, M. A., Dorrian, J., Coussens, S., and Short, M. A. (2017). An experimental study of adolescent sleep restriction during a simulated school week: changes in phase, sleep staging, performance and sleepiness. *J. Sleep Res.* 26, 227–235. doi: 10.1111/jsr.12473

Anaby, D., Law, M., Coster, W., Bedell, G., Khetani, M., Avery, L., et al. (2014). The mediating role of the environment in explaining participation of children and youth with and without disabilities across home, school, and community. *Arch. Phys. Med. Rehabil.* 95, 908–917. doi: 10.1016/j.apmr.2014.01.005

Becker, S. P., Sidol, C. A., Van Dyk, T. R., Epstein, J. N., and Beebe, D. W. (2017). Intraindividual variability of sleep/wake patterns in relation to child and adolescent functioning: a systematic review. *Sleep Med. Rev.* 34, 94–121. doi: 10.1016/j.smrv.2016.07.004

Berg, K. L., Medrano, J., Acharya, K., Lynch, A., and Msall, M. E. (2018). Health impact of participation for vulnerable youth with disabilities. *Am. J. Occup. Ther.* 72, 7205195040p1–7205195040p9. doi: 10.5014/ajot.2018.023622

Bland, J. M., and Altman, D. G. (1995). Multiple significance tests: the Bonferroni method. *BMJ* 310:170. doi: 10.1136/bmj.310.6973.170

Bolinger, E., Born, J., and Zinke, K. (2018). Sleep divergently affects cognitive and automatic emotional response in children. *Neuropsychologia* 117, 84–91. doi: 10.1016/j.neuropsychologia.2018.05.015

Brown, T., O'Keefe, S., and Stagnitti, K. (2011). Activity preferences and participation of school-age children living in urban and rural environments. *Occup. Ther. Health Care.* 25, 225–239. doi: 10.3109/07380577.2011.589889

Calamaro, C. J., Mason, T. B., and Ratcliffe, S. J. (2009). Adolescents living the 24/7 lifestyle: effects of caffeine and technology on sleep duration and daytime functioning. *Pediatrics* 123, 1005–1010. doi: 10.1542/peds.2008-3641

Chaput, J. P., Gray, C. E., Poitras, V. J., Carson, V., Gruber, R., Olds, T., et al. (2016). Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. *Appl. Physiol. Nutr. Metab.* 41, 266–282. doi: 10.1139/apnm-2015-0627

Chien, C. W., Li-Tsang, C. W. P., Cheung, P. P. P., Leung, K. Y., and Lin, C. Y. (2019). Development and psychometric evaluation of the Chinese version of the participation and environment measure for children and youth. *Disabil. Rehabil.* doi: 10.1080/09638288.09632018.01553210 [Epub ahead of print].

Chien, C. W., and Rodger, S. (2011). Applying a new participation definition in paediatric populations: issues and challenges. *Arch. Phys. Med. Rehabil.* 92:2096. doi: 10.1016/j.apmr.2011.08.033

Chien, C. W., Rodger, S., and Copley, J. (2017). Parent-reported participation in children with moderate-to-severe developmental disabilities: preliminary analysis of associated factors using the ICF. *Int. J. Disabil. Dev. Edu.* 64, 483–496. doi: 10.1080/1034912x.2017.1290221

Chien, C. W., Rodger, S., Copley, J., and Skorka, K. (2014). Comparative content review of children's participation measures using the international classification of functioning, disability and health-children and youth. *Arch. Phys. Med. Rehabil.* 95, 141–152. doi: 10.1016/j.apmr.2013.06.027

Cho, M., Rodger, S., Copley, J., and Chien, C. W. (2018). Participation in school-related activities that require hand use for children with and without developmental disabilities. *J. Intellect. Disabil. Res.* 62, 262–268. doi: 10.1111/jir.12459

Colver, A. (2009). Quality of life and participation. *Dev. Med. Child. Neurol.* 51, 656–659.

Coster, W., Bedell, G., Law, M., Khetani, M. A., Teplicky, R., Liljenquist, K., et al. (2011a). Psychometric evaluation of the participation and environment measure for children and youth. *Dev. Med. Child. Neurol.* 53, 1030–1037. doi: 10.1111/j.1469-8749.2011.04094.x

Coster, W., Law, M., Bedell, G., Khetani, M., Cousins, M., and Teplicky, R. (2011b). Development of the participation and environment measure for children and youth: conceptual basis. *Disabil. Rehabil.* 34, 238–246. doi: 10.3109/09638288.2011.603017

Curcio, G., Ferrara, M., and De Gennaro, L. (2006). Sleep loss, learning capacity and academic performance. *Sleep Med. Rev.* 10, 323–337. doi: 10.1016/j.smrv.2005.11.001

Engle-Friedman, M. (2014). The effects of sleep loss on capacity and effort. *Sleep Sci.* 7, 213–224. doi: 10.1016/j.slsci.2014.11.001

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., et al. (2015). National sleep foundation's sleep time duration recommendations: methodology and results summary. *Sleep Health.* 1, 40–43. doi: 10.1016/j.sleh.2014.12.010

Holder, M. D., Coleman, B., and Sehn, Z. L. (2009). The contribution of active and passive leisure to children's well-being. *J. Health Psychol.* 14, 378–386. doi: 10.1177/1359105308101676

Hoogsteen, L., and Woodgate, R. L. (2010). Can I play? A concept analysis of participation in children with disabilities. *Phys. Occup. Ther. Pediatr.* 30, 325–339. doi: 10.3109/01942638.2010.481661

Imms, C., Froude, E., Adair, B., and Shields, N. (2016a). A descriptive study of the participation of children and adolescents in activities outside school. *BMC Pediatr.* 16:84. doi: 10.1186/s12887-016-0623-9

Imms, C., Granlund, M., Wilson, P. H., Steenbergen, B., Rosenbaum, P. L., and Gordon, A. M. (2016b). Participation, both a means and an end: a conceptual analysis of processes and outcomes in childhood disability. *Dev. Med. Child. Neurol.* 59, 16–25. doi: 10.1111/dmcn.13237

Jiang, X., Hardy, L. L., Baur, L. A., Ding, D., Wang, L., and Shi, H. (2015). Sleep duration, schedule and quality among urban Chinese children and adolescents: associations with routine after-school activities. *PLoS One* 10:e0115326. doi: 10.1371/journal.pone.0115326

Kang, L. J., Palisano, R. J., King, G. A., and Chiarello, L. A. (2014). A multidimensional model of optimal participation of children with physical disabilities. *Disabil. Rehabil.* 36, 1735–1741. doi: 10.3109/09638288.2013.863392

Khan, M. K., Chu, Y. L., Kirk, S. F., and Veugelers, P. J. (2015). Are sleep duration and sleep quality associated with diet quality, physical activity, and body weight status? A population-based study of Canadian children. *Can. J. Public Health.* 106, 277–282. doi: 10.17269/cjph.106.4892

Kuula, L., Pesonen, A. K., Martikainen, S., Kajantie, E., Lahti, J., Strandberg, T., et al. (2015). Poor sleep and neurocognitive function in early adolescence. *Sleep Med.* 16, 1207–1212. doi: 10.1016/j.sleep.2015.06.017

Law, M. (2002). Participation in the occupations of everyday life. *Am. J. Occup. Ther.* 56, 640–649. doi: 10.5014/ajot.56.6.640

Law, M., Petrenchik, T., King, G., and Hurley, P. (2007). Perceived environmental barriers to recreational, community, and school participation for children and youth with physical disabilities. *Arch. Phys. Med. Rehabil.* 88, 1636–1642. doi: 10.1016/j.apmr.2007.07.035

Li, S., Jin, X., Wu, S., Jiang, F., Yan, C., and Shen, X. (2007). The impact of media use on sleep patterns and sleep disorders among school-aged children in China. *Sleep* 30, 361–367. doi: 10.1093/sleep/30.3.361

Li, S., Yang, Q., Chen, Z., Jin, X., Jiang, F., and Shen, X. (2014). Homework schedule: an important factor associated with shorter sleep duration among Chinese school-aged children. *Behav. Sleep Med.* 12, 389–397. doi: 10.1080/15402002.2013.821654

Lin, Y., Tremblay, M. S., Katzmarzyk, P. T., Fogelholm, M., Hu, G., Lambert, E. V., et al. (2018). Temporal and bi-directional associations between sleep duration and physical activity/sedentary time in children: an international comparison. *Prev. Med.* 111, 436–441. doi: 10.1016/j.ypmed.2017.12.006

Magee, C. A., Robinson, L., and Keane, C. (2017). Sleep quality subtypes predict health-related quality of life in children. *Sleep Med.* 35, 67–73. doi: 10.1016/j.sleep.2017.04.007

Matricciani, L., Olds, T., and Petkov, J. (2012). In search of lost sleep: secular trends in the sleep time of school-aged children and adolescents. *Sleep Med. Rev.* 16, 203–211. doi: 10.1016/j.smrv.2011.03.005

Medic, G., Wille, M., and Hemels, M. E. (2017). Short- and long-term health consequences of sleep disruption. *Nat. Sci. Sleep.* 9, 151–161. doi: 10.2147/NSS.S134864

O'Brien, L. M. (2009). The neurocognitive effects of sleep disruption in children and adolescents. *Child Adolesc. Psychiatr. Clin. N. Am.* 18, 813–823. doi: 10.1016/j.chc.2009.04.008

Ortega, F. B., Ruiz, J. R., Labayen, I., Kwak, L., Harro, J., Oja, L., et al. (2011). Sleep duration and activity levels in estonian and Swedish children and adolescents. *Eur. J. Appl. Physiol.* 111, 2615–2623. doi: 10.1007/s00421-011-1883-6

Pallant, J. F. (2007). *SPSS Survival Manual: A Step-by-Step Guide to Data Analysis With SPSS,* 3rd Edn. Crows Nest, NSW: Allen & Unwin.

Smaldone, A., Honig, J. C., and Byrne, M. W. (2007). Sleepless in America: inadequate sleep and relationships to health and well-being of our nation's children. *Pediatrics* 119(Suppl. 1), 29–37.

St-Onge, M. P. (2013). The role of sleep duration in the regulation of energy balance: effects on energy intakes and expenditure. *J. Clin. Sleep Med.* 9, 73–80. doi: 10.5664/jcsm.2348

Sun, W., Ling, J., Zhu, X., Lee, T. M., and Li, S. X. (2019). Associations of weekday-to-weekend sleep differences with academic performance and health-related outcomes in school-age children and youths. *Sleep Med. Rev.* 46, 27–53. doi: 10.1016/j.smrv.2019.04.003

Tabachnik, B. G., and Fiddel, L. S. (2007). *Using Multivariate Statistics*, 5th Edn. Boston, NY: Allyn and Bacon.

Verdonschot, M. M., de Witte, L. P., Reichrath, E., Buntinx, W. H., and Curfs, L. M. (2009). Impact of environmental factors on community participation of persons with an intellectual disability: a systematic review. *J. Intellect. Disabil. Res.* 53, 54–64. doi: 10.1111/j.1365-2788.2008.01128.x

Wing, Y. K., Li, S. X., Li, A. M., Zhang, J., and Kong, A. P. (2009). The effect of weekend and holiday sleep compensation on childhood overweight and obesity. *Pediatrics* 124, 994–1000. doi: 10.1542/peds.2008-3602

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Bedtime Procrastination, Sleep-Related Behaviors, and Demographic Factors in an Online Survey on a Polish Sample

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The sufficient length and good quality of night sleep play a vital role in maintaining health, well-being and effective functioning. Nevertheless, an increase in the prevalence of sleep deprivation can be observed recently. The concept of bedtime procrastination, defined as going to bed later than intended, has been proposed to explain one of the psychological determinants of sleep deficiency. To investigate the prevalence of bedtime procrastination among Poles we carried out a Polish adaptation of the Bedtime Procrastination Scale (BPS), a self-report questionnaire for measuring the tendency to voluntarily postpone going to bed in the absence of any external circumstances for doing so. The aim of the research was to determine the main psychometric properties of the Polish version of the BPS. We also aimed to identify the relationships between bedtime procrastination and selected demographic variables in the Polish sample, and to examine the impact of bedtime procrastination on self-reported sleep outcomes. The data obtained from online surveys conducted on two Polish samples were analyzed, including demographic factors, self-reported sleep outcomes, and responses to items of the BPS. The Polish version of the BPS has a unifactorial structure like the original version. It also exhibits satisfactory internal consistency and moderate temporal stability in a 10-week retest study. BPS scores were not significantly related to the place of residence, the highest completed level of education, living with a spouse or partner, and living with children. Scores in BPS slightly decreased with age and females scored higher on BPS than males. Higher BPS scores were obtained for a group of students in comparison to a group of subjects who were not students, and lower BPS scores were found in working respondents in comparison to respondents who were not working. BPS scores correlate negatively with sleep length on workdays and a feeling of sleep sufficiency, and positively with sleep length on weekdays relative to workdays, sleeping later than one would like, and a feeling of fatigue. Several relationships between self-reported sleep outcomes and demographic variables were also identified.

Keywords: health behaviors, bedtime procrastination, intention-behavior gap, sleep outcomes, sleep insufficiency, demographic factors, gender differences, students

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INTRODUCTION

Sleep is an important part of human life and is of key importance for physical and mental health, cognitive performance and good functioning at school, work, and leisure. Sleep deprivation may be the cause of poor working efficiency, low school performance (Wolfson and Carskadon, 2003; Curcio et al., 2006; Ming et al., 2011) traffic accidents (Connor et al., 2001; Connor, 2002; Abdoli et al., 2015a,b, 2018), mental stress, depressed mood and anxiety (Eller et al., 2006). It also involves medical conditions, including obesity, diabetes, cardiovascular disease, and an increased risk of death (Strine and Chapman, 2005; Gangwisch et al., 2006; Roane and Taylor, 2008; Fernandez-Mendoza et al., 2015). In addition, it was found that lack of sleep leads to a reduction in the level of optimism and sociability (Haack and Mullington, 2005).

Various factors may contribute to the delayed onset of night sleep. Length and quality of sleep are often negatively affected by various psychological and psychiatric issues such as insomnia and affective disorders, as well as several neurodegenerative diseases (Ondo et al., 2001; Bliwise, 2004; Herzog-Krzywoszanska and Krzywoszanski, 2019). Numerous studies have shown that female gender is a strong risk factor of poor sleep and insomnia; this is probably largely due to changes in sex steroid production during the menstrual cycle, pregnancy, and menopausal transition (Shaver et al., 1988; Pien and Schwab, 2004; Baker and Driver, 2007; Mong and Cusmano, 2016). On the other hand, numerous environmental and sociocultural factors, like exposure to noise and light at night, shift work, daily routines, lifestyle (Irish et al., 2015), and use of electronic media (Gradisar et al., 2013) all considerably contribute to postponing going to bed. Because of the growing mobility, accessibility, and user-friendliness of electronic media, we spend an increasing amount of time in front of screens (Rideout et al., 2010). As we devote more time to media, there is less time available for other activities, including sleep. One of the most profound effects of media use on sleep is sleep displacement, whereby media use leads to later bedtimes and shorter sleep duration (Cain and Gradisar, 2010; Van den Bulck, 2010).

The role of psychological conditions as the third potentially important group of factors in determining chronobiological health has been highlighted recently (Harvey, 2002; Harvey and Payne, 2002; Brand et al., 2015). Most research in this area focuses on patients with sleep disorders (ex., Szentkirályi et al., 2009; Swanson et al., 2011), but much less attention is paid to sleep problems that are a result of lifestyle and bad sleep habits in the general population (Kroese et al., 2016a). Going to bed on time may have a crucial role in providing sufficient sleep length and quality. Sleep deficiency can, therefore, be treated as the effect of a behavioral problem in that people have insufficient sleep because they go to bed late and the next morning they must get up for school or work. Most of them could fall asleep and sleep enough hours if they went to bed, but they delay doing so. Most often these individuals can easily predict that if they do not go to sleep early enough, they will be sleepy and tired the next day (Kroese et al., 2016b). Kroese et al. (2014, 2016a) called this phenomenon "bedtime procrastination," defined as "needlessly and voluntarily delaying going to bed, despite foreseeably being worse off as a result" (Kroese et al., 2016b). Bedtime procrastination, like general procrastination, is associated with poor self-regulation. Self-regulation failure increases the tendency to seek immediate rewards, increases susceptibility to temptation and hinders concentration in goal-directed activities (Tangney et al., 2004). The ability to resist temptations is crucial in order to realize the intention to go to bed at a certain time by giving up attractive activities such as watching TV or surfing the internet (Hofmann et al., 2008; Mann et al., 2013). To measure the general tendency to go to bed later than intended, the Bedtime Procrastination Scale (BPS) was developed (Kroese et al., 2014). English (Kroese et al., 2014; Sirois et al., 2019), Danish (Kroese et al., 2016a) and Flemish (Exelmans and Van den Bulck, 2017) versions of the BPS have been used in previous studies on bedtime procrastination. In addition, the preliminary results of work on the Polish adaptation of BPS were presented recently by Herzog-Krzywoszanska and Krzywoszanski (2017).

In Poland, as in other countries, sleep deprivation is a fairly common problem (National Sleep Foundation, 2008; Oginska et al., 2014). The results of a study on a representative sample of Polish adults (Boguszewski, 2016) showed that half of Poles declared that they sleep for less than 6 h at least once a week, and 8% that they always sleep less than 6 h. Students are particularly vulnerable to sleep deprivation since they have worse health habits than subjects in other groups (Trockel et al., 2000; Buboltz et al., 2001; Gaultney, 2010; Owens et al., 2017). Research on Polish high-school students revealed that they were sleep-deprived as 88.5% of adolescents reported getting less than 9 h of sleep, and 78% adolescents felt tired during the day on 3 or more days per week (Kadzikowska-Wrzosek, 2018a). Nearly half of Polish university students always or often slept less than 6 h per day and over 60% felt tired in the morning (Błońska and Gotlib, 2012; Kasperczyk and Jośko, 2012). This high prevalence of sleep deprivation among students indicates the need for more comprehensive studies on the psychological factors that affect it. Taking into account the phenomenon of bedtime procrastination, which is recognized as a specific sleep-related deficit of self-regulation, this seems a very promising approach in this field. However, to the best of our knowledge no studies on the prevalence of bedtime procrastination in different demographic groups in Poland have yet been presented. In order to support our other aims, the first goal of our study was to develop a Polish version of the BPS and examine its psychometric properties. Secondly, since the role of demographic factors in bedtime procrastination has not yet been thoroughly analyzed, we intended to investigate the possible variations of BPS scores due to demographic variables. In particular, it seemed to us to be particularly interesting to compare the severity of bedtime procrastination in Polish students against subjects from groups with different professional status. Thirdly, we attempted to identify the impact of bedtime procrastination on sleep duration and sleep outcomes in the general Polish population.

MATERIALS AND METHODS

Subjects

Since principal component analysis (PCA) and confirmatory factor analysis (CFA) had to be conducted on separate samples (Matsunaga, 2010), we conducted online surveys on two different samples of respondents. Sample 1 consisted of 431 students of the Pedagogical University of Kraków, who were studying various academic fields and disciplines. They participated voluntarily and received credit points for a voluntary academic course involving participation in research as subjects. Answers to survey questions were recorded anonymously. The possibility to withdraw from the research at any stage without providing explanations was assured. All students gave informed consent for their participation in the survey. Ten weeks (from 9 to 11 weeks) after the first test, the retest study was conducted on the participants from Sample 1.

Participants of Sample 2 were recruited via email invitations sent to a pool of research volunteers from the database maintained by Biostat, a Polish company providing an online social research service. For completing the survey participants were granted credit points with a value corresponding to five Polish zlotys (approximately 1 Euro). Credit points obtained by participants are redeemable for financial compensation from Biostat when a total sum of points worth at least 50 Polish zlotys has been accrued. Responses from 335 subjects from Sample 2 were analyzed as we excluded data from 42 participants (11.1% out of 377 respondents) who reported working nightshifts, indicated that they had received treatment for sleeping problems, or had consulted a doctor regarding sleep difficulties and were therefore considered as having a clinical history of sleep disorders. The minimum group sizes needed to detect the effect size of $\delta \geq 0.5$ with probability ≥ 0.8, assuming type I error rate two-tailed set at $\alpha = 0.05$ with two-tailed testing were 295 and 36. The size of group 2 (students) relative to group 1 (other respondents) was assumed to be 0.12.

Measures

The BPS is a self-report questionnaire consisting of nine individual items, that describe sleep-related behaviors and habits that are considered indicators of a high or low level of bedtime procrastination. The subject is asked to indicate whether given statements apply to him or her, choosing responses on a five-point Likert scale labeled 1 = "(almost) never" and 5 = "(almost) always." Four items are reverse scored. The total BPS score is computed by averaging responses to all individual items and it may range from 1 to 5 points with a scale midpoint of 3 points. The total score reflects the extent to which people unnecessarily delay going to bed, with higher scores indicating more bedtime procrastination. Sample items are "I go to bed later than I had intended" and "I do not go to bed on time" (reverse coded). For the English version of BPS, Cronbach's α of 0.92, 0.89, and 0.90 was obtained in an online survey of users of an internet crowdsourcing platform (Kroese et al., 2014) and on two samples of internet users (Sirois et al., 2019), respectively. Cronbach's α of 0.88 was reported for the Dutch version of BPS in an online survey on a representative sample of Dutch adults (Kroese et al., 2016a) and for the Flemish version of BPS in a survey on a randomly selected sample of Flemish-speaking adults (Exelmans and Van den Bulck, 2017).

Demographic questions included gender, age, the place of residence (from village to big town/city), and education. The highest completed level of education (from lower secondary to doctoral, postgraduate, or equivalent) was coded according to the 2011 International Standard Classification of Education (ISCED) categories. Responses to questions about household composition and vocational status were also collected. For the purpose of data analysis, information about living with a child or children and living with a spouse or partner were extracted from the responses to the question about household composition and coded into two dummy variables with "yes" or "no" values. The responses to questions about vocational status were recoded into two dummy variables: employment (1 = employed, 0 = not employed) and student (1 = student, 0 = not a student).

Sleep descriptives and sleep outcomes were assessed using measures created by Kroese et al. (2014, 2016a). Participants' self-perceived average night sleep duration was measured by answers to questions about sleep length on workdays and sleep length on weekdays; these were expressed in hours a day and given on the 5-point response scale (less than 5 | 5–6 | 7–8 | 9–10 | more than 10). The average frequency of going to bed later than intended was assessed by answers to the question "In an average week, how many days do you go to bed later than you would like to?," given on the response scale described above. The answers to the question "On average, how many days a week do you feel tired during the day?" were given on a five-point response scale (0 days/never | 1–2 days | 3–4 days | 5–6 days | 7 days/always) and were used as a self-report measure of sleep-related daytime fatigue. Experienced sleep insufficiency was assessed by responses to the question "To what extent do you feel the number of hours of sleep you usually get is sufficient," given on a four-point response scale (completely insufficient | rather insufficient | rather sufficient | completely sufficient).

Procedure

The Polish BPS version was prepared in accordance with the rules of the translation and backtranslation procedure suggested by Brislin (1986). The initial translations of the BPS items were done by three Polish-speaking people (including two psychologists with Ph.D. in psychology) with a very good command of English. After comparing all Polish translations, the final Polish version was agreed through discussion (see: **Appendix**). The final Polish version of BPS items was subsequently back-translated into English, showing a satisfactory convergence with the original.

Statistical Analysis

Principal component analysis that determined the number of components based on simulations on random data obtained in parallel analysis was performed as an exploratory assessment of the factorial structure of responses to items of the Polish BPS version in Sample 1. Bartlett's test of the sphericity of the correlation matrix and the Kaiser-Meyer-Olkin measure of sampling adequacy (MSA) were also computed. To verify the

unifactorial structure of the Polish version of BPS that was indicated by the results of PCA analysis, the responses obtained in Sample 2 were subjected to CFA. A single-factor model with one latent variable representing total BPS score was specified. Since the distribution of responses to items in the Polish BPS version deviated from normal distribution, the diagonally weighted least squares (DWLS) estimation method with robust error estimation was used. Chi-square to df ratio (χ^2/df), root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), Bentler's Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Bentler-Bonett Normed Fit Index (NFI) were used to evaluate the overall model fit.

Cronbach's α (Cronbach, 1951) and McDonald's ω (McDonald, 1999) were applied as measures of the internal consistency of the total score in the Polish BPS version. Means, standard deviations, and item-rest correlations were computed. Measures of internal consistency were also calculated if an item was dropped for individual items. Pearson correlation was used for analysis of test–retest reliability. The R 'cocron' package for the statistical comparison of Cronbach's α coefficients (Diedenhofen and Musch, 2016) was used to compare values of Cronbach's α in independent samples. Values of standard error of measurement (Guilford, 1954; Harvill, 1991), the halfwidth of its 95% confidence interval, and minimal detectable change, also called smallest real change (Beckerman et al., 2001) were determined on the basis of Cronbach's α as the measure of scale reliability. Mean, median, standard deviation, skewness, and kurtosis was given to describe the distribution of raw scores of the Polish BPS version in Sample 2.

Since the distribution of BPS scores were slightly skewed, the relations between raw total BPS scores and responses to sleep-related questions with demographic factors were examined using Spearman rank-order correlation and the Mann–Whitney *U*-test, with rank-biserial correlation as the measure of effect size. To find the best subset of demographic predictors of high severity of bedtime procrastination (defined as a high categorized score in BPS), multivariate binomial logistic regression was conducted to predict the ratio for high versus not-high BPS scores from demographic variables (gender, median-split dichotomized age, living with a spouse or partner, living with children, being a student and employment status). The backward elimination of variables with p-values > 0.05 in each step was applied.

A series of univariate ordinal logistic regression analyses predicting answers to sleep-related questions from raw BPS scores was performed to examine the impact of bedtime procrastination on sleep outcomes. To determine whether the impact of BPS scores on responses to demographic questions can be attributed to demographic variables, a series of two-step hierarchical multiple ordinal logistic regression analyses was performed in which demographics were entered in the first step, and sleep outcomes were entered in the second step.

The interrelationships between answers to sleep-related questions, respondents' highest completed level of education, and the place of residence were analyzed using Spearman rank-order correlations. The impact on answers to sleep-related questions of gender, median-split dichotomized age (below 38 years versus 38 years or more), living with a spouse or partner, living with children, being a student and employment were examined using univariate ordinal logistic regressions. Multivariate ordinal logistic regressions with backward elimination of variables with p-values > 0.05 in each step were also conducted to select the best demographic predictors of sleep outcomes.

Jamovi (The jamovi project 2019) and JASP (JASP Team 2019) open-source statistical programs were used for statistical analyses. The lavaan R Package for Structural Equation Modeling (Rosseel, 2012) implemented in JASP was used for CFA computations.

RESULTS

Demographic Characteristics of the Studied Samples

Distribution of respondents' age and their responses to demographic questions are presented in **Tables 1**, **2**.

As can be seen in **Tables 1**, **2**, Sample 2 represents a similar share of females and males and covers a wide range of ages and completed levels of education, with varied household composition; Sample 1 is dominated by young female adults with upper secondary or higher education, living without children and without a spouse or partner, all of which is due to their status as university students.

Psychometric Characteristics of BPS

Principal Component Analysis

Following the approach of the authors of the original BPS version (Kroese et al., 2014), PCA was used to explore the component structure of responses to items of the Polish version of this questionnaire in Sample 1 All interitem correlations of the Polish BPS version in this sample were significant at $p < 0.001$, ranging from 0.24 to 0.59, with average of 0.41. The results of Bartlett's test of sphericity of the correlation matrix, $\chi^2(36) = 1354$, $p < 0.001$, showed significant relationships among responses to the individual items of the Polish version of BPS in Sample 1 and indicated that they are correlated enough for PCA. The overall Kaiser-Meyer-Olkin MSA was high (MSA = 0.90) and all MSA values for individual items were > 0.87, which confirmed the good factorability of responses to items of the Polish BPS version in this sample. Only the first eigenvalue was greater than one (4.29), and the inspection of a scree plot also suggested the extraction of the component which accounted for 48 percent of the total variance. Parallel analysis confirmed the adequacy

TABLE 1 | Distribution of respondents' age in Sample 1 and Sample 2.

Statistic	Sample 1	Sample 2
Minimum	19	18
Lower quartile	20	28
Median	21	38
Upper quartile	23	49
Maximum	47	73
Mean	22.2	38.7
Standard deviation	3.23	13.3

TABLE 2 | Frequencies of responses to demographic questions in Sample 1 and Sample 2 with percentages of total sample size.

Variable	Category	Sample 1	Sample 2
Gender	Female	383(88.9%)	171(51.0%)
	Male	48(11.1%)	164(49.0%)
Highest completed level of education	ISCED 2-24 Lower secondary – general	0(0.0%)	52(15.5%)
	ISCED 2-25 Lower secondary – vocational	0(0.0%)	55(16.4%)
	ISCED 3-34 Upper secondary – general	162(37.6%)	46(13.7%)
	ISCED 3-35 Upper secondary – vocational	32(7.4%)	27(8.1%)
	ISCED 4 or 5 Post-secondary or short cycle non-tertiary	128(29.7%)	30(9.0%)
	ISCED 6 Bachelor's or equivalent	90(20.9%)	36(10.7%)
	ISCED 7 Master's or equivalent	18(4.2%)	76(22.7%)
	ISCED 8 Doctoral or equivalent	1(0.2%)	13(3.9%)
Place of residence	Village	179(41.5%)	61(18.2%)
	Small town (below 50k inhabitants)	89(20.6%)	89(26.5%)
	Middle town (50 to 500k inhabitants)	40(9.3%)	109(32.5%)
	Big town/city (over 500k inhabitants)	123(28.5%)	76(22.7%)
Living with a spouse or partner	No	362(84.0%)	116(34.6%)
	Yes	69(16.0%)	219(65.4%)
Living with a child (children)	No	396(96.4%)	172(51.3%)
	Yes	15(3.6%)	163(48.7%)
Student	Not a student	0(0.0%)	292(87.2%)
	Student	431(100.0%)	43(12.8%)
Employment status	Not working		108(32.2%)
	Working		227(67.8%)

of the one-dimensional solution (see **Figure 1**). Since only one component was extracted, no rotation was applied. As depicted in **Table 3**, all component loadings for PCA in Sample 1 were high, ranging from 0.60 to 0.79.

Confirmatory Factor Analysis

To verify the validity of the unifactorial structure of the Polish BPS version that were suggested by the results of PCA analysis, the responses obtained in Sample 2 were subjected to CFA. All path coefficients between the latent variable and individual BPS items were significant at $p < 0.001$, with standardized estimates (factor loadings) ranging from 0.48 to 0.76 (see **Table 3** for details), thus indicating that the factor that represents the total BPS score substantially contributed to the variance of all BPS items. It is worth noting that the configuration of values of component loadings and uniqueness in PCA correspond to factor loadings and errors in CFA. The values of the adopted fit indices indicated a good overall fit of the specified CFA model: $\chi^2/df = 1.31$, RMSEA = 0.031, with 90% confidence intervals from 0.000 to 0.053, SRMR = 0.052, CFI = 0.994, TLI = 0.992, NFI = 0.976.

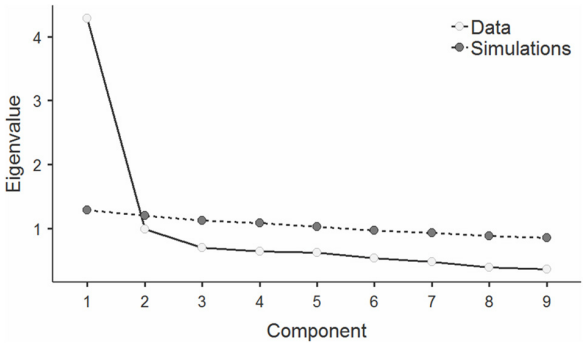

FIGURE 1 | Scree plot with eigenvalues for consecutive components in principal component analysis (PCA) of responses to items of the Polish BPS version in Sample 1, with values of upper 95% confidence intervals for eigenvalues in simulations on random data obtained in parallel analysis.

TABLE 3 | Results of Kaiser-Meyer-Olkin measure of sampling adequacy (MSA), principal component analysis (PCA), and confirmatory factor analysis (CFA) of responses to items of the Polish BPS version.

	Sample 1			Sample 2	
BPS item	Kaiser-Meyer-Olkin MSA	Component loadings in PCA	Uniqueness in PCA	Factor loadings in CFA	Standardized errors in CFA
1	0.901	0.780	0.391	0.755	0.430
2	0.876	0.681	0.536	0.506	0.744
3	0.869	0.614	0.623	0.476	0.773
4	0.891	0.769	0.408	0.737	0.457
5	0.878	0.603	0.636	0.484	0.766
6	0.896	0.791	0.374	0.720	0.482
7	0.918	0.676	0.543	0.670	0.550
8	0.923	0.627	0.607	0.560	0.687
9	0.933	0.640	0.590	0.521	0.729

Items' Descriptives, Item-Rest Correlations, and Scale Reliability

Means, standard deviations, item-rest correlations and measures of internal consistency if an item was dropped are given in **Table 4** for individual items of the Polish BPS version in Sample 1 and Sample 2. Item-rest correlations in Sample 1 ranged from 0.50 to 0.70, with an average of 0.59; in Sample 2 they ranged from 0.44 to 0.67, with an average of 0.54.

Reliability and Measurement Error of BPS Total Score

As presented in **Table 5**, Cronbach's α and McDonald's ω for the whole scale were greater than 0.8 in both samples. The values of Cronbach's α did not differ significantly between both samples, $\chi^2(1) = 2.01$, $p = 0.156$, and the 95% confidence intervals of this coefficient overlapped considerably. Cronbach's α for the Polish BPS version in Sample 2 differed significantly from Cronbach's α obtained for the English (Kroese et al., 2014), Dutch (Kroese et al., 2016a), and Flemish (Exelmans and Van den Bulck, 2017) BPS versions: $\chi^2(1) = 22.3$,

TABLE 4 | Means, standard deviations, item-rest correlations for BPS items and measures of internal consistency (Cronbach's α and McDonald's ω), computed if items dropped for Sample 1 and Sample 2.

Sample	BPS item	Mean	Standard deviation	Item-rest correlations	Cronbach's α	McDonald's ω
					If item dropped	
1.	1	3.78	1.26	0.688	0.835	0.838
	2	3.07	1.34	0.582	0.845	0.849
	3	2.83	1.36	0.511	0.852	0.855
	4	3.47	1.28	0.677	0.836	0.839
	5	3.11	1.32	0.495	0.853	0.856
	6	3.33	1.30	0.699	0.833	0.836
	7	1.99	1.23	0.571	0.846	0.849
	8	2.98	1.37	0.519	0.851	0.854
	9	2.59	1.27	0.539	0.849	0.853
2.	1	3.71	1.17	0.673	0.804	0.808
	2	3.28	1.34	0.461	0.826	0.832
	3	3.09	1.36	0.438	0.829	0.834
	4	3.29	1.30	0.665	0.803	0.809
	5	3.16	1.31	0.435	0.828	0.834
	6	3.43	1.30	0.643	0.806	0.811
	7	2.56	1.39	0.608	0.809	0.817
	8	3.13	1.34	0.501	0.821	0.827
	9	2.77	1.32	0.478	0.824	0.831

TABLE 5 | Reliability statistics, standard error of measurement with halfwidth of 95% confidence intervals and minimal detectable change for the Polish BPS version.

Statistic	Sample	Value of statistic (95% confidence intervals)
Average interitem correlation	1	0.406
	2	0.361
Cronbach's α	1	0.859 (0.839 | 0.878)
	2	0.834 (0.806 | 0.859)
McDonald's ω	1	0.862
	2	0.839
Pearson correlation for test–retest	1	0.675 (0.618 | 0.726)
Standard error of measurement*	2	0.351
Halfwidth of the 95% confidence interval for measurement error*	2	0.668
Minimal detectable change*	2	0.973

**Statistics computed with value of Cronbach's α in Sample 2 as the measure of scale reliability. 95% confidence intervals for Cronbach's α and Pearson correlation are given in parentheses.*

$p < 0.001$; $\chi^2(1) = 13.4$, $p < 0.001$; $\chi^2(1) = 11.5$, $p = 0.001$, respectively. It also differed significantly from Cronbach's α for the English BPS version applied by Sirois et al. (2019) in study 1, $\chi^2(1) = 6.03$, $p = 0.014$, and study 2, $\chi^2(1) = 23.6$, $p < 0.001$. The Pearson correlation coefficient was equal to 0.675 in the 10-week test–retest analysis of total BPS score in 395 subjects with non-missing data from Sample 1, which indicates moderate temporal stability of the BPS score. Standard error of measurement values and halfwidth of the 95% confidence interval for measurement error for the total score of the Polish BPS version in Sample 2 are given in **Table 5**.

Distribution of Raw and Categorized BPS Total Score

Considering that Sample 2 was more diverse in terms of demographic variables, the results obtained in this sample were used to compute the measures of distribution of the raw total score in the Polish BPS version. The observed minimum and maximum are equal to the lowest and highest possible values of the scale (1 and 5 points), which shows that the obtained raw scores fully cover the scale's entire range. Mean, median, standard deviation, skewness, kurtosis, and their 95% confidence intervals for Sample 1 and Sample 2 are presented in **Table 6**.

Since both mean and median are higher than the scale midpoint (3.0) with a negative value of skewness, the distribution of the total scores of the Polish BPS version is slightly left-skewed. A histogram with a smoothed density plot showing the distribution of total scores of the Polish BPS version in Sample 2 is depicted in **Figure 2**.

For discriminating between low, moderate and high levels of the Polish BPS version scores, two cut-off points that are distant by the halfwidth of the 95% confidence interval for the measurement error (Lyles and Kupper, 1999) from the scale midpoint were determined to have values of 2.332 and 3.668. Proportions of subjects with three levels of scores in the Polish BPS version are depicted in **Figure 3**.

Relations Between BPS Scores and Demographic and Sleep-Related Variables

BPS Scores and Demographic Variables

Spearman rank-order correlations between raw BPS scores and respondents' age ($\rho = -0.120$ with 95% confidence intervals from

TABLE 6 | Descriptive statistics with 95% confidence intervals where appropriate for distribution of raw total score of Polish PBS version in Sample 2.

Statistic	Value of statistic (95% confidence intervals)
Mean	3.224 (3.132 | 3.316)
Median	3.222 (3.111 | 3.333)
Std. dev.	0.861
Skewness	−0.358 (−0.619 | −0.097)
Kurtosis	−0.326 (−0.847 | 0.195)

Confidence intervals are given where appropriate.

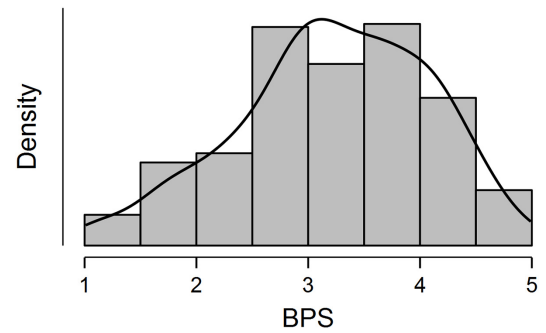

FIGURE 2 | Histogram and smoothed density plot showing distribution of total raw scores of the Polish version of the Bedtime Procrastination Scale (BPS) in Sample 2.

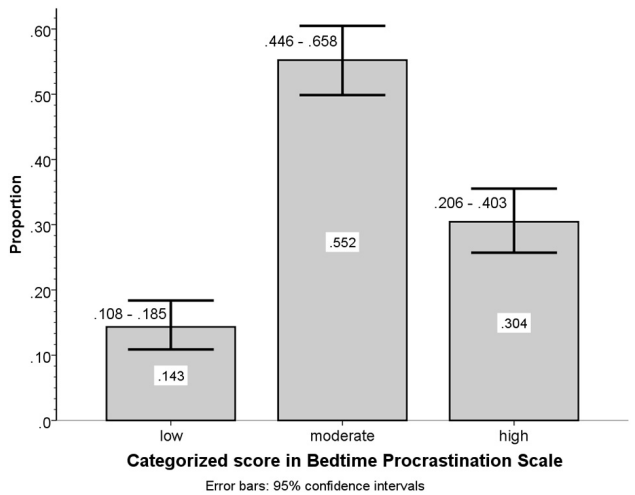

FIGURE 3 | Group frequency to total sample size proportions with 95% confidence intervals for categorized scores of the Polish version of the BPS in Sample 2.

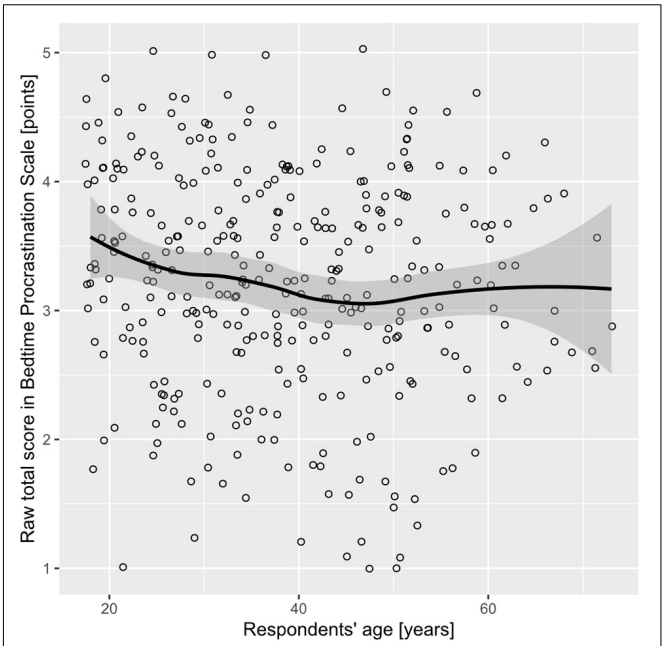

FIGURE 4 | Scatterplot of raw total scores in BPS by respondents' age with smoothed regression line and 95% confidence interval in Sample 2. The loess function was used for smoothing.

−0.224 to −0.013) indicate that bedtime procrastination slightly decreases with age. The relationship between BPS scores and respondents' age are plotted in **Figure 4**. As can be inferred from the confidence bands in **Figure 4**, mean BPS scores for respondents aged 18 to 37 deviate from the scale midpoint, whereas for subjects aged 38 or more years the scale midpoint is within the range of 95% confidence intervals (compare the confidence interval bands with the horizontal grid line at BPS value 3.0 in **Figure 4**).

Spearman rank-order correlations between raw BPS scores and respondents' highest completed level of education (ρ = −0.101 with 95% confidence intervals from −0.206 to 0.006) and place of residence (ρ = 0.018 with 95% confidence intervals from −0.089 to 0.125) did not deviate significantly from zero. Results of the Mann–Whitney *U*-test that was used to examine the differences in raw BPS scores between groups distinguished by binomial demographic variables are presented in **Table 7**. The group means for raw BPS scores, probabilities and odds of high BPS categorized scores, and odds ratios for high versus not-high BPS scores are also given. Females scored higher on the BPS than males; higher BPS scores were obtained for the group of students in comparison to the group of non-students, and lower BPS scores were found in working respondents in comparison to non-working respondents.

To find the best subset of demographic predictors of a BPS score above 3.668 points cut-off, multivariate binomial logistic regression was conducted to predict the ratio of high to not-high BPS scores from demographic variables, with backward elimination of variables with *p*-values > 0.05 in each step. Female gender and being a student were selected as best demographic predictors of high BPS scores (odds ratio: 2.17 with 95% confidence intervals from 1.31 to 3.44, and 2.04 with 95% confidence intervals from 1.05 to 3.96, respectively). The test of the overall model was significant (χ^2 = 10.8 with 2 degrees of freedom, p = 0.004), and Nagelkerke pseudo R^2 was equal to 0.057.

Scores in BPS and Responses to Sleep-Related Questions

Relationships between responses to questions about sleep duration and sleep outcomes, and the total score of the Polish PBS in Sample 2 are presented in **Table 8**. Raw total scores in BPS correlate negatively with sleep length on workdays and a feeling of sleep sufficiency, and positively with sleep length on weekdays relative to workdays, sleeping later than one would like and a feeling of fatigue.

TABLE 7 | Comparison of total score of Polish PBS version for different categories of demographic variables in Sample 2.

Variable	W (p)	Rank-biserial correlation (95% CI)	Category	BPS mean	Probability for high BPS score	Odd for high BPS score	Odds ratio for high/not high BPS score (95% CI)
Gender	11718 (0.009)	0.164 (0.042 | 0.282)	Female	3.34	0.380	0.613	2.11 (1.30 | 3.40)
			Male	3.11	0.226	0.291	Reference
Spouse (partner)	11162 (0.068)	−0.121 (−0.247 | 0.008)	Living with a spouse (partner)	3.16	0.274	0.377	0.665 (0.411 | 1.08)
			Living without a spouse (partner)	3.34	0.362	0.568	Reference
Children	14374 (0.688)	0.025 (−0.098 | 0.148)	Living with children	3.25	0.294	0.417	0.912 (0.572 | 1.45)
			Living without children	3.20	0.314	0.458	Reference
Student	7736 (0.014)	0.232 (0.051 | 0.398)	Student	3.49	0.442	0.792	1.99 (1.04 | 3.83)
			Not a student	3.18	0.284	0.397	Reference
Employment status	9934 (0.005)	−0.190 (−0.313 | −0.059)	Working	3.13	0.269	0.367	0.600 (0.369 | 0.977)
			Not working	3.41	0.380	0.612	Reference

W is the W statistic for the Mann–Whitney U-test; CI is confidence intervals. BPS high scores defined as BPS mean is greater than the 3.668 points cut-off. p-Values for given odds ratios are equal to p-values for the Mann–Whitney U-test.

The results from univariate and multivariate hierarchical ordinal logistic regression analyses that predict answers to sleep-related questions from raw BPS scores are presented in **Table 9**. Except for sleep length on weekdays, for all remaining sleep-related questions adding BPS scores to the regression models with demographics significantly improved the model's fit. No considerable differences could be found when the values of pseudo R^2 in univariate analyses were compared to pseudo R^2 changes for adding BPS scores to the model in hierarchical analyses. This indicates that the impact of BPS scores on responses to sleep-related questions cannot be attributed to demographic variables.

Answers to Sleep-Related Questions and Demographic Variables

Spearman rank-order correlations indicated that answers to the question measuring the feeling of fatigue correlated negatively with the highest completed level of education, $\rho = -0.131$ with 95% confidence intervals from −0.235 to −0.024. No significant differences from zero were found for correlations between the place of residence and responses to any sleep-related questions.

The odds ratios with 95% confidence intervals obtained in univariate analyses predicting sleep outcomes from demographic variables are given in **Table 10**. In backward elimination multivariate analyses, being a student was the only predictor of sleep length on workdays and sleep length on weekdays relative to workdays; living with children was the only predictor for sleep length on weekdays; female gender was the only predictor for feeling of fatigue. The obtained odds ratios are identical to the corresponding ones from the univariate analyses (see **Table 10**). Living with children and employment were included in the final step (odds ratio: 1.70 with 95% confidence intervals from 1.15 to 2.52, and 0.571 with 95% confidence intervals from 0.375 to 0.866, respectively) for going to bed later than one likes.

DISCUSSION

In order to determine the psychometric properties of the Polish BPS version, we first tested whether its total score allows measurement of the general tendency to procrastinate going to bed, conceptualized as a uniform dispositional construct. Results of PCA on Sample 1 and CFA on Sample 2 consistently and clearly showed that responses to all individual items of the Polish BPS version are considerably intercorrelated and a substantial part of their variance could be attributed to one common latent variable: total BPS score. This justified computing the composite score of the Polish BPS version by averaging the values assigned to the responses to all individual items. All values of corrected item-rest correlations between responses to all individual items and total BPS score well above the recommended 0.3 threshold, showing that in both samples all the items were substantially related to the total scores computed from all other BPS items. The values of Cronbach's α and McDonald's ω for the whole scale were greater than 0.8 in both samples. It should also be noted that the values of Cronbach's α obtained for the English (Kroese et al., 2014; Sirois et al., 2019), Dutch (Kroese et al., 2016a), and Flemish (Exelmans and Van den Bulck, 2017) BPS versions were slightly higher than Cronbach's α for the Polish BPS version in Sample 2, which was drawn from the general population. However, the values of the internal consistency indicators obtained in our samples for the Polish BPS version are high enough to allow reliable qualitative measurement of the

TABLE 8 | Responses to sleep-related questions and averaged raw scores in Polish BPS version with Spearman rank-order correlations in Sample 2.

Question	Response category	*n*	*n* to sample size ratio [%]	BPS mean	Spearman correlation (95% CI) *p*
Sleep length on workdays	Less than 5	10	3.0%	4.00	−0.339 (−0.430 | −0.240) <0.001
	5–6	117	34.9%	3.57	
	7–8	187	55.8%	2.98	
	9–10	21	6.3%	3.12	
	More than 10	0	0.0%		
Sleep length on weekdays	Less than 5	5	1.5%	3.62	−0.055 (−0.161 | −0.053) 0.320
	5–6	42	12.5%	3.50	
	7–8	164	49.0%	3.14	
	9–10	119	35.5%	3.20	
	More than 10	5	1.5%	3.96	
Sleep length on weekdays relative to workdays	Over 3 h shorter	1	0.3%	3.67	0.195 (0.089 | 0.296) <0.001
	1–3 h shorter	11	3.3%	3.08	
	Equal	151	45.1%	3.07	
	1–3 h longer	145	43.3%	3.28	
	Over 3 h longer	27	8.1%	3.80	
Sleep later than would like	Never	22	6.6%	1.87	0.416 (0.653 | 0.760) <0.001
	1–2 days	94	28.1%	2.58	
	3–4 days	100	29.9%	3.41	
	5–6 days	53	15.8	3.65	
	Always	66	19.7%	3.98	
Feeling of fatigue	Never	19	5.7%	2.64	0.338 (0.239 | 0.429) <0.001
	1–2 days	124	37.0%	2.95	
	3–4 days	96	28.7%	3.38	
	5–6 days	41	12.2%	3.38	
	Always	55	16.4%	3.66	
Feeling of sleep sufficiency	Completely insufficient	25	7.5%	3.58	−0.382 (−0.470 | −0.287) <0.001
	Rather insufficient	138	41.2%	3.53	
	Rather sufficient	148	44.2%	3.00	
	Completely sufficient	24	7.2%	2.44	

CI, confidence intervals. Spearman rank-order correlation was computed for relationships between raw BPS scores and answers to sleep-related questions.

general tendency to procrastinate going to bed with a relatively low error of measurement. The use of the Polish BPS version also makes it possible to differentiate between subjects with varying levels of this behavioral tendency.

We also proposed two cut-off points for discriminating low, middle and high levels of bedtime procrastination, based on determining values distant from the scale midpoint by the halfwidth of the 95% confidence interval for the measurement error. By applying the given cut-off points, the level of bedtime procrastination of about one-third of respondents recruited from the general population were classified as high, whereas about half as many subjects demonstrated a low level of bedtime procrastination. The slightly left-skewed distribution of the total score of the Polish BPS version may be related to a possible ceiling effect which limits its suitability for differentiation between subjects with very high severity of bedtime procrastination. In further studies, this limitation could possibly be overcome by the extending the response format to a Likert scale with more than five points and modifying the anchor labels if necessary, in surveys conducted on subjects with very high bedtime procrastination. Moderate correlation in test–retest comparisons of BPS scores indicates relatively temporal stability of bedtime procrastination and suggests its dispositional status, but on the other hand it shows that it can be partially subject to change.

We found that in the Polish sample the level of bedtime procrastination was significantly higher by about half the standard deviation compared to international English-speaking users of an internet crowdsourcing platform (Kroese et al., 2014), a representative sample of Dutch adults participating in internet surveys (Kroese et al., 2016a) and a randomly selected sample of adults residing in Flanders, Belgium (Exelmans and Van den Bulck, 2017). In view of the similarity of our research methodology to the methodology of previous studies (Kroese et al., 2014, 2016a; Exelmans and Van den Bulck, 2017), there are no grounds for attributing the higher level of bedtime procrastination among Poles to any methodological issues. On the other hand, the mean BPS scores in the Polish sample do not differ substantially from the results reported by Sirois et al. (2019) for study 1 and study 2: $M = 3.23 \pm 0.89$, and $M = 3.05 \pm 0.90$, respectively. Further research on the role of socioeconomic and psychological factors in bedtime and sleep-related behaviors is needed to explain the relatively high level of bedtime procrastination found in the Polish sample, which was drawn from the general population.

Average BPS scores were related to reduced sleep length on workdays, increased sleep length on weekdays relative to workdays, a feeling of sleep insufficiency, and a feeling of fatigue. Despite the fact that responses to sleep-related questions showed several relationships with demographic variables, the results of multivariate analyses indicate that the impact of bedtime procrastination on self-reported sleep outcomes cannot be attributed to demographic variables.

In this study, we also attempted to delineate more precisely the differences in bedtime procrastination between demographic groups. We found a relatively low negative correlation between BPS scores and age ($\rho = -0.120$). A decrease in the mean level of bedtime procrastination with age was also reported several times in the results of previous studies. Significantly different-from-zero negative correlation coefficients between BPS scores and age were found by Exelmans and Van den Bulck (2017) in a sample of inhabitants of Flanders ($r = -0.404$), and by Sirois et al. (2019) in a sample of internet users ($r = -0.32$). A negative correlation between BPS scores and age ($r = -0.11$) was also obtained in a sample of users of an internet crowdsourcing platform (Kroese et al., 2014), but due to the relatively low sample size it did not meet the criterion of statistical significance. In addition, a negative correlation ($r = -0.19$) between age and bedtime procrastination assessed by means of sleep diaries was found in employees working in various industries (Kühnel et al., 2018). Apart from confirming a negative correlation between BPS

TABLE 9 | Odds ratios (with 95% confidence intervals) for ordinal logistic regressions predicting answers to sleep-related questions from raw BPS scores in univariate models and multivariate hierarchical models controlled for demographic variables in Sample 2.

	Effects of BPS scores in univariate analyses		Effects of BPS scores controlled for demographic variables in multivariate analyses		
Sleep-related question	**Nagelkerke pseudo R^2**	**Odds ratio (95% CI)**	**Total model χ^2 change (p)**	**Nagelkerke pseudo R^2 change**	**Odds ratio (95% CI)**
Sleep length on workdays	0.070	0.456*** (0.348 | 0.592)	36.0 (<0.001)	0.069	0.442*** (0.333 | 0.582)
Sleep length on weekdays	0.001	0.908 (0.718 | 1.15)	1.07 (0.301)	0.002	0.879 (0.687 | 1.12)
Sleep length on weekdays relative to workdays	0.020	1.54*** (1.22 | 1.97)	12.7 (<0.001)	0.020	1.57*** (1.22| 2.02)
Sleep later than desired	0.291	9.93*** (7.09 | 14.2)	230 (<0.001)	0.281	10.5*** (7.39 | 15.6)
Feeling of fatigue	0.057	2.24*** (1.75 | 2.88)	37.3 (<0.001)	0.050	2.18*** (1.69 | 2.82)
Feeling of sleep sufficiency	0.095	0.372*** (0.282 | 0.487)	53.9 (<0.001)	0.092	0.364*** (0.273 | 0.481)

****$p < 0.001$; CI, confidence intervals. Nagelkerke pseudo R^2 change is given for adding the effect of BPS to the regression model in the second step into the model with demographic variables (gender, dichotomized age, spouse/partner, children, student, employed) entered in the first step.*

TABLE 10 | Odds ratios with 95% confidence intervals for univariate ordinal logistic regressions predicting answers to sleep-related questions from demographic variables in Sample 2.

	Demographic variable					
Sleep-related question	**Gender (female vs. male)**	**Age (<38 years vs. older)**	**Spouse (partner)**	**Children**	**Student**	**Employed**
Sleep length on workdays	1.08 (0.711 | 1.65)	1.14 (0.747 | 1.73)	1.09 (0.700 | 1.69)	0.920 (0.605 | 1.40)	0.482* (0.259 | 0.894)	1.17 (0.744 | 1.83)
Sleep length on weekdays	1.07 (0.714 | 1.61)	0.755 (0.502 | 1.13)	0.588* (0.381 | 0.903)	0.504** (0.332 | 0.760)	2.18* (1.15 | 4.18)	1.05 (0.676 | 1.63)
Sleep length on weekdays relative to workdays	1.04 (0.692 | 1.57)	0.724 (0.480 | 1.09)	0.593* (0.384 | 0.915)	0.608* (0.402 | 0.916)	3.69*** (1.92 | 7.2)	1.01 (0.654 | 1.56)
Sleep later than would like	1.44 (0.983 | 2.12)	0.860 (0.586 | 1.26)	1.14 (0.768 | 1.7)	1.57* (1.07 | 2.31)	1.15 (0.673 | 1.98)	0.623* (0.412 | 0.940)
Feeling of fatigue	2.29*** (1.55 | 3.42)	0.719 (0.487 | 1.06)	1.00 (0.667 | 1.5)	0.902 (0.612 | 1.33)	1.49 (0.842 | 2.62)	0.688 (0.454 | 1.04)
Feeling of sleep sufficiency	0.683 (0.454 | 1.02)	0.991 (0.661 | 1.48)	1.32 (0.862 | 2.03)	1.05 (0.702 | 1.58)	0.676 (0.373 | 1.22)	0.947 (0.615 | 1.46)

**$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, 95% confidence intervals are given in parentheses. Age was dichotomized into a binomial variable with 0 for less than 38 years and 1 for 38 years or more.*

scores and age, we also managed to capture the more detailed pattern of the associations between bedtime procrastination and age. The highest average BPS scores were observed in the group of the youngest respondents, with a weak decreasing tendency for the middle-aged group, followed by a relative stabilization of the scores around the scale midpoint in older participants (see **Figure 4**).

Place of residence, highest completed level of education, living with a spouse or partner, and living with children were not significantly associated with BPS scores. On raw BPS scores, females scored about one-fourth of the standard deviation higher than males. Higher BPS scores were obtained for a group of students in comparison to a group of non-student subjects, and lower BPS scores were found in working respondents in comparison to non-working respondents. Female gender and being a student appeared to be the best demographic predictors of high BPS scores in the analysis with backward elimination of parameters in the multivariate regression model, therefore the effects of age and employment could be explained by the impact of being a student because being young and unemployed considerably overlaps with being a student.

Although females scored slightly higher than males in the raw BPS scores, when taking into account the odds ratio for the effect of gender on categorized BPS scores (OR = 2.11 in univariate analysis, and OR = 2.17 in multivariate analysis) it should be noted that the chance of severe bedtime procrastination is more than twice as high for females than for males. Differences between the sexes in delaying sleep already appear in school children. Kubiszewski's et al. (2014) research has shown that 70% of girls and only 55% of boys among adolescents aged 11–15 go to sleep after 10 p.m. The earlier age of onset of bedtime delay in girls than in boys may increase the risk of formation of poor sleep habits, thus leading to sleep deprivation. This problem is all the more important due to the fact that women report a greater need for sleep than men (Oginska and Pokorski, 2006; Cheng et al., 2012) and they also have a higher risk than men of developing cardiovascular and metabolic disease (Cappuccio et al., 2007; Ferrie et al., 2007; Suarez, 2008; Kronholm et al., 2011; Lyytikäinen et al., 2011; Miller, 2015) and depression (Armitage and Hoffmann, 2001; Krystal, 2004) as a result of sleep deprivation. A higher prevalence of sleep disorders and poorer sleep quality in women compared to men have been reported in several studies and attributed to biological factors (Manber and Armitage, 1999; Zhang et al., 2011, 2014; Nowakowski et al., 2013). Our research suggests that, along with biological factors, sleep-related behaviors, i.e., voluntarily delaying going to sleep without valid external reasons, could also be an important determinant of the poorer sleep quality in women.

The results of our research for the first time show that students have a higher level of bedtime procrastination than non-students. As can be inferred from effect of being a student on categorized BPS scores (OR = 1.99 in univariate analysis, and OR = 2.04 in multivariate analysis), the chance of severe bedtime procrastination is about twice as high for a group of students than for subjects who are not students. These findings are in line with much research that reports a considerable degree of sleep problems and poor sleep quality in students (Kang and Chen, 2009; Cheng et al., 2012). There are several possible reasons for the occurrence of sleep problems in students, including anxiety and depression (Moo-Estrella et al., 2005; Eller et al., 2006). However, as our research shows, an important reason for poor sleep quality in students may also be inappropriate sleep behavior. Students generally have poor health habits, including irregular meal patterns and high consumption of recreational drugs, both of which can impair sleep hygiene (Brown et al., 2002; Brick et al., 2010; Spanos and Hankey, 2010). Previous researchers have shown a high incidence of irregular sleeping habits and insufficient sleep in students (Kang and Chen, 2009). The research of Manber et al. (1996) revealed that regularizing sleep-wake schedules in students with irregular sleep schedules and excessive daytime sleepiness resulted in increased sleep efficiency and improved alertness compared to the control group. The lack of a regular sleep-wake schedule requires more attentional control and effort to regulate sleep behavior, which may be difficult, especially in the evening when self-regulatory resources are exhausted (Hofmann et al., 2012). Self-control allows delay of gratification in order to achieve a long-term goal, so it is crucial for the implementation of health intentions related to diet, physical activity or sleep. A number of studies have shown that self-control is negatively associated with bedtime procrastination (Kroese et al., 2014, 2016a; Exelmans and Van den Bulck, 2017; Kadzikowska-Wrzosek, 2018b). Self-control is important for behavior that allows you to go to sleep at the right time to get enough sleep; for example, refraining from drinking caffeinated beverages in the evening or engaging in raising the level of stimulation by watching exciting movies (Nauts and Kroese, 2017). Studies show that most bedtime procrastinators' habitual leisure activities, such as watching TV or using other electronic media, can cause sleep delay (Kroese et al., 2014). Exelmans and Van den Bulck (2017) found positive correlations between evening television viewing and bedtime procrastination and between bedtime procrastination and deficient self-regulation of television viewing. These results suggest that low self-regulation makes it difficult to stop using electronic media when going to sleep, which leads to delayed sleep. Having good sleep habits, including regular bedtimes and waketimes, reduces the risk of self-regulation failure, especially in situations in which it is weakened due to tiredness when going to bed at night. Habit formation can be supported by self-regulation techniques such as intention implementation. Loft and Cameron (2013) found that the implementation intention intervention can improve sleep behavior and in turn improve sleep quality in workers. The effectiveness of the implementation intention and other interventions that normalize the rhythm of the day in students – thus forming proper sleep habits and preventing bedtime delay – requires further research.

CONCLUSION

The Polish BPS version has psychometric properties similar to the original version. It allows reliable measurement of bedtime procrastination, conceptualized as a uniform construct. The level of bedtime procrastination among Poles is highly varied, with high scores clearly being much more common than low ones. Average BPS scores were related to worse self-reported sleep outcomes. In the youngest subjects, the highest averaged BPS scores were observed with a slightly decreasing tendency and subsequent stabilization around the scale midpoint in middle-aged and older respondents. Average total BPS scores were also dependent on the employment status of respondents. However, female gender and being a student were found to be the best demographic predictors of high BPS scores in the multivariate regression model, which indicates that the effects of age and employment status on bedtime procrastination stems from the fact, that students are younger and usually are not employed. Students should be considered as the group most vulnerable to bedtime procrastination; thus, they may require further research, as well as health promotion interventions to correct their sleep-related habits and attitudes.

DATA AVAILABILITY

The data supporting the findings of this study will be made available by the authors to qualified researchers upon reasonable request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Faculty Committee for Research Ethics, Faculty of Pedagogy, Pedagogical University of Kraków. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RH-K and LK contributed to the concept and design of the study, administration of the surveys, and revision of the manuscript, interpreted the results, wrote the sections of the manuscript, and read and approved the submitted version. LK designed and maintained the database, and performed the statistical analysis.

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REFERENCES

Abdoli, N., Farnia, V., Delavar, A., Dortaj, F., Esmaeili, A., Farrokhi, N., et al. (2015a). Mental health status, aggression, and poor driving distinguish traffic offenders from non-offenders but health status predicts driving behavior in both groups. *Neuropsychiatr. Dis. Treat.* 11, 2063–2070. doi: 10.2147/NDT.S89916

Abdoli, N., Farnia, V., Delavar, A., Esmaeili, A., Dortaj, F., Farrokhi, N., et al. (2015b). Poor mental health status and aggression are associated with poor driving behavior among male traffic offenders. *Neuropsychiatr. Dis. Treat.* 11, 2071–2078. doi: 10.2147/NDT.S88835

Abdoli, N., Sadeghi Bahmani, D., Farnia, V., Alikhani, M., Golshani, S., Holsboer-Trachsler, E., et al. (2018). Among substance-abusing traffic offenders, poor sleep and poor general health predict lower driving skills but not slower reaction times. *Psychol. Res. Behav. Manag.* 11, 557–566. doi: 10.2147/PRBM.S173946

Armitage, R., and Hoffmann, R. F. (2001). Sleep EEG, depression and gender. *Sleep Med. Rev.* 5, 237–246. doi: 10.1053/smrv.2000.0144

Baker, F. C., and Driver, H. S. (2007). Circadian rhythms, sleep, and the menstrual cycle. *Sleep Med.* 8, 613–622. doi: 10.1016/j.sleep.2006.09.011

Beckerman, H., Roebroeck, M. E., Lankhorst, G. J., Becher, J. G., Bezemer, P. D., and Verbeek, A. L. (2001). Smallest real difference, a link between reproducibility and responsiveness. *Qual. Life Res.* 10, 571–578. doi: 10.1023/A:1013138911638

Bliwise, D. L. (2004). Sleep disorders in Alzheimer's disease and other dementias. *Clin. Cornerstone* 6, 16–28. doi: 10.1016/S1098-3597(04)90014-90012

Błońska, B. K., and Gotlib, J. (2012). Występowanie zaburzeń snu wśród studentów Prevalence of sleep disorders among students [prevalence of sleep disorders among students]. *Przegląd Medyczny Uniwersytetu Rzeszowskiego i Narodowego Instytutu Leków w Warszawie* 4, 485–497.

Boguszewski, R. (2016). Zdrowie i prozdrowotne zachowania Polaków [Health and health-related behavior of Poles]. Centrum Badania Opinii Społecznej: Komunikat z Badań 138/1016, 1–15. Available at: https://www.cbos.pl/SPISKOM.POL/2016/K_138_16.PDF (Accessed August 18, 2019).

Brand, S., Kirov, R., Kalak, N., Gerber, M., Pühse, U., Lemola, S., et al. (2015). Perfectionism related to self-reported insomnia severity, but not when controlled for stress and emotion regulation. *Neuropsychiatr. Dis. Treat.* 11, 263–271. doi: 10.2147/NDT.S74905

Brick, C. A., Seely, D. L., and Palermo, T. M. (2010). Association between sleep hygiene and sleep quality in medical students. *Behav. Sleep Med.* 8, 113–121. doi: 10.1080/15402001003622925

Brislin, R. W. (1986). "The wording and translation of research instruments," in *Field Methods in Cross-Cultural Research Cross-Cultural Research and Methodology Series*, eds W. J. Lonner and J. W. Berry (Thousand Oaks, CA: Sage Publications, Inc), 137–164.

Brown, F. C., Buboltz, W. C., and Soper, B. (2002). Relationship of sleep hygiene awareness, sleep hygiene practices, and sleep quality in university students. *Behav. Med.* 28, 33–38. doi: 10.1080/08964280209596396

Buboltz, W. C., Brown, F., and Soper, B. (2001). Sleep habits and patterns of college students: a preliminary study. *J. Am. Coll. Health* 50, 131–135. doi: 10.1080/07448480109596017

Cain, N., and Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: a review. *Sleep Med.* 11, 735–742. doi: 10.1016/j.sleep.2010.02.006

Cappuccio, F. P., Stranges, S., Kandala, N.-B., Miller, M. A., Taggart, F. M., Kumari, M., et al. (2007). Gender-specific associations of short sleep duration with prevalent and incident hypertension. *Hypertension* 50, 693–700. doi: 10.1161/HYPERTENSIONAHA.107.095471

Cheng, S. H., Shih, C.-C., Lee, I. H., Hou, Y.-W., Chen, K. C., Chen, K.-T., et al. (2012). A study on the sleep quality of incoming university students. *Psychiatr. Res.* 197, 270–274. doi: 10.1016/j.psychres.2011.08.011

Connor, J. (2002). Driver sleepiness and risk of serious injury to car occupants: population based case control study. *BMJ* 324, 1125–1125. doi: 10.1136/bmj.324.7346.1125

Connor, J., Whitlock, G., Norton, R., and Jackson, R. (2001). The role of driver sleepiness in car crashes: a systematic review of epidemiological studies. *Accid. Anal. Prev.* 33, 31–41. doi: 10.1016/S0001-4575(00)00013-10

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika* 16, 297–334. doi: 10.1007/BF02310555

Curcio, G., Ferrara, M., and De Gennaro, L. (2006). Sleep loss, learning capacity and academic performance. *Sleep Med. Rev.* 10, 323–337. doi: 10.1016/j.smrv.2005.11.001

Diedenhofen, B., and Musch, J. (2016). Cocron: a web interface and r package for the statistical comparison of cronbach ' s alpha coefficients. *Int. J. Internet Sci.* 11, 51–60.

Eller, T., Aluoja, A., Vasar, V., and Veldi, M. (2006). Symptoms of anxiety and depression in Estonian medical students with sleep problems. *Depress. Anxiety* 23, 250–256. doi: 10.1002/da.20166

Exelmans, L., and Van den Bulck, J. (2017). Glued to the tube. *Commun. Res.* 0, 1–23. doi: 10.1177/0093650216686877

Fernandez-Mendoza, J., Shea, S., Vgontzas, A. N., Calhoun, S. L., Liao, D., and Bixler, E. O. (2015). Insomnia and incident depression: role of objective sleep duration and natural history. *J. Sleep Res.* 24, 390–398. doi: 10.1111/jsr.12285

Ferrie, J. E., Shipley, M. J., Cappuccio, F. P., Brunner, E., Miller, M. A., Kumari, M., et al. (2007). A prospective study of change in sleep duration: associations with mortality in the whitehall II cohort. *Sleep* 30, 1659–1666. doi: 10.1093/sleep/30.12.1659

Gangwisch, J. E., Heymsfield, S. B., Boden-Albala, B., Buijs, R. M., Kreier, F., Pickering, T. G., et al. (2006). Short sleep duration as a risk factor for hypertension. *Hypertension* 47, 833–839. doi: 10.1161/01.HYP.0000217362.34748.e0

Gaultney, J. F. (2010). The prevalence of sleep disorders in college students: impact on academic performance. *J. Am. Coll. Health* 59, 91–97. doi: 10.1080/07448481.2010.483708

Gradisar, M., Wolfson, A. R., Harvey, A. G., Hale, L., Rosenberg, R., and Czeisler, C. A. (2013). The sleep and technology use of Americans: findings from the national sleep foundation's 2011 sleep in America poll. *J. Clin. Sleep Med.* 9, 1291–1299. doi: 10.5664/jcsm.3272

Guilford, J. P. (1954). *Psychometric Methods*, 2nd Edn. New York, NY: McGraw-Hill.

Haack, M., and Mullington, J. M. (2005). Sustained sleep restriction reduces emotional and physical well-being. *Pain* 119, 56–64. doi: 10.1016/j.pain.2005.09.011

Harvey, A. G. (2002). A cognitive model of insomnia. *Behav. Res. Ther.* 40, 869–893. doi: 10.1016/S0005-7967(01)00061-64

Harvey, A. G., and Payne, S. (2002). The management of unwanted pre-sleep thoughts in insomnia: distraction with imagery versus general distraction. *Behav. Res. Ther.* 40, 267–277. doi: 10.1016/S0005-7967(01)00012-12

Harvill, L. M. (1991). An NCME instructional module on standard error of measurement. *Educ. Meas.* 10, 33–41. doi: 10.1111/j.1745-3992.1991.tb00195.x

Herzog-Krzywoszanska, R., and Krzywoszanski, L. (2017). *Polska adaptacja Bedtime Procrastination Scale [Polish Adaptation of Bedtime Procrastination Scale]. in Kongres Polskiego Towarzystwa Psychologicznego: Psychologia Dla Zdrowia Osoby I Społeczeństwa: Księga Abstraktów. [Congress of the Polish Psychological Association: Psychology for the Health of a Person and Society: Abstract Book]*. Gdańsk: Polskie Towarzystwo Psychologiczne.

Herzog-Krzywoszanska, R., and Krzywoszanski, L. (2019). Sleep disorders in Huntington's disease. *Front. Psychiatr.* 10:221. doi: 10.3389/fpsyt.2019.00221

Hofmann, W., Friese, M., and Wiers, R. W. (2008). Impulsive versus reflective influences on health behavior: a theoretical framework and empirical review. *Health Psychol. Rev.* 2, 111–137. doi: 10.1080/17437190802617668

Hofmann, W., Vohs, K. D., and Baumeister, R. F. (2012). What people desire, feel conflicted about, and try to resist in everyday life. *Psychol. Sci.* 23, 582–588. doi: 10.1177/0956797612437426

Irish, L. A., Kline, C. E., Gunn, H. E., Buysse, D. J., and Hall, M. H. (2015). The role of sleep hygiene in promoting public health: a review of empirical evidence. *Sleep Med. Rev.* 22, 23–36. doi: 10.1016/j.smrv.2014.10.001

Kadzikowska-Wrzosek, R. (2018a). Insufficient sleep among adolescents: the role of bedtime procrastination, chronotype and autonomous vs. controlled motivational regulations. *Curr. Psychol.* 1–10. doi: 10.1007/s12144-018-9825-9827

Kadzikowska-Wrzosek, R. (2018b). Self-regulation and bedtime procrastination: the role of self-regulation skills and chronotype. *Pers. Indiv. Dif.* 128, 10–15. doi: 10.1016/j.paid.2018.02.015

Kang, J.-H., and Chen, S.-C. (2009). Effects of an irregular bedtime schedule on sleep quality, daytime sleepiness, and fatigue among university students in Taiwan. *BMC Public Health* 9:248. doi: 10.1186/1471-2458-9-248

Kasperczyk, J., and Jośko, J. (2012). Analiza czynników odpowiedzialnych za złą jakość snu u studentów śląskiego uniwersytetu medycznego [The analysis of factors responsible for poor sleep quality in silesian medical school students]. *Hygeia Public Health* 47, 191–195.

Kroese, F. M., De Ridder, D. T. D., Evers, C., and Adriaanse, M. A. (2014). Bedtime procrastination: introducing a new area of procrastination. *Front. Psychol.* 5:611. doi: 10.3389/fpsyg.2014.00611

Kroese, F. M., Evers, C., Adriaanse, M. A., and de Ridder, D. T. (2016a). Bedtime procrastination: a self-regulation perspective on sleep insufficiency in the general population. *J. Health Psychol.* 21, 853–862. doi: 10.1177/1359105314540014

Kroese, F. M., Nauts, S., Kamphorst, B. A., Anderson, J. H., and de Ridder, D. T. D. (2016b). "Bedtime procrastination: a behavioral perspective on sleep insufficiency," in *Procrastination, Health, and Well-Being*, eds P. Tim and S. Fuschia (Amsterdam: Elsevier), 93–119. doi: 10.1016/b978-0-12-802862-9.00005-0

Kronholm, E., Laatikainen, T., Peltonen, M., Sippola, R., and Partonen, T. (2011). Self-reported sleep duration, all-cause mortality, cardiovascular mortality and morbidity in Finland. *Sleep Med.* 12, 215–221. doi: 10.1016/j.sleep.2010.07.021

Krystal, A. D. (2004). Depression and insomnia in women. *Clin. Cornerstone* 6, S19–S28. doi: 10.1016/S1098-3597(04)80022-X

Kubiszewski′s, V., Fontaine, R., Rusch, E., and Hazouard, E. (2014). Association between electronic media use and sleep habits: an eight-day follow-up study. *Int. J. Adolesc. Youth* 19, 395–407. doi: 10.1080/02673843.2012.751039

Kühnel, J., Syrek, C. J., and Dreher, A. (2018). Why don't you go to bed on time? A daily diary study on the relationships between chronotype, self-control resources and the phenomenon of bedtime procrastination. *Front. Psychol.* 9:77. doi: 10.3389/fpsyg.2018.00077

Loft, M. H., and Cameron, L. D. (2013). Using mental imagery to deliver self-regulation techniques to improve sleep behaviors. *Ann. Behav. Med.* 46, 260–272. doi: 10.1007/s12160-013-9503-9509

Lyles, R. H., and Kupper, L. L. (1999). A note on confidence interval estimation in measurement error adjustment. *Am. Stat.* 53, 247–253. doi: 10.1080/00031305.1999.10474467

Lyytikäinen, P., Rahkonen, O., Lahelma, E., and Lallukka, T. (2011). Association of sleep duration with weight and weight gain: a prospective follow-up study. *J. Sleep Res.* 20, 298–302. doi: 10.1111/j.1365-2869.2010.00903.x

Manber, R., and Armitage, R. (1999). Sex, steroids, and sleep: a review. *Sleep* 22, 540–555.

Manber, R., Bootzin, R. R., Acebo, C., and Carskadon, M. A. (1996). The effects of regularizing sleep-wake schedules on daytime sleepiness. *Sleep* 19, 432–441. doi: 10.1093/sleep/19.5.432

Mann, T., de Ridder, D., and Fujita, K. (2013). Self-regulation of health behavior: social psychological approaches to goal setting and goal striving. *Health Psychol.* 32, 487–498. doi: 10.1037/a0028533

Matsunaga, M. (2010). How to factor-analyze your data right: do's, don'ts, and how-To's. *Int. J. Psychol. Res.* 3, 97–110.

McDonald, R. P. (1999). *Test Theory*. Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Miller, M. A. (2015). The role of sleep and sleep disorders in the development, diagnosis, and management of neurocognitive disorders. *Front. Neurol.* 6:224. doi: 10.3389/fneur.2015.00224

Ming, X., Koransky, R., Kang, V., Buchman, S., Sarris, C. E., and Wagner, G. C. (2011). Sleep insufficiency, sleep health problems and performance in high school students. *Clin. Med. Insights* 5, 71–79. doi: 10.4137/CCRPM.S7955

Mong, J. A., and Cusmano, D. M. (2016). Sex differences in sleep: impact of biological sex and sex steroids. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 371:20150110. doi: 10.1098/rstb.2015.0110

Moo-Estrella, J., Pérez-Benítez, H., Solís-Rodríguez, F., and Arankowsky-Sandoval, G. (2005). Evaluation of depressive symptoms and sleep alterations in college students. *Arch. Med. Res.* 36, 393–398. doi: 10.1016/j.arcmed.2005.03.018

National Sleep Foundation, (2008). *Sleep in America Poll. Summary of Findings*. Available at: https://www.sleepfoundation.org/sites/default/files/2018-11/2008_POLL_SOF.pdf (accessed August 18, 2019).

Nauts, S., and Kroese, F. M. (2017). "The role of self-control in sleep behavior," in *Routledge International Handbook of Self-Control in Health and Well-Being*, eds K. F. D. de Ridder and M. Adriaanse (Abingdon: Routledge), 288–299. doi: 10.4324/9781315648576-23

Nowakowski, S., Meers, J., and Heimbach, E. (2013). Sleep and women's health. *Sleep Med. Res.* 4, 1–22. doi: 10.17241/smr.2013.4.1.1

Oginska, H., Mojsa-Kaja, J., Fafrowicz, M., and Marek, T. (2014). Measuring individual vulnerability to sleep loss-the CHICa scale. *J. Sleep Res.* 23, 341–348. doi: 10.1111/jsr.12115

Oginska, H., and Pokorski, J. (2006). Fatigue and mood correlates of sleep length in three age-social groups: school children, students, and employees. *Chronobiol. Int.* 23, 1317–1328. doi: 10.1080/07420520601089349

Ondo, W. G., Dat Vuong, K., Khan, H., Atassi, F., Kwak, C., and Jankovic, J. (2001). Daytime sleepiness and other sleep disorders in Parkinson's disease. *Neurology* 57, 1392–1396. doi: 10.1212/WNL.57.8.1392

Owens, H., Christian, B., and Polivka, B. (2017). Sleep behaviors in traditional-age college students. *J. Am. Assoc. Nurse Pract.* 29, 695–703. doi: 10.1002/2327-6924.12520

Pien, G. W., and Schwab, R. J. (2004). Sleep disorders during pregnancy. *Sleep* 27, 1405–1417. doi: 10.1093/sleep/27.7.1405

Rideout, V. J., Foehr, U. G., and Roberts, D. F. (2010). *Generation M2. Media in the Lives of 8- to 18-Year-Olds*. Menlo Park, CA: A Kaiser Family Foundation Study.

Roane, B. M., and Taylor, D. J. (2008). Adolescent insomnia as a risk factor for early adult depression and substance abuse. *Sleep* 31, 1351–1356.

Rosseel, Y. (2012). lavaan: an R package for structural equation modeling. *J. Stat. Softw.* 48, 1–36. doi: 10.18637/jss.v048.i02

Shaver, J., Giblin, E., Lentz, M., and Lee, K. (1988). Sleep patterns and stability in perimenopausal women. *Sleep* 11, 556–561. doi: 10.1093/sleep/11.6.556

Sirois, F. M., Nauts, S., and Molnar, D. S. (2019). Self-compassion and bedtime procrastination: an emotion regulation perspective. *Mindfulness* 10, 434–445. doi: 10.1007/s12671-018-0983-983

Spanos, D., and Hankey, C. R. (2010). The habitual meal and snacking patterns of university students in two countries and their use of vending machines. *J. Hum. Nutr. Diet.* 23, 102–107. doi: 10.1111/j.1365-277X.2009.01005.x

Strine, T. W., and Chapman, D. P. (2005). Associations of frequent sleep insufficiency with health-related quality of life and health behaviors. *Sleep Med.* 6, 23–27. doi: 10.1016/j.sleep.2004.06.003

Suarez, E. C. (2008). Self-reported symptoms of sleep disturbance and inflammation, coagulation, insulin resistance and psychosocial distress: evidence for gender disparity. *Brain Behav. Immun.* 22, 960–968. doi: 10.1016/j.bbi.2008.01.011

Swanson, L. M., Arnedt, J. T., Rosekind, M. R., Belenky, G., Balkin, T. J., and Drake, C. (2011). Sleep disorders and work performance: findings from the 2008 national sleep foundation sleep in America poll. *J. Sleep Res.* 20, 487–494. doi: 10.1111/j.1365-2869.2010.00890.x

Szentkirályi, A., Madarász, C. Z., and Novák, M. (2009). Sleep disorders: impact on daytime functioning and quality of life. *Expert Rev. Pharmacoecon. Outcomes Res.* 9, 49–64. doi: 10.1586/14737167.9.1.49

Tangney, J. P., Baumeister, R. F., and Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *J. Pers.* 72, 271–324. doi: 10.1111/j.0022-3506.2004.00263.x

Trockel, M. T., Barnes, M. D., and Egget, D. L. (2000). Health-related variables and academic performance among first-year college students: implications for sleep and other behaviors. *J. Am. Coll. Health* 49, 125–131. doi: 10.1080/07448480009596294

Van den Bulck, J. (2010). The effects of media on sleep. *Adolesc. Med. State Art Rev.* 21, 418–429.

Wolfson, A. R., and Carskadon, M. A. (2003). Understanding adolescent's sleep patterns and school performance: a critical appraisal. *Sleep Med. Rev.* 7, 491–506. doi: 10.1016/S1087-0792(03)90003-90007

Zhang, J., Lam, S.-P., Li, S. X., Ma, R. C. W., Kong, A. P. S., Chan, M. H. M., et al. (2014). A community-based study on the association between insomnia and hypothalamic-pituitary-adrenal axis: sex and pubertal influences. *J. Clin. Endocrinol. Metab.* 99, 2277–2287. doi: 10.1210/jc.2013-3728

Zhang, J., Ma, R. C. W., Kong, A. P., So, W. Y., Li, A. M., Lam, S. P., et al. (2011). Relationship of sleep quantity and quality with 24-hour urinary catecholamines and salivary awakening cortisol in healthy middle-aged adults. *Sleep* 34, 225–233. doi: 10.1093/sleep/34.2.225 doi: 10.1093/sleep/34.2.225

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

APPENDIX

Bedtime Procrastinationscale – Polish Version

W odniesieniu do każdego z poniższych stwierdzeń zdecyduj w jakim stopniu dotyczy ono ciebie, wybierając odpowiedź na skali od 1 (nigdy lub prawie nigdy) do 5 (zawsze lub prawie zawsze):

1. Chodzę spać później niż zamierzałem(am).
2. Kładę się spać wcześnie, jeśli muszę wstać wcześnie rano (reverse coded).
3. Gdy wieczorem nadchodzi czas gaszenia światła, robię to od razu (reverse coded).
4. Często wciąż robię inne rzeczy, kiedy jest już czas żeby pójść spać.
5. Łatwo rozpraszają mnie różne rzeczy, kiedy właściwie już chciał(a)bym iść spać.
6. Nie chodzę spać na czas.
7. Mam stałą porę kładzenia się spać, której się trzymam (reverse coded).
8. Chcę iść spać o właściwej porze, ale po prostu nie mogę.
9. Łatwo mogę przerwać to co robię, kiedy jest czas kłaść się spać (reverse coded).

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The Predictive Relationship of Health Related Quality of Life on Objectively-Measured Sleep in Children: A Comparison Across BMI Ranges

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Sleep is considered a major factor related to children's general quality of life with regards to their health outcomes, general well-being, and daily life functions. Kid-KINDL, a health-related quality of life (HRQOL) measure, was used in a consecutive 12-week longitudinal study to compare the association between children's quality of life (QoL) and sleep duration across different BMI ranges. To reduce recall bias, each child wore an electronic pedometer on their wrist to record their sleep duration. The Pearson $\chi 2$ test, one-way analysis of variance (ANOVA), and mixed effect repeated measures analysis was used to investigate the association between children's QoL and their sleep duration. The original QoL scores showed that underweight children had lower emotional, family relationship, friendship, and school-related scores, and that overweight children had lower physical satisfaction and self-esteem scores. Emotional (beta = −0.3, $p < 0.01$) and family relationships (beta = 0.20, $p = 0.01$) significantly influenced the sleep duration of underweight children. The score of emotional well-being decreased by 0.3, while sleep duration increased by an hour. The poorer the emotional well-being of children, the longer they slept. The score of family well-being increased by 0.2, while sleep duration increased by an hour. The better family quality children had, the longer they slept; For overweight children, the score of family well-being increased by 0.08, while sleep duration increased by an hour (beta = 0.08, $p = 0.04$). Their sleep got longer when they had better family quality. Physical and school satisfaction scores also significantly affected the sleep duration of obese children. When the score of physical and school increased by 0.09, the sleep duration increases by an hour (beta = 0.09, $p = 0.01$; beta = 0.09, $p < 0.01$, respectively). The better the quality of physical condition and school life was, the longer sleep they would get. This study might be the first longitudinal study to evaluate the relationship between QoL and sleep duration, using an objective device but subjective questionnaires, across BMI ranges in a pediatric population.

Keywords: children, sleeo, health related quality of life, weight classification, longitudinal study, objective measure

INTRODUCTION

Sleep, a crucial physiological need for humans, is important for maintaining health (Lin P.H. et al., 2018), and more specially, sleep duration is mostly used as a sleep variable (Galland et al., 2012). Children from Asian countries are commonly reported to sleep less compared to their counterparts. Sleep duration is a pivotal correlation and factor of various aspects of child development, which relates to quality of life (QoL) in general (El-Sheikh and Kelly, 2017). Sufficient sleep is critical for children's comprehensive functions: physical health, cognitive processing, and socioemotional adjustment and mental functioning (Paruthi et al., 2016; El-Sheikh and Kelly, 2017; Lin et al., 2018a). The association between sleep duration and QoL has been well discussed in the adult population, as well as in clinical cases in children (Gruber et al., 2014). A longitudinal study indicated that short sleep duration had increased the odds of poor QoL (Roberts et al., 2009) while a cross-sectional study stated that longer sleep duration is associated with better QoL (Do et al., 2013; Perkinson-Gloor et al., 2013).

Health-Related Quality of Life (HRQOL) is an inclusive measurement tool of children's health outcomes, general well-being, and everyday functions (Delahaye et al., 2014). More specifically, HRQOL has a wide-ranging scope of elements that elaborate how QoL affects children's physical and psychological condition, social experiences, independence, and environmental influences (Lin, 2018; Lin Y.C. et al., 2018). It is measured in generic and specific conditions. Generic instruments generate a summary of HRQOL, and specific instruments generate data on health problems associated with specific diseases or malfunctions. Generic instruments are used primarily for health profiles of general groups (Guyatt et al., 1993). HRQOL is used to assess generally healthy or chronically ill groups undergoing treatments (Delahaye et al., 2014).

Kid- KINDL is an all-inclusive and multi-dimensional set of generic HRQOL assessments, intended to measure well-being across different health statuses, e.g., overweight and obesity (Hoedjes et al., 2018; Lin, 2018; Lin et al., 2018a).

Childhood overweight and obesity are global health problems that cause cardiovascular disease, diabetes mellitus, hypertension, and adolescent and adult obesity (Brisbois et al., 2012). Overweight and obese children undergo physical and psychosomatic consequences (Puhl and Latner, 2007; Lin et al., 2013). For instance, they might experience social stigma, which impairs their psychological well-being and, ultimately, their QoL (Farhangi et al., 2017; Hoedjes et al., 2018). They are more likely to have impaired HRQOL than their normal-weight counterparts because a high body mass index (BMI) is negatively associated with a poor QoL (Tsiros et al., 2009). How and how much this association affects health outcomes, like poor sleep duration, warrant additional studies.

Although the association between sleep, overweight, and obesity has been well established in adolescents and adults, little is known about the relationship in young children. Prior studies (Cappuccio et al., 2008; Fatima et al., 2015) have claimed an association between poor sleep duration and weight gain in children, but these findings were confounded because of racial or socioeconomic characteristics of the diverse cohorts studied (Lumeng et al., 2007; Lemola et al., 2011; Pakpour et al., 2019).

There are no published multi-dimensional studies on the effects of sleep duration on children in different BMI ranges. Moreover, most sleep studies have used self-rated or parent-rated questionnaires (Chervin et al., 2000; Owens et al., 2000; Sadeh et al., 2000). The data might be biased because of subjective perceptions. Furthermore, for pediatric groups, measuring sleep is quite difficult because parents become less involved with older children's sleep duration, bedtime routines, and night wakening (Pakpour et al., 2019). Thus, using an electronic pedometer to objectively capture children's sleep patterns might be helpful (Lin et al., 2018b, 2019).

Because prior research data were acquired primarily from cross-sectional studies, the effects of longitudinal associations are unknown. Thus, we conducted a 12-week longitudinal study to identify and assess sleep patterns in real time.

MATERIALS AND METHODS

Participants: Recruitment and Eligibility

The study was conducted in a community-centered elementary school in New Taipei City, Taiwan, during the second semester of 2017. We recruited 320 parent-child pairs. The eligibility criteria for children were being enrolled in 1st through 5th grades and having no chronic physical, emotional, or intellectual disabilities. Parents had to be between 25 and 50 years old, be the primary caretakers of the child, be interested in promoting the child's physical activity (PA), and have no chronic physical, emotional, or intellectual disabilities. Subsequently, four classes from each grade (1st through 5th) were randomly selected. All participants were informed of the study purpose and their right to drop out of the study at any time for any reason without prejudice. Signed written informed consent was obtained from all the children's parents.

The children were asked to wear the waterproof MI Band as often and as long as possible to fully record their sleep duration. The children were issued the user names and passwords for their MI Band and parents authorized the data for use by the research team. Trained research assistants retrieved and recorded the data every 2 weeks. The study procedures were approved by the Institutional Review Board of National Taiwan University Hospital (IRB#: 201604076RIND).

Measures

Anthropometric Measures

Height was measured to the nearest 0.1 cm using a stadiometer, and weight was measured to the nearest 0.01 kg using portable digital scales. From these data, body mass index (BMI) was calculated and subsequently converted to age- and sex-specific standardized scores using the 1990 growth curves from Cole et al. (1995). We used the standard BMI ranges at different age levels from the Taiwan Ministry of Health and Welfare.

Health-Related Quality of Life Inventory: Kid-KINDL Proxy

The Kid-KINDL Proxy is a generic QoL instrument designed for parents to rate QoL for their 8- to 13-year-old children. The Proxy has 24 items in six domains: [1]. Physical well-being (4 items; e.g., "My child feels tired and worn-out"); [2]. Emotional well-being (4 items; e.g., "My child feels alone"); [3]. Self-esteem (4 items; e.g., "My child is proud of him-/herself"); [4]. Family (4 items; e.g., "My child gets on well with my parents"); [5]. Friends (4 items; e.g., "My child gets on well with his/her friends"); and [6]. School (4 items; e.g., "My child easily copes with schoolwork"). Each item was rated on a five-point Likert-type scale from "Never" (1) to "all the time" (5), and the scores were converted into a 0–100 scale using (1) = 100, (2) = 75, (3) = 50, (4) = 25, and (5) = 0, where a higher score represents a higher QoL. The construct validity of Kid-KINDL Proxy (Taiwan version) has been tested and confirmed using confirmatory factor analysis (Lin et al., 2014; Lin and Lin, 2017). The internal consistency of the entire set of items was 0.78. The data were collected before the consecutive 12-weeks. The participating parents were asked to fill out the QoL questionnaire and to report the level of each domain for their children.

Sleep Duration

A pedometer, the MI Band, was worn on the children's wrist to detect their PA and sleep duration (Weiss et al., 2010; Meltzer et al., 2012, 2015). Five main health indicators—heart rate, number of steps walked, energy consumption, distance walked, and sleep duration—are the most common indicators used in these devices. Those indicators are validated by determining their respective mean absolute percentage errors (MAPEs). The MI Band is highly accurate: MAPE = ca. 0.10 (Shelgikar et al., 2016; Xie et al., 2018). Data were extracted on at least three weeknights and at least one weekend night (for weekend period) for calculation.

The study started from the Fall semester in 2017. Children were asked to wear the MI Band for 12 consecutive weeks for the purpose of research data collection. Their averaged sleep duration from weekdays and weekends were both retrieved by research assistants and then generated for the study. However, compared to children's sleep duration during weekends, their sleep duration during weekdays was more confined by the school schedule. Weekday data were more consistent, rather than the weekend data that may include the need of "catch-up" sleep (Epstein et al., 1998). Therefore, considering their actual bodily needs and sleep habits, the data of their sleep duration on weekends was also considered for the analysis.

Statistical Analysis

The two major objectives of the study were the effects of QoL on sleep duration and how they compared across different BMI ranges (underweight, normal weight, overweight and obesity). Significance was set at $p < 0.05$. The analyses were conducted through bivariate associations between the studied variables using cross tabulations and one-way ANOVA. Moreover, a mixed effect repeated measures analysis was performed to estimate children's sleep. The associations between children's QoL, defined as a fixed effect, and children's sleep duration, in four different linear mixed effects models with different BMI ranges, were measured through a 12-week period. The model tested the divergence of sleep duration based on children's QoL to respond to the research assumptions. The analyses described above employed the Statistical Package for Social Sciences (SPSS) statistical software version 20.0 package (IBM Corp., Armonk, NY).

RESULTS

We assessed the data of 263 children (121 [46%] were boys; 184 [ca. 70%] were normal-weight, and 65 [ca. 25%] were overweight and obese (**Table 1**). The effect of QoL on sleep duration on weekdays, weekends, and entire weeks for children were all examined as a sensitivity analysis (**Appendix A**). The results showed that children's QoL could not significantly predict their sleep duration on weekdays, but, for obese children, their school domain in QoL had a significantly positive impact on their sleep duration. In other words, the better their experience in school, their longer they sleep. As aforementioned, only the sleep duration on weekends was further explored and the findings were presented as follows: For different aspects of heath related QoL, the school domain had the lowest mean (64.12), and the physical domain had the highest (74.62); Underweight children scored low on the Emotion, Family, Friend, and School domains, while obese children scored high on the Family, Friend, and Physical domains (**Table 1**).

Mixed-effect repeated measures measured that sex, age, and BMI were not significant for sleep but that the length of the study negatively affected all of the participants' sleep. The consecutive weeks seemed like an important factor that impacted the children's sleep (**Table 2**). The findings showed that on-going weekends had a significant effect on children's sleep for children of underweight, normal weight, overweight and obese groups respectively [$F(1, 25.04) = 7.47^{**}$; $F(1, 632.08) = 77.78^{***}$; $F(1, 127.81) = 15.328^{***}$; $F(1, 79.51) = 15.42^{***}$]. As the study went on ($\beta \leq -0.35$, $p \leq 0.01$), the worse their sleep became, regardless of their BMI ranges.

For groups of underweight children, the emotional well-being [$F(1, 12.78) = 16.18^{**}$] and family [$F(1, 12.78) = 9.36^{**}$] dimensions were potentially important predictors of children's sleep. The effect of emotional well-being was significantly but negatively associated with children's sleep duration, which indicated when the score of emotional well-being decreased by 0.3, the sleep duration increased by an hour (beta = −0.3, $p < 0.01$). The poorer the emotional well-being of children, the longer they slept. In addition, the effect of family was significant, and its coefficient was positive when the score of family well-being increased by 0.2, while sleep duration increased by an hour (beta = 0.20, $p = 0.01$). In other words, the better family quality children had, the longer they slept.

On the other hand, for the group of overweight children, family is a possibly critical predictor of their sleep [$F(1, 59.07) = 3.85^{**}$]. The effect of family was significant, and its coefficient showed when the score of family well-being increased

TABLE 1 | Descriptive statistics for participants' background characteristics and Kid-KINDL Quality of Life across different BMI ranges.

		All	Underweight 14(5.3%)	Normal 184(70%)	Overweight 40(15.2%)	Obese 25(9.5%)	X^2 or F	*P*
Sex							0.68	0.88
	Boys	121(46%)	5(35.7%)	85(46.2%)	19(47.5%)	12(48%)		
	Girls	142(54%)	9(64.3%)	99(53.8%)	21(52.5%)	13(52%)		
Grade							11.28	0.51
	1st	52(19.8%)	3(5.77%)	34(65.38%)	13(25.00%)	2(3.85%)		
	2nd	68(25.9%)	4(5.88%)	49(72.06%)	8(11.76%)	7(10.29%)		
	3th	48(18.3%)	4(8.33%)	35(72.92%)	6(12.50%)	3(6.25%)		
	4th	44(16.7%)	2(4.55%)	30(86.18%)	7(15.91%)	5(11.36%)		
	5th	51(19.4%)	1(1.96)	36(70.59%)	6(11.76%)	8(15.69%)		
BMI		17.42 ± 3.01	13.57 ± 0.65	16.28 ± 1.49	19.88 ± 1.47	24.08 ± 1.98		
Kid-KINDL QoL								
Physical		74.62 ± 15.30	72.60 ± 11.56	75.21 ± 15.81	71.53 ± 13.65	76.04 ± 15.71	0.72	0.54
Emotion		74.21 ± 16.32	71.15 ± 12.90	74.20 ± 16.89	75 ± 13.74	74.73 ± 18.02	0.19	0.91
Esteem		68.96 ± 18.92	73.08 ± 16.81	69.34 ± 19.57	66.39 ± 17.82	68 ± 17.15	0.48	0.70
Family		71.87 ± 16.23	67.31 ± 15.34	70.93 ± 16.59	75 ± 13.66	76.25 ± 16.93	1.62	0.19
Friend		70.11 ± 17.76	62.97 ± 15.96	70.04 ± 17.92	71.34 ± 17.54	72.75 ± 17.85	1.00	0.39
School		64.12 ± 17.33	54.91 ± 20.54	65.60 ± 17.34	62.33 ± 14.47	61.50 ± 18.10	2.10	0.10
Total		70.80 ± 11.75	66.83 ± 9.33	71.01 ± 12.37	70.39 ± 9.491	72.10 ± 11.67	0.62	0.60

TABLE 2 | Health-related quality of life indicators of children's sleep duration across different BMI ranges.

	Underweight			Normal Weight			Overweight			Obese		
Variables	β	**SE**	*p*	β	**SE**	*p*	β	**SE**	*p*	β	**SE**	*p*
Intercept	35.83	9.86	0.00	6.72	1.93	0.00	−1.28	4.05	0.75	−12.9	7.58	0.10
Sex	2.55	1.38	0.09	0.59	0.37	0.11	1.49	0.83	0.08	**1.81**	**0.83**	**0.03**
Age	0.71	0.75	0.36	0.00	0.00	0.59	0.34	0.36	0.34	0.00	0.00	0.39
Week	**−0.30**	**0.11**	**0.01**	**−0.35**	**0.04**	**0.00**	**−0.31**	**0.08**	**0.00**	**−0.27**	**0.07**	**0.00**
BMI	−2.21	1.01	0.05	−0.12	0.10	0.22	−0.21	0.25	0.40	0.20	0.13	0.14
Kid-KINDL QoL												
Physical	−0.07	0.07	0.31	0.02	0.01	0.22	0.00	0.04	0.94	**0.09**	**0.03**	**0.01**
Emotion	**−0.30**	**0.07**	**< 0.01**	0.00	0.01	0.87	0.02	0.04	0.57	0.03	0.03	0.42
Esteem	0.08	0.06	0.21	0.00	0.01	0.89	−0.02	0.03	0.36	0.02	0.03	0.31
Family	**0.20**	**0.06**	**0.01**	0.00	0.01	0.96	**0.08**	**0.04**	**0.04**	−0.02	0.02	0.17
Friend	0.03	0.06	0.59	−0.02	0.01	0.21	−0.02	0.02	0.50	−0.05	0.04	0.11
School	−0.03	0.03	0.34	0.02	0.01	0.20	0.04	0.03	0.18	**0.09**	**0.02**	**< 0.01**
Interaction between QoL with Weekend Sleep[a]												
Physical	0.00	0.03	0.90	–	–	–	0.00	0.05	0.94	0.03	0.04	0.42
Emotion	−0.07	0.05	0.12	–	–	–	−0.08	0.05	0.15	−0.04	0.04	0.36
Esteem	0.05	0.04	0.22	–	–	–	0.00	0.04	0.98	0.05	0.05	0.28
Family	0.03	0.04	0.46	–	–	–	0.05	0.04	0.14	−0.05	0.03	0.11
Friend	0.00	0.04	0.90	–	–	–	0.00	0.03	0.95	−0.02	0.06	0.76
School	0.00	0.03	0.96	–	–	–	0.02	0.03	0.52	0.04	0.03	0.22

[a] *For the interaction models between QoL with Weekend Sleep, the normal weight group was used as the reference group. Bold values indicate being statistically significant at level of* $p < 0.05$.

by 0.08, the sleep duration increased by an hour (beta = 0.08, $p = 0.04$). For overweight children, their sleep duration became longer when they had better family quality. In addition, for the group of obese children, physical condition [$F(1, 40.46) = 7.59^{**}$] and school [$F(1, 40.46) = 10.98^{**}$] were possibly critical factors of their sleep. The effect of physical condition and school were significant, and their coefficients were positive when the physical condition and school score increased by 0.09, while sleep duration increased by an hour (beta = 0.09, $p = 0.01$; beta = 0.09, $p < 0.01$, respectively). The better the quality of physical condition and school life was, the longer the duration of sleep they would get. However, there was no statistical significance between QoL and the sleep of children with a normal weight, which means that these dimensions of QoL were

not significant factors associated with the sleep of children of a normal weight.

In order to further look into whether the association between QoL and sleep duration differs by BMI ranges, the interaction models were applied using the normal weight group as the reference group. The results indicated no significant interactions, which showed that the influences of QoL on sleep duration were not different between children of a normal weight and their counterparts.

DISCUSSION

Given a lack of studies on the association between children's QoL and their sleep duration (Chaput et al., 2016), the findings are expected to fulfill the research gap. The present study found that, over the course of the semester, children's QoL had a significantly negative effect on sleep duration, which is opposite to the literature (Liguori et al., 2011; Do et al., 2013; Perkinson-Gloor et al., 2013). A possible explanation could be that, the levels of the QoL, for the children that participated, were identified at the beginning of the semester, but their sleep duration were measured as the semester proceeded. Usually, school load increases as the semester continues; therefore, the sleep duration could decrease along with the consecutive weeks.

Other important findings were that underweight children had lower scores in the emotion, family, friends, and school domains, and that overweight children had lower scores in the physical and self-esteem domains. These findings were consistent with prior studies (e.g., Friedlander et al., 2003; Sato et al., 2008; Strong et al., 2017). We also found that, for underweight and overweight children, the quality of their family life significantly affected their sleep duration, which is consistent with a prior study (Lumeng et al., 2007) that reported poor sleep duration and being overweight might simply reflect an underlying lack of daily life structure or unsatisfying parenting in the family. Children's sleep patterns are embedded and shaped by family relationships (El-Sheikh and Kelly, 2017), however, children's sleep duration within a family context is usually investigated as a correlation, rather than being investigated by familial factors through longitudinal studies (Kelly and El-Sheikh, 2011).

Although the developmental trajectories of children's emotional (internalized) problems have often been addressed, limited attention has been given to underweight children. Underweight children are more likely to have internalized problems (e.g., depression and anxiety) than normal-weight and overweight children are (Cimino et al., 2016), for girls in particular (Xie et al., 2013). For underweight children, the present study found that the worse the emotional wellbeing was, the longer they slept, which is consistent with prior literature (Wolfson and Carskadon, 1998; Yen et al., 2010) indicating that suboptimal emotion is related to longer sleep duration. It is also assumed that children may use sleep as a get-away approach to avoid emotional difficulties in real life. However, limited literature and the present finding emphasize the need for future research on the relationship between emotional problems and long sleep duration. We also found that the physical and school domains significantly affected the sleep duration of obese children: the higher their scores in these domains were, the longer they slept. This is consistent with prior studies which claim that, compared with normal-weight children, overweight and obese children are two to four times more likely to have a higher risk of physical functioning and psychosocial health-related internalized problems (Friedlander et al., 2003; Dumuid et al., 2017). Therefore, it is understandable that children's sleep duration could become longer if they are in optimal physical and psychosocial conditions; the phenomenon was significant for obese children because they were more likely to encounter discrimination (social stigma) or social isolation due to their oversized bodies (Lin and Lin, 2017). If they feel positive about their physical self-perception and social interaction in school, the experiences will promote their sleep duration.

This seems to be the first longitudinal study that has used an objective device, a MI-Band pedometer worn on the wrist, to objectively record and evaluate sleep duration and its relationship with HRQOL across BMI ranges in elementary school children. The significance of our findings is that we used an objective measure in addition to subjective questionnaires to avoid bias from retrospective memories. The wrist-pedometer has become popular for detecting the sleep patterns of children because it is inexpensive, portable, and user friendly (Meltzer et al., 2012, 2015). Additionally, using pedometers to assess sleep duration gives an advantage for the area of inquiry, which allows multiple sleep parameters to be measured simultaneously without recall bias (Kouros and El-Sheikh, 2017). This study also showed the integrated and subscale effects of domains on children's sleep. We identified unique information distinct from physiological measures using Kid-KINDL. These findings should lead to research that is even more innovative.

Limitations

Our study had limitations. First, the study was done in an urban city with a small sample of 263 parent-child dyads, which might limit the generalizability of the findings. Second, although the proxy report seems reasonable when children are too young to respond on their own (Lin Y.C. et al., 2018), the bias from a proxy report is inevitable: e.g., parents of overweight and obese children are more likely to report their children's health and well-being as poor. This bias needs to be recognized and understood. Additionally, the data of health-related QoL was not collected every week with the sleep duration. The solidity of the analyses would have been strengthened if the levels of QoL were collected every week or at least more frequently.

CONCLUSION

The study used repeated and objective assessments of children's sleep duration, underlining the necessity of consistent efforts to promote sufficient sleep for children's overall health. Children's QoL might be a feasible and accurate indicator of their sleep duration and quality. Even though the results did not differ

by BMI ranges, the findings can be perceived as a preventive health promotion approach for school-aged children. More studies that relate to the association between children's QoL and sleep are warranted.

DATA AVAILABILITY

All datasets generated for this study are included in the manuscript and/or the supplementary files.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the research ethics guidelines from the Institutional Review Board (IRB) in the University of Taipei with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Institutional Review Board (IRB; approval no. 201604076RIND) in the University of Taipei.

AUTHOR CONTRIBUTIONS

Y-CL conceptualized the structure of the study, collected the data, conducted the formal analysis, wrote the manuscript, and completed the final review and editing solely.

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REFERENCES

Brisbois, T. D., Farmer, A. P., and McCargar, L. J. (2012). Early markers of adult obesity: a review. *Obes. Rev.* 13, 347–367. doi: 10.1111/j.1467-789X.2011.00965.x

Cappuccio, F. P., Taggart, F. M., Kandala, N. B., Currie, A., Peile, E., Stranges, S., et al. (2008). Meta-analysis of short sleep duration and obesity in children and adults. *Sleep* 31, 619–626.

Chaput, J. P., Gray, C. E., Poitras, V. J., Carson, V., Gruber, R., Olds, T., et al. (2016). Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. *Appl. Physiol. Nutr. Metab.* 41, S266–S282. doi: 10.1139/apnm-2015-0627

Chervin, R. D., Hedger, K., Dillon, J. E., and Pituch, K. J. (2000). Pediatric sleep questionnaire (PSQ): validity and reliability of scales for sleep-disordered breathing, snoring, sleepiness, and behavioral problems. *Sleep Med.* 1, 21–32.

Cimino, S., Cerniglia, L., Almenara, C. A., Jezek, S., Erriu, M., and Tambelli, R. (2016). Developmental trajectories of body mass index and emotional-behavioral functioning of underweight children: a longitudinal study. *Sci. Rep.* 6:20211. doi: 10.1038/srep20211

Cole, T. J., Freeman, J. V., and Preece, M. A. (1995). Body mass index reference curves for the UK, 1990. *Arch. Dis. Child.* 73, 25–29. doi: 10.1136/adc.73.1.25

Delahaye, J., Kovacs, E., Sikora, D., Hall, T. A., Orlich, F., Clemons, T. E., et al. (2014). The relationship between health-related quality of life and sleep problems in children with autism spectrum disorders. *Res. Autism. Spectr. Disord.* 8, 292–303.

Do, Y. K., Shin, E., Bautista, M. A., and Foo, K. (2013). The associations between self-reported sleep duration and adolescent health outcomes: what is the role of time spent on Internet use? *Sleep Med.* 14, 195–200. doi: 10.1016/j.sleep.2012.09.004

Dumuid, D., Olds, T., Lewis, L. K., Martin-Fernández, J. A., Katzmarzyk, P. T., Barreira, T., et al. (2017). Health-related quality of life and lifestyle behavior clusters in school-aged children from 12 countries. *J. Pediatr.* 183, 178–183. doi: 10.1016/j.jpeds.2016.12.048

El-Sheikh, M., and Kelly, R. J. (2017). Family functioning and children's sleep. *Child Dev. Perspect.* 11, 264–269. doi: 10.1111/cdep.12243

Epstein, R., Chillag, N., and Lavie, P. (1998). Starting times of school: effects on daytime functioning of fifth-grade children in Israel. *Sleep* 21, 250–256.

Farhangi, M. A., Emam-Alizadeh, M., Hamedi, F., and Jahangiry, L. (2017). Weight self-stigma and its association with quality of life and psychological distress among overweight and obese women. *Eat. Weight Disord.* 22, 451–456. doi: 10.1007/s40519-016-0288-2

Fatima, Y., Doi, S. A. R., and Mamun, A. A. (2015). Longitudinal impact of sleep on overweight and obesity in children and adolescents: a systematic review and bias-adjusted meta-analysis. *Obes. Rev.* 16, 137–149. doi: 10.1111/obr.12245

Friedlander, S. L., Larkin, E. K., Rosen, C. L., Palermo, T. M., and Redline, S. (2003). Decreased quality of life associated with obesity in school -aged children. *Arch. Pediatr. Adolesc. Med.* 157, 1206–1211.

Galland, B. C., Taylor, B. J., Elder, D. E., and Herbison, P. (2012). Normal sleep patterns in infants and children: a systematic review of observational studies. *Sleep Med. Rev.* 16, 213–222. doi: 10.1016/j.smrv.2011.06.001

Gruber, R., Carrey, N., Weiss, S. K., Frappier, J. Y., Rourke, L., Brouillette, R. T., et al. (2014). Position statement on pediatric sleep for psychiatrists. *J. Can. Acad. Child Adolesc. Psych.* 23, 174–195.

Guyatt, G. H., Feeny, D. H., and Patrick, D. L. (1993). Measuring health-related quality of life. *Ann. Intern. Med.* 118, 622–629.

Hoedjes, M., Makkes, S., Halberstadt, J., Noordam, H., Renders, C. M., Bosmans, J. E., et al. (2018). Health-related quality of life in children and adolescents with severe obesity after intensive lifestyle treatment and at 1-year follow-up. *Obes. Facts.* 2, 116–128.

Kelly, R. J., and El-Sheikh, M. (2011). Marital conflict and children's sleep: reciprocal relations and socioeconomic effects. *J. Fam. Psychol.* 25, 412–422.

Kouros, C. D., and El-Sheikh, M. (2017). Within-family relations in objective sleep duration, quality, and schedule. *Child Dev.* 88, 1983–2000. doi: 10.1111/cdev.12667

Lemola, S., Räikkönen, K., Scheier, M. F., Matthews, K. A., Pesonen, A. K., Heinonen, K., et al. (2011). Sleep quantity, quality and optimism in children. *J. Sleep Res.* 20, 12–20. doi: 10.1111/j.1365-2869.2010.00856.x

Liguori, G., Schuna, J. Jr., and Mozumdar, A. (2011). Semester long changes in sleep duration for college students. *Coll. Stud. J.* 45, 481–493.

Lin, C. Y. (2018). Comparing quality of life instruments: sizing them up versus pediatric quality of life inventory and Kid-KINDL. *Soc. Health Behav.* 1, 42–47.

Lin, C.-Y., Cheng, A. S. K., Nejati, B., Imani, V., Ulander, M., Browall, M., et al. (2019). A thorough psychometric comparison between Athens Insomnia Scale and Insomnia Severity Index among patients with advanced cancer. *J. Sleep Res.* e12891. doi: 10.1111/jsr.12891

Lin, C.-Y., Luh, W.-M., Cheng, C.-P., Yang, A.-L., and Ma, H.-I. (2014). Evaluating the wording effect and psychometric properties of the Kid-KINDL. *Eur. J. Psychol. Assess.* 30, 100–109. doi: 10.1027/1015-5759/a000175

Lin, C. Y., Strong, C., Scott, A. J., Broström, A., Pakpour, A. H., and Webb, T. L. (2018a). A cluster randomized controlled trial of a theory-based sleep hygiene intervention for adolescents. *Sleep* 41:zsy170. doi: 10.1093/sleep/zsy170

Lin, C. Y., Strong, C., Siu, A. M. H., Jalilolghadr, S., Nilsen, P., Broström, A., et al. (2018b). Validating the persian adolescent sleep hygiene scale revised version (ASHSr) using comprehensive psychometric testing methods. *Sleep Med.* 50, 63–71.

Lin, C. Y., Su, C. T., Wang, J. D., and Ma, H. I. (2013). Self-rated and parent-rated quality of life (QoL) for community-based obese and overweight children. *Acta Paediatr.* 102, e114–e119. doi: 10.1111/apa.12108

Lin, P. H., Lin, C. Y., Wang, P. Y., and Yang, S. Y. (2018). Association between sleeping duration and health-related behaviors in college student. *Soc. Health Behav.* 1, 31–36.

Lin, Y.-C., and Lin, C.-Y. (2017). Minor symptoms talk: how children react to encountered bullying. *Child Indic. Res.* 11, 1755–1768. doi: 10.1007/s12187-017-9505-4

Lin, Y. C., Strong, C., Tsai, M. C., Lin, C. Y., and Fung, X. C. (2018). Validating sizing them up: a parent-proxy weight-related quality-of-life measure, with community-based children. *Int. J. Clin. Health Psychol.* 18, 81–89. doi: 10.1016/j.ijchp.2017.10.001

Lumeng, J. C., Somashekar, D., Appugliese, D., Kaciroti, N., Corwyn, R. F., and Bradley, R. H. (2007). Shorter sleep duration is associated with increased risk for being overweight at ages 9 to 12 years. *Pediatrics* 120, 1020–1029.

Meltzer, L. J., Hiruma, L. S., Avis, K., Montgomery-Downs, H., and Valentin, J. (2015). Comparison of a commercial accelerometer with polysomnography and actigraphy in children and adolescents. *Sleep* 38, 1323–1330. doi: 10.5665/sleep.4918

Meltzer, L. J., Montgomery-Downs, H. E., Insana, S. P., and Walsh, C. M. (2012). Use of actigraphy for assessment in pediatric sleep research. *Sleep Med. Rev.* 16, 463–475. doi: 10.1016/j.smrv.2011.10.002

Owens, J. A., Spirito, A., and McGuinn, M. (2000). The children's sleep habits questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep* 23, 1043–1051.

Pakpour, A. H., Chen, C.-Y., Lin, C.-Y., Strong, C., Tsai, M.-C., and Lin, Y.-C. (2019). The relationship between children's overweight and quality of life: a comparison of Sizing Me Up, PedsQL and Kid-KINDL. *Int. J. Clin. Health Psychol.* 19, 49–56. doi: 10.1016/j.ijchp.2018.06.002

Paruthi, S., Brooks, L. J., D'Ambrosio, C., Hall, W. A., Kotagal, S., Lloyd, R. M., et al. (2016). Recommended amount of sleep for pediatric populations: a consensus statement of the American academy of sleep medicine. *J. Clin. Sleep Med.* 12, 785–786. doi: 10.5664/jcsm.5866

Perkinson-Gloor, N., Lemola, S., and Grob, A. (2013). Sleep duration, positive attitude toward life, and academic achievement: the role of daytime tiredness, behavioral persistence, and school start times. *J. Adolesc.* 36, 311–318. doi: 10.1016/j.adolescence.2012.11.008

Puhl, R. M., and Latner, J. D. (2007). Stigma, obesity, and the health of the nation's children. *Psychol. Bull.* 133, 557–580. doi: 10.1037/0033-2909.133.4.557

Roberts, R. E., Roberts, C. R., and Duong, H. T. (2009). Sleepless in adolescence: prospective data on sleep deprivation, health and functioning. *J. Adolesc.* 32, 1045–1057. doi: 10.1016/j.adolescence.2009.03.007

Sadeh, A., Raviv, A., and Gruber, R. (2000). Sleep patterns and sleep disruptions in school-age children. *Dev. Psychol.* 36, 291–301.

Sato, H., Nakamura, N., and Sasaki, N. (2008). Effects of bodyweight on health-related quality of life in school-aged children and adolescents. *Pediatr. Int.* 50, 552–556. doi: 10.1111/j.1442-200X.2008.02628.x

Shelgikar, A. V., Anderson, P. F., and Stephens, M. R. (2016). Sleep tracking, wearable technology, and opportunities for research and clinical care. *Chest* 150, 732–743. doi: 10.1016/j.chest.2016.04.016

Strong, C., Lin, Y. C., Tsai, M. C., and Lin, C. Y. (2017). Factor structure of Sizing Me Up, a self-reported weight-related quality of life instrument, in community children across weight status. *Child Obes.* 13, 111–119. doi: 10.1089/chi.2016.0259

Tsiros, M. D., Olds, T., Buckley, J. D., Grimshaw, P., Brennan, L., Walkley, J., et al. (2009). Health-related quality of life in obese children and adolescents. *Int. J. Obes.* 33, 387–400. doi: 10.1038/ijo.2009.42

Weiss, A. R., Johnson, N. L., Berger, N. A., and Redline, S. (2010). Validity of activity-based devices to estimate sleep. *J. Clin. Sleep Med.* 6, 336–342.

Wolfson, A. R., and Carskadon, M. A. (1998). Sleep schedules and daytime functioning in adolescents. *Child Dev.* 69, 875–887.

Xie, B., Ishibashi, K., Lin, C., Peterson, D. V., and Susman, E. J. (2013). Overweight trajectories and psychosocial adjustment among adolescents. *Prev. Med.* 57, 837–843. doi: 10.1016/j.ypmed.2013.09.008

Xie, J., Wen, D., Liang, L., Jia, Y., Gao, L., and Lei, J. (2018). Evaluating the validity of current mainstream wearable devices in fitness tracking under various physical activities: comparative study. *JMIR MHealth UHealth* 6:e94. doi: 10.2196/mhealth.9754

Yen, C. F., King, B. H., and Tang, T. C. (2010). The association between short and long nocturnal sleep durations and risky behaviours and the moderating factors in Taiwanese adolescents. *Psychiatry Res.* 179, 69–74. doi: 10.1016/j.psychres.2009.02.016

Conflict of Interest Statement: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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APPENDIX

APPENDIX A | Health-related quality of life indicators of children's sleep duration across different BMI ranges in consecutive 12 weekdays, weekends and weeks.

	Underweight									**Normal weight**								
	Weekdays			**Weekends**			**Weeks**			**Weekdays**			**Weekends**			**Weeks**		
	B	**SE**	***p***	***B***	**SE**	***p***	***B***	**SE**	***p***	***B***	**SE**	***p***	***B***	**SE**	***p***	***B***	**SE**	***p***
Intercept	−2.94	4.83	0.56	0.87	3.09	0.78	−0.85	4.57	0.86	−0.22	0.09	0.01	−0.20	0.07	0.00	−0.25	0.08	0.00
Sex	0.70	0.51	0.22	0.60	0.33	0.09	0.65	0.48	0.22	0.09	0.11	0.39	0.14	0.09	0.11	0.11	0.10	0.30
Age	−5.24	39.16	0.90	23.64	25.07	0.36	11.88	37.07	0.76	0.09	0.09	0.35	0.04	0.08	0.59	0.06	0.09	0.54
Week	**−0.20**	**0.12**	**0.01**	**−0.25**	**0.09**	**0.01**	**−0.25**	**0.11**	**0.04**	**−0.22**	**0.03**	**0.00**	**−0.29**	**0.03**	**<0.01**	**−0.28**	**0.03**	**<0.01**
BMI	−1.40	1.34	0.34	**−1.87**	**0.86**	**0.05**	−1.78	1.27	0.21	−0.03	0.10	0.78	−0.11	0.09	0.22	−0.07	0.10	0.50
Kid-KINDL QoL																		
Physical	−0.42	0.39	0.32	−0.26	0.25	0.31	−0.32	0.37	0.42	0.03	0.06	0.55	0.06	0.05	0.22	0.05	0.06	0.37
Emotion	−1.09	0.45	0.05	**−1.15**	**0.29**	**<0.01**	**−1.09**	**0.42**	**0.04**	0.02	0.06	0.70	0.01	0.05	0.87	0.01	0.06	0.84
Esteem	0.29	0.39	0.49	0.33	0.25	0.21	0.28	0.37	0.47	0.02	0.06	0.80	0.01	0.05	0.89	0.01	0.06	0.82
Family	0.56	0.38	0.19	**0.75**	**0.25**	**0.01**	0.67	0.36	0.11	0.00	0.06	0.97	0.00	0.05	0.96	0.00	0.06	0.95
Friend	0.29	0.38	0.48	0.14	0.25	0.59	0.17	0.36	0.66	−0.09	0.07	0.22	−0.07	0.06	0.21	−0.08	0.07	0.24
School	0.00	0.17	0.99	−0.11	0.11	0.34	−0.05	0.16	0.77	0.07	0.06	0.25	0.07	0.05	0.20	0.07	0.06	0.25

(Continued)

APPENDIX A | Continued

	Overweight									Obese								
	Weekdays			Weekends			Weeks			Weekdays			Weekends			Weeks		
	B	**SE**	***p***	***B***	**SE**	***p***	***B***	**SE**	***p***	***B***	**SE**	***p***	***B***	**SE**	***p***	***B***	**SE**	***p***
Intercept	1.26	2.27	0.58	1.38	1.85	0.46	1.41	2.23	0.53	−0.66	0.44	0.14	−0.72	0.38	0.06	−0.77	0.45	0.10
Sex	0.37	0.24	0.14	0.35	0.20	0.08	0.37	0.24	0.12	0.60	0.23	0.01	**0.43**	**0.20**	**0.03**	0.52	0.23	0.03
Age	11.20	14.63	0.45	11.49	11.92	0.34	12.23	14.38	0.40	0.05	0.10	0.58	0.07	0.08	0.39	0.06	0.10	0.56
Week	**−0.18**	**0.07**	**0.01**	**−0.26**	**0.07**	**<0.01**	**−0.24**	**0.07**	**<0.01**	**−0.17**	**0.08**	**0.04**	**−0.29**	**0.07**	**<0.01**	**−0.26**	**0.08**	**<0.01**
BMI	−0.19	0.26	0.47	−0.18	0.21	0.40	−0.20	0.26	0.45	0.16	0.18	0.38	0.24	0.16	0.14	0.21	0.19	0.26
Kid-KINDL QoL																		
Physical	−0.01	0.17	0.98	0.01	0.14	0.94	0.01	0.17	0.93	0.38	0.16	0.02	**0.37**	**0.14**	**0.01**	**0.39**	**0.16**	**0.02**
Emotion	−0.03	0.19	0.90	0.09	0.16	0.57	0.03	0.19	0.87	0.07	0.17	0.68	0.12	0.15	0.42	0.11	0.17	0.54
Esteem	−0.08	0.14	0.56	−0.11	0.11	0.36	−0.10	0.14	0.46	0.29	0.24	0.24	0.22	0.21	0.31	0.27	0.25	0.28
Family	0.32	0.18	0.08	**0.29**	**0.15**	**0.05**	0.31	0.18	0.08	−0.17	0.13	0.21	−0.16	0.12	0.17	−0.18	0.14	0.21
Friend	0.07	0.11	0.52	−0.06	0.09	0.50	0.00	0.11	0.98	−0.46	0.25	0.08	−0.35	0.22	0.11	−0.42	0.26	0.11
School	0.09	0.14	0.54	0.15	0.11	0.18	0.13	0.14	0.34	**0.50**	**0.16**	**<0.01**	**0.45**	**0.13**	**<0.01**	**0.48**	**0.16**	**0.01**

Bold values indicate being statistically significant at level of $p < 0.05$.

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SYSTEMATIC REVIEW
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Sleep Problems and Workplace Violence: A Systematic Review and Meta-Analysis

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Background: This systematic review with meta-analysis was carried out to study the relationship between workplace violence and sleep problems.

Methods: The PRISMA statement was used to conduct a systematic search of the literature on PubMed/MEDLINE, Scopus, Sociological abstract, DOAJ, Web of Science, and Google Scholar databases. Of the original number of 749 studies, 34 were included in the systematic review, and 7 in the meta-analysis.

Results: A total of 119,361 participants from 15 different countries took part in these studies which were published between 1999 and 2019. Significant heterogeneity was observed among the studies (I^2 = 96%). In a random-effects meta-analysis model, pooled odds ratio (OR) analysis revealed that there was a direct relationship between occupational exposure to violence and sleep problems (OR = 2.55; 95% CI = 1.77–3.66). According to the GRADE guidelines, the quality of evidence of the association was low.

Conclusions: The findings of this study demonstrate that occupational exposure to physical, verbal, or sexual violence is associated with sleep problems. Further research on the relationship between violence and sleep is needed so that appropriate measures can be taken to prevent violence and improve sleep hygiene in the workplace.

Trial Registration Number: PROSPERO International prospective register of systematic reviews (CRD42019124903) February 9, 2019.

Keywords: workplace violence, sleep quality, sleep problems, psychological trauma, neurophysiology, sleep disorders, bullying, stress

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INTRODUCTION

Rationale

Sleep is very important for workers' health, safety, well-being, and productivity (Garbarino et al., 2016c; Magnavita and Garbarino, 2017). Sleep loss can have serious detrimental effects on cognitive performance, including vigilant attention (Hudson et al., 2019), dexterity (Banfi et al., 2019), executive functioning and performance (Massar et al., 2019), and memory and emotional function (Cousins and Fernández, 2019). These may increase the rate of occupational road accidents, near-miss accidents (Garbarino et al., 2016a, 2017), and occupational injuries (Garbarino et al., 2016b), and lead

to negative organizational and individual outcomes in the workplace. Considering insufficient sleep duration only, it is estimated that on an annual basis, the U.S. loses an equivalent of about 9.9 million working hours. The annual economic loss ranges between $280 billion and $411 billion (Hafner et al., 2017). The costs that result from poor quality of sleep are difficult to determine but very relevant (Garbarino et al., 2016c). Poor quality sleep may also impair occupational memory capacity (Xie et al., 2019) and productivity (Park et al., 2018), and may contribute to reduced control over emotions and aggression, thereby incrementing hostile and aggressive behavior at the workplace (Garbarino and Sannita, 2017). Aggression is considered to be a key component of social behavior that must be properly controlled (De Almeida et al., 2015). Although aggressions may be especially distressing for exposed workers (López-López et al., 2019), and distress is associated with a range of negative outcomes, including sleep problems (Vleeshouwers et al., 2015), previous research has mainly focused on examining the impact of job stress on sleep (Yang et al., 2018) or the relationship between work and sleep (Litwiller et al., 2017), generally without considering violence. The relationship between workplace violence and sleep is extremely important (Magnavita and Garbarino, 2017) since the workplace is the environment where individuals spend most of their time.

Violence is one of the most pervasive and poorly controlled problems in the workplace (Hart and Heybrock, 2017). Night and shift workers are among the most exposed (Fischer et al., 2019). Currently, there is no single, consistent definition of workplace violence (WV). Different types of physical and verbal abuse are grouped under the WV heading, and the perception of what constitutes violence varies according to different contexts and cultures (Magnavita, 2011). According to NIOSH/CDC [The National Institute for Occupational Safety Health (NIOSH) Centers for Disease Control Prevention (CDC) Workplace Violence Prevention for Nurses, 2013], WV can be classified into four types: Type 1, Criminal Intent, when no legitimate relationship exists between the perpetrator and the business or its employees and the perpetrator commits a crime (robbery, shoplifting, trespassing) in addition to violence; Type 2, Violence toward the worker on the part of the customer/client; Type 3, worker-on-worker, commonly referred to as lateral or horizontal violence; Type 4, personal relationship, in which a relationship between the perpetrator and the worker outside of work is transferred to the work environment. The first type of violence, which can often be fatal, affects mainly police officers, bank employees, taxi drivers, and traders. Type 2 is common in health care and teaching. Type 3 and 4 are possible in all types of work [The National Institute for Occupational Safety Health (NIOSH) Centers for Disease Control Prevention (CDC) Workplace Violence Prevention for Nurses, 2013]. WV can have a significant effect on workers' health. While physical injuries are immediately apparent, damage to the psychic and social spheres is more difficult to perceive. Of all the effects, impairment of the quantity and quality of sleep is probably the least frequently investigated consequence.

Differing definitions of the term "WV" make it impossible to obtain an accurate assessment of the extent of the phenomenon. Data from the 6th European Working Conditions Survey (EWCS), conducted in 35 countries in 2015, showed that 12 and 2% of European workers had been exposed to verbal abuse and physical violence, respectively, in the month prior to the study. A significant number of European workers also complained of difficulty in falling asleep (12% at least several times a week); others reported waking up repeatedly (17%) and waking up feeling tired (14%; Eurofound Sixth European Working Conditions Survey, 2017). However, the Eurofound researchers failed to investigate a possible association between the two phenomena. Minor psychological trauma experienced in the workplace can nevertheless be associated with sleep complaints (Magnavita, 2015; Magnavita et al., 2015). Bullying and other psychosocial work factors may also have an impact on sleep disturbances (Ansoleaga et al., 2015; Linton et al., 2015; van Geel et al., 2016). However, few studies have focused specifically on the relationship between bullying or workplace violence and sleep problems.

Objectives

The aim of this review was to systematically review studies on the association between workplace violence (WV) and sleep problems (SPs), and to evaluate the prevalence of the latter in workers exposed to violence. Other objectives were to calculate the odds ratio for meta-analysis and to identify in published studies the occupational factors affecting the association between violence and sleep problems so that preventive measures could be taken.

Research Question

The questions posed by this research are: Is occupational violence associated with sleep problems? Which neurophysiological mechanisms can explain this type of association?

METHODS

Study Design

Systematic review and meta-analysis.

Participants, Interventions, Comparators, Outcome (PICO)

P: workers. I: exposure to workplace violence. C: workers not experiencing violence at work. O: sleep problems.

Systematic Review Protocol

The study protocol of this research was registered on PROSPERO, on February 9, 2019, with the following registration number: CRD42019124903.

Search Strategy

A systematic search of the literature was carried out, between March and April 2019, on PubMed/MEDLINE, Scopus, Sociological abstract, DOAJ, Web of Science, and Google Scholar databases in accordance with the "Preferred Reporting Items for Systematic reviews and Meta-Analyses" (PRISMA)

guidelines. To define the terms PICO, according to evidence based practice (Rathbone et al., 2017; FGCU Library, 2019), our search initially started by using only one or two PICO elements in combination. Once few relevant studies were found, the database's bibliographic references were examined and the search was refined using subject headings or keywords for searching for similar relevant articles. A comparison of the keywords chosen for this review with those used by studies on similar topics (Nielsen et al., 2018) was carried out. Keyword checking was performed by five authors independently, without the help of external experts. The electronic search strategy for PubMed used keywords related to the topic under investigation (workplace violence OR workplace bullying OR workplace sexual harassment) in conjunction with sleep quality or quantity and their synonyms (sleep OR sleep quality OR sleep quantity), properly combined by Boolean operators. The PICOS was adapted to the other databases. Only original studies with English abstracts and keywords, with a text written both in English and Italian were retrieved, with no limits of years considered. Data from gray literature were not included. Although review studies and commentaries were excluded from the present review, additional eligible studies were included after a hand-search of their reference lists.

Data Sources, Studies Sections, and Data Extraction

The principal criterion for eligibility was the presence of occupational violence and sleep problems. All studies that took into consideration any type of violence at work or that indicated the presence of any type of sleep problem were included, while studies on WV that failed to provide any information on sleep were excluded. Similarly, studies that reported violence, bullying, or harassment of a non-occupational type (e.g., war violence, disasters, and non-occupational accidents) were excluded. Moreover, studies on violence and bullying in young people (e.g., bullying at school) or in family, and studies on epigenetic determinants of violence were excluded. All the papers that mentioned sleep problems among the observed effects of WV were included. Both quantitative and semi-quantitative studies with cross-sectional, retrospective, case-control, and prospective design were screened for inclusion. Second level studies (review studies) were excluded, although they were examined in order to identify further research to be included in this review.

After independently reviewing all titles/abstracts to identify potentially relevant articles, two authors (NM and FC) used the aforementioned inclusion/exclusion criteria to select studies on the basis of a full-text review. Disagreements were resolved by discussion with a third author (SG), who acted as the final referee. The selected studies that met the pre-defined inclusion/exclusion criteria and were related to the topic of interest were included in our systematic review. These studies were then examined to ensure that they fulfilled specific meta-analysis criteria. Papers that failed to provide sufficient data for the calculation of odds ratios with 95% confidence intervals were excluded. The authors computed the correct parameters for a number of articles.

Data concerning the country of study, job type, the type of WV, the method of measurement and the recall period, the type of sleep problem and, when applicable, the WV and sleep problem prevalence rate were extracted from each study. The relative risk (RR) or the odds ratio (OR) were also extracted when available. The authors carried out the data extraction process independently. The results of the studies were analyzed qualitatively, and when possible, also quantitatively for meta-analysis. The findings obtained were discussed by all the authors. **Figure 1** illustrates the paper extraction flow diagram for this systematic review and meta-analysis.

Study Quality Assessment

The quality of cohort and case-control studies was assessed by the Newcastle-Ottawa Scale (NOS) that evaluates selection, comparability and exposure criteria, attributing a maximum score of 9 points (Deeks et al., 2003; Wells et al., 2012). The quality of other studies was assessed using an adapted version of the Newcastle-Ottawa Quality Assessment Scale (NOS-A) for Case-Control/Cross-sectional studies (Modesti et al., 2016) that awards a maximum score of 10 points.

Quantitative Data Synthesis

A recent systematic review of studies on workplace bullying concluded that research methods were too heterogeneous to enable meta-analysis to be performed (Linton et al., 2015). Bearing in mind this limitation and the considerable heterogeneity (different types of violence at work and various sleep problems) of the studies retrieved, an attempt was made to carry out a meta-analysis of the latter.

Statistical analysis on the relationships between WV and sleep problems based on odds ratios was used for the meta-analysis. Due to divergence in study designs, methods of data collection, and adjustment of the results, findings for this meta-analysis were reported according to a random-effects model (Clarke et al., 2010). The consistency of the results was tested by the heterogeneity indicator, I-squared (I^2) statistic, with I^2 of 25, 50, and 75% corresponding to a small, medium, and large degree of heterogeneity, respectively (Borenstein et al., 2011). Furthermore, the publication bias of the five effect sizes was tested by visual inspection, according to which an asymmetric shape in the funnel plots implied the existence of publication bias (Duval and Tweedie, 2000). The quality of evidence was assessed, with reference to the GRADE guidelines (Balshem et al., 2011). Analyses were performed with Review Manager 5.3 (RevMan5), Cochrane Community.

RESULTS

Research on databases resulted in a total of 749 studies. After the removal of duplicates and studies that failed to meet the eligibility criteria, 50 full-text articles were assessed. Three studies that failed to report sleep problems among the outcomes and five studies that failed to consider violence at work as a predictor were excluded, as was a study written in Icelandic. Six studies were excluded on the grounds that they were literature reviews or methodological articles, and a further study failed

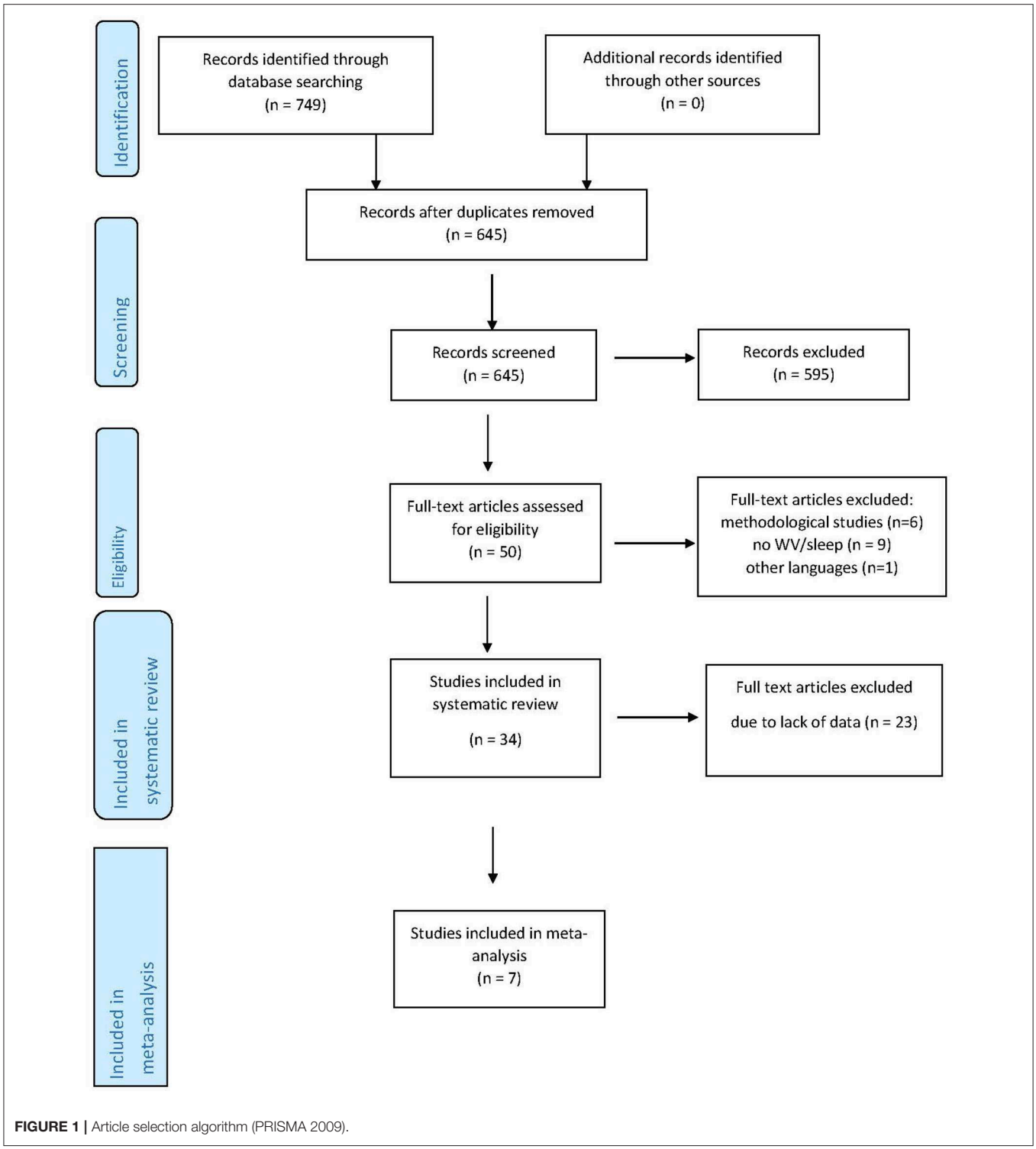

FIGURE 1 | Article selection algorithm (PRISMA 2009).

to meet the criteria as it was not conducted on workers. The final sample for systematic review consisted of 34 studies. Seven studies were included in the quantitative analysis since they contained prevalence data for calculating the odds ratio (**Figure 1**).

Study Selection and Characteristics

The studies on workplace violence and sleep problems were mainly descriptive, cross-sectional, or retrospective ($n = 23$). These included nine longitudinal cohort or prospective studies, one mixed-method research study, and one case-control study

TABLE 1 | Studies on workplace violence and sleep disorders.

References	Country	Study design	N. cases	Quality*	Type of population	Violence			Sleep			Results	Prevalence data
						Type of violence	Length of recall period	WV measure	Type of sleep problem	Length of recall period	Sleep measure		
Zahid et al., 1999	Kuwait	Cross-sectional	101	2/10	A&E doctors	Physical and verbal	n.s.	*Ad hoc*	Insomnia	n.s.	*Ad hoc*	Exposure was associated with insomnia and other symptoms	86% of the exposed doctors reported symptoms, including insomnia.
Vartia, 2001§	Finland	Cross-sectional	949	4/10	General	Bullying	12 mths	LIPT	Use of drugs	n.s.	*Ad hoc* 1 item	Exposure was associated with use of sleep-inducing drugs	Prevalence of bullying: 10%. Prevalence of use of sleep-inducing drugs among bullied: 13%
Atawneh et al., 2003	Kuwait	Cross-sectional	81	2/10	Hospital nurses	Physical and verbal	n.s.	*Ad hoc* questionnaire	sleeplessness	n.s.	*Ad hoc* 1 item.	Exposure was associated with sleeplessness	Prevalence of WV: 86%. Prevalence of sleeplessness: 73%.
Arthur et al., 2003	USA	Cross-sectional	1,131	3/10	Mental health providers	Physical and verbal	n.s.	*Ad hoc* questionnaire	Being unable to sleep	n.s.	*Ad hoc* questionnaire	Exposure was associated with insomnia	Prevalence of WV: 61%. Prevalence of sleeplessness 9.0%
Eriksen et al., 2008§	Norway	Prospective	4,471	5/9	Nurse aids	Physical and verbal	3 mths	QPSNORDIC	Sleep quality	3 mths	1 item from the BNSQ	Exposure to violence and threats was associated with poor sleep quality (OR = 1.19; 95% CI = 1.01–1.40).	Prevalence of WV, 41.08% Prevalence of "poor sleep" at baseline: 29.7%, at follow-up: 37.3%.
Niedhammer et al., 2009§	France	Cross-sectional	7,694	7/10	General	Bullying	12 mths	LIPT	Sleep disturbances	n.s.	*Ad hoc* 2 items question	Exposure was associated with sleep disturbances in men (aOR = 4.40; 95% CI = 3.35–5.78) and women (aOR = 3.83; 95% CI = 3.12–4.70)	Prevalence of bullying, 9.91% Prevalence of bullied people with sleep disturbances: 4.62%.
Takaki et al., 2010	Japan	Cross sectional	2,500	5/10	General	Bullying	6 mths	NAQ	Sleep disturbances	1 mth	PSQI	WV plays a mediating role in the relationship between job strain and sleep disturbances	Prevalence of WV: 81.2% No prevalence data on sleep problems
Rodriguez-Munoz and Notelaers, 2011	Belgium	Cross-sectional	4,068	3/10	General	Bullying	6 mths	NAQ	Sleep quality	n.s.	*Ad hoc*	Exposure was associated with poor sleep quality	No prevalence data
Lallukka et al., 2011	Finland	Prospective	7,332	5/9	General	Bullying	n.s.	*Ad hoc* 2 items question	Sleep problems	n.s.	*Ad hoc* 4 items question	Exposure was associated with sleep problems (OR = 1.69; 95% CI = 1.30–2.20 in female) (OR = 3.17; 95% CI = 1.85–5.43 in male).	Prevalence of bullying at baseline: 22.85%. Prevalence of sleep problems at baseline 20.2%; at follow-up: 24.8%.
Bambi et al., 2013	Italy	Cross-sectional	444	5/10	A&E nurses	Bullying	n.s.	*Ad hoc* questionnaire	Sleep disturbances	n.s.	*Ad hoc* questionnaire	Exposure was associated with complaints including sleep disturbances	81.6% nurses were victims of lateral hostilities No prevalence data on sleep problems

(Continued)

TABLE 1 | Continued

References	Country	Study design	N. cases	Quality*	Type of population	Violence			Sleep			Results	Prevalence data
						Type of violence	Length of recall period	WV measure	Type of sleep problem	Length of recall period	Sleep measure		
Ziemska et al., 2013§	Poland	Cross-sectional	1,096	2/10	University workers	Bullying	n.s.	*Ad hoc* questionnaire	Sleep disorders	n.s.	*Ad hoc* questionnaire	Exposure was associated with sleep disorders (OR = 3.43; 95% CI = 2.30–5.13)	Prevalence of exposure to bullying: 19.34%. Prevalence of sleep disorders: 10.94%. Prevalence of exposed people with sleep disorders: 11%
Park et al., 2013	Korea	Cross-sectional	10,039	7/10	General	Physical, verbal, and sexual	12 mths	*Ad hoc* questionnaire	Sleep problems	n.s.	*Ad hoc* 1 item question	Exposure to physical (aOR = 1.98; 95% CI = 1.06–3.68) or sexual violence (aOR = 3.47; 95% CI = 1.77–6.81), was associated with sleep problems	Prevalence of WV 6.9% Prevalence of sleep problems 5.1% (95% CI = 4.7–5.5%).
Slopen and Williams, 2014	USA	Cross-sectional	2,983	7/10	General	Verbal (discrimination).	n.s.	Perceived Racism Scale, adapted	Sleep duration and difficulties	4 wks	*Ad hoc* 3 items question.	Exposure to workplace harassment was associated with shorter sleep duration (B = −0.09) and sleep difficulties (B = 0.04)	No prevalence data
Tutenges et al., 2015	Denmark	Cross-sectional	151	2/10	Bouncers	Physical and verbal	n.s.	*Ad hoc* questionnaire	Trouble sleeping	12 mths	*Ad hoc* 1 item question	Exposure was associated with sleep problems	Prevalence of WV 96%. Prevalence of sleeping problems 50.4%
Miranda et al., 2014	USA	Prospective	344	5/9	Home Care	Physical assaults	3 mths	*Ad hoc* questionnaire	Pain interference with sleep	n.s.	*Ad hoc* 1 item question	Exposure was associated with pain interfering with sleep at baseline (aPR = 1.8; 95% CI = 1.2–2.6) and at 2-year follow-up (PR = 2.2; 95% CI = 1.5–3.0)	Prevalence of WV: 55% at baseline, 25% in all three periods ("persistent violence"). Pain interfering with sleep at baseline: 42% and in 3 surveys: 41%.
Kostev et al., 2014§	Germany	Case-control	2,625	5/9	General	Mthbbing	n.s.	*Ad hoc*	Sleep disorder (ICD-10)	12 mths	*Ad hoc*	Exposure was associated with sleep disorders (OR = 2.4, $p < 0.05$)	Prevalence of sleep disorders: 13.3% in workers reporting mobbing, 5.1% in workers without mobbing.
Min et al., 2014	Korea	Cross-sectional	7,007	6/10	General	Verbal & sexual	12 mths	*Ad hoc* 1 item question	Sleeping problems	n.s.	*Ad hoc* 1 item question	Exposure was associated with sleeping problems (male: PR = 2.3; 95%; CI = 1.7–3.2; female: 3.0; 95% CI = 1.9–4.7).	Prevalence of WV 7.2%. Prevalence of sleep problems: 5.12% (male: 6%, female: 4.3%)
Ovayolu et al., 2014	Turkey	Cross-sectional	260	2/10	Hospital Nurses	Bullying	n.s.	*Ad hoc* questionaire	Sleep disorders	n.s.	*Ad hoc*	Exposure was associated with sleep disorders	Prevalence of workplace bullying: 3.1%. Prevalence of health or sleeping problems: 66.2%.

(Continued)

TABLE 1 | Continued

References	Country	Study design	N. cases	Quality*	Type of population	Violence			Sleep			Results	Prevalence data
						Type of violence	Length of recall period	WV measure	Type of sleep problem	Length of recall period	Sleep measure		
Hansen et al., 2014	Denmark	Prospective	2,919	5/9	General	Bullying	n.s.	*Ad hoc* questionaire	Sleep problems	3 monnths	KSQ	Exposure was associated with poor sleep quality (3.56; 95% CI = 1.09;11.59)	Prevalence of bullying 12.16% No prevalence data on sleep problems
Hanson et al., 2015	USA	Cross-sectional	1,214	5/10	Home Care	Physical, verbal, and sexual	12 mths	*Ad hoc* questionaire	General sleeping troubles	n.s.	1 item from COPSOQ	Exposure was associated with sleep problems	Prevalence of WV: 61.3%. No prevalence data on sleep problems
Magee et al., 2015	Australia	Cross-sectional	1,454	6/10	General	Bullying	6 mths	NAQ	Sleep quality	1 mth	PSQI	Dose-response relationship between the number of WV episodes and sleep quality.	Prevalence of frequent bullying: 8.4%. No prevalence data on sleep problems
Bonde et al., 2016§	Denmark	Prospective	7,502	4/9	General	Bullying	n.s.	*Ad hoc* 1 item question	Sleep quality	3 mths	KSQ	Bullying at baseline significantly predicted sleep disturbance (ORa = 1.29; 95% CI = 0.9–1.7)	Prevalence of bullying, baseline 7.4% Prevalence of sleep problems, baseline 10.3% Prevalence of sleep problems in bullied people 15.5%
Yoo et al., 2016§	Korea	Cross-sectional	25,138	3/10	General	Physical, verbal, and sexual	1 mth	*Ad hoc* questionaire	Sleep disturbances	12 mths	*Ad hoc* 1 item question	WV was associated with sleep disturbance (OR = 3.773; 95% CI = 3.058–4.655). Lateral violence was associated with sleep disturbances (OR = 5.688; 95% CI = 4.189–7.723)	Prevalence of WV 6.0% Prevalence of sleep disturbance: 2.4%
Nabe-Nielsen et al., 2016	Denmark	Prospective	7,650	5/9	General	Bullying, unwanted sexual attention	n.s.	*Ad hoc* questionaire	Disturbed sleep	3 mths	KSQ	Disturbed sleep mediated 12.8% (95% CI = 8.1–19.8) of the association between bullying and long-term sickness absence, and 8.5% (95% CI = −0.45 to 37.1) of the association between unwanted sexual attention and long-term sickness absence	Prevalence of bullying varies across studies (WHB, 2006 and 2008; PRISME, 2007 and 2009): from 5 to 10% and unwanted sexual attention from 1 to 4%. No prevalence data on sleep problems
Hansen et al., 2016	Denmark	Prospective	3,278	5/9	General	Bullying	n.s.	*Ad hoc* 1 item question	Sleep problems	3 mths	KSQ	Exposure at baseline was associated with early awakening (β = 0.06; 95% CI = 0.01–0.11) and lack of restful sleep (β = 0.07; 95% CI = 0.02–0.11) at follow-up.	Prevalence of bullying 9.20% No prevalence data on sleep problems

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TABLE 1 | Continued

References	Country	Study design	N. cases	Quality*	Type of population	Violence			Sleep			Results	Prevalence data
						Type of violence	Length of recall period	WV measure	Type of sleep problem	Length of recall period	Sleep measure		
Pitney et al., 2016	USA	Mixed-methods.	567	6/10	Athletic trainers	Bullying	6 mths	NAQ	Sleep disturbances	n.s.	SSI	Exposure was associated with sleep disturbances	Prevalence of bullying: 7.8%. No prevalence data on sleep problems.
Vedaa et al., 2016	Norway	Prospective	799	4/9	Shift working nurses	Bullying	6 mths	NAQ	Sleep problems	1 mth	BIS	Exposure predicted increased symptoms of insomnia over time.	No prevalence data
Acquadro Maran et al., 2017	Italy	Cross-sectional	1,842	4/10	Hospital	Stalking	n.s.	Stalking Questionnaire	Sleep disorders	n.s.	*Ad hoc* 1 item question	Stalking was significantly associated with sleep disorder.	Prevalence of stalking 13.9%. Prevalence of sleep disorders among victims of stalking: 50.7%
Gluschkoff et al., 2017	Finland	Prospective	4,988	5/9	Teachers	Physical and verbal	n.s.	*Ad hoc* 1 item question	Sleep disturbances	4 wks	JSPS	Exposure was associated with an increased rate of sleep disorders (RR = 1.32; 95% CI = 1.15–1.52).	Prevalence of WV: 33% No prevalence data on sleep problems
Sun et al., 2017	China	Cross-sectional	3,016	3/10	Hospital	Physical, verbal and sexual	n.s.	*Ad hoc* questionaire	Sleep quality	n.s.	*Ad hoc* 1 item question	Exposure was negatively correlated with sleep quality ($r = -0.281$, $p < 0.001$)	Prevalence of WV: 83.4%. No prevalence data on sleep problems.
Pekurinen et al., 2017	Finland	Cross-sectional	5,228	5/10	Nurses	Physical and verbal	12 mths	*Ad hoc* 1 item question	Sleep disturbances	4 wks	JSPS	Psychiatric nurses who experienced WV were less likely to suffer from sleep disturbances compared to nurses working in medical, surgical and emergency settings (OR = 0.65, $p = 0.007$ and OR = 0.39, $p < 0.001$).	Prevalence of exposure to aggression by patients: 41%. Prevalence of sleep disturbances: 49%.
Zhang et al., 2018	China	Cross-sectional	1,024	2/10	Nurses	Physical, verbal and sexual	12 mths	*Ad hoc* 1 item question	Sleep quality	n.s.	*Ad hoc* 1 item question	WV exposure was negatively associated with sleep quality ($r = -0.194$, $p < 0.01$) Psychological stress was a mediator in the relationship between violence and sleep quality.	Prevalence of WV: 75.4%. No prevalence data on sleep problems.
Karhula et al., 2018	Finland	Cross-sectional	9,312	5/10	Nurses	Physical and verbal	12 mths	*Ad hoc* questions	Sleep difficulties	4 wks	*Ad hoc* 1 item question	Permanent night workers reported difficulties in falling asleep more often than day and shift workers, but reported difficulties in maintaining sleep less often than other colleagues	Prevalence of WV: 53.90 Prevalence of insufficient sleep: 24.18%

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TABLE 1 | Continued

References	Country	Study design	N. cases	Quality*	Type of population	Violence			Sleep			Results	Prevalence data
						Type of violence	Length of recall period	WV measure	Type of sleep problem	Length of recall period	Sleep measure		
Thurston et al., 2019	USA	Cross-sectional	304	5/10	General, women	Sexual harassment and assault	Longlife	BTQ	Sleep quality	1 mth	PSQI	Exposure to Sexual Harassment was associated with poor sleep (aOR = 1.89; 95% CI = 1.05–3.42). Exposure to Sexual assault was associated with poor sleep (aOR = 2.15; 95% CI = 1.23–3.77)	Prevalence of sexual harassment: 19%. Prevalence of sexual assault: 22%. No prevalence data on sleep problems

A&E, Accidents and Emergency; n.s., not specified; mths, months; wks, weeks; LIPT, Leymann Inventory of Psychological Terror; NAQ, Negative Acts Questionnaire; BTQ, Brief Trauma Questionnaire; QPSNORDIC, General Nordic questionnaire for psychological and social factors at work; JSPS, Jenkins Sleep Problems Scale; KSQ, Karolinska Sleep Questionnaire; BIS, Bergen Insomnia Scale; PSQI, Pittsburgh Sleep Questionnaire Index; BNSQ, Basic Nordic Sleep Questionnaire; SSI, Semi-structured interviews.

(*): Newcastle-Ottawa Quality Assessment Form for Cohort studies score (maximum score = 9) and Newcastle-Ottawa Quality Assessment Scale for Case-Control/Cross-sectional studies score (maximum score = 10).

(§) Selected for meta-analysis.

(**Table 1**). It should be noted that in all studies the experience of violence was related to a previous period and that sleep problems continued over time. Consequently, cross-sectional studies always had a retrospective approach, and prospective studies were generally organized as repeated cross-sectional studies. The distinction between the two types of epidemiological design was often blurred. For example, the study by Thurston et al. (2019), was described by the authors as "a prospective cohort study" although it was a cross-sectional study with retrospective reporting of violent experiences.

According to our evaluation, the prospective studies had a moderate to low quality score (ranging from 4 to 5 on the 9-point NOS scale, and from 2 to 7 on the 10-point NOS-A scale). Overall, the 10 cohort or case-control studies had an average score of 4.8 on 9 points on the NOS scale, the other 24 studies an average score of 4.2 points out of 10 of the NOS-A scale.

The selected studies had been conducted in the USA (Cousins and Fernández, 2019), Finland (Massar et al., 2019), Denmark (Massar et al., 2019), Korea (Hudson et al., 2019), Norway (Garbarino et al., 2016c), China (Garbarino et al., 2016c), Italy (Garbarino et al., 2016c), Kuwait (Garbarino et al., 2016c), France, Japan, Belgium, Poland, Germany, Turkey, and Australia, and involved a total of 119,361 workers.

The risk factors taken into consideration were: workplace bullying (13 studies), bullying and unwanted sexual attention (2 studies), mobbing (1 study), physical and verbal violence (8 studies), physical, verbal, and sexual violence (5 studies). Other studies considered physical assaults, verbal discrimination, verbal and sexual harassment, stalking, sexual harassment, and assaults as the independent variable. The experience of violence was analyzed retrospectively, generally by means of questionnaires, with a reference period that varied from 1 to 12 months. Some studies failed to indicate the length of the recall period.

Most studies (21 studies) investigated a general type of working population or focused on health care workers and social services (14 studies), although a few studies considered other populations (bouncers, athletic trainers, teachers, university workers).

Outcomes were described as "sleep problems" in 6 studies; "sleep disturbances" or "disturbed sleep" in 7 studies; "interference with sleep due to pain" in 1 study; "poor sleep quality" in 8 studies; "sleep difficulties" or similar terms in 7 studies; "sleep disorders" in 4 studies (explicit reference was made to ICD-10 in only one study), and "use of sleep-inducing drugs and sedatives" in 1 study. The sleep problems referred to a period ranging from 4 weeks to 12 months prior to the survey.

Finding 1: Relationship Between WV and Sleep Problems

The first report of an association between WV and insomnia was published by Zahid et al. (1999). This was followed by further sporadic reports on this relationship (Vartia, 2001; Arthur et al., 2003). A more recent short-time longitudinal study by Eriksen et al. (2008) included WV among predictors of poor sleep quality in Norwegian nursing assistants and estimated a small

increase in the risk (OR = 1.19; 95% CI = 1.01–1.40), whereas the retrospective French study conducted by Niedhammer et al. (2009) suggested that WV exposure could quadruple the risk of sleep problems (SPs).

Studies on violence and SPs have often focused on health care workers who are frequently subjected to physical attacks and verbal aggression (Magnavita and Heponiemi, 2012). These two conditions (being physically assaulted or threatened by patients/visitors, or being mistreated by superiors and colleagues) do not have the same effect on health. The literature indicates that lateral violence, which is less frequent than physical aggression from patients or visitors, seems to result in more severe health-related outcomes (Reknes et al., 2017), especially in younger and inexperienced workers (Magnavita and Heponiemi, 2011). In our review, the harmful effect of violence perpetrated by colleagues was confirmed in a study conducted in five hospitals in the Italian Region of Tuscany. Lateral hostilities among emergency and critical care nurses have been associated with SPs in victims (Bambi et al., 2013), and the same phenomenon has been observed in Turkish hospital nurses (Ovayolu et al., 2014). Lateral violence was among the predictors of insomnia in a longitudinal study on Norwegian shift nurses (Vedaa et al., 2016) and in many studies that focused specifically on workplace bullying (Lallukka et al., 2011; Rodriguez-Munoz and Notelaers, 2011; Ziemska et al., 2013; Hansen et al., 2014, 2016; Kostev et al., 2014; Magee et al., 2015; Bonde et al., 2016; Pitney et al., 2016).

The association between WV and SPs in health care workers has been corroborated by studies carried out in various parts of the world. A cross-sectional study conducted across eight provinces in China demonstrated that exposure to WV significantly affected the sleep quality of employees. Distressed workers manifested the most apparent impairment (Zhang et al., 2018). Another study on Chinese doctors revealed that exposure to WV significantly affected sleep quality and self-reported level of health (Sun et al., 2017). In 50 Japanese companies, workers exposed to violence had a higher rate of SPs and depression than non-exposed employees (Takaki et al., 2010). Data from the 4th Korean Working Conditions Survey indicated that WV was a factor affecting SPs (OR = 3.773; 95% CI = 3.058–4.655). The same study found that SPs were reported more frequently when the perpetrator was a colleague or boss (OR = 5.688; 95% CI = 4.189–7.723) rather than a client (OR = 2.992; 95% CI = 2.301–3.890; Yoo et al., 2016).

Similar data have been obtained from studies conducted in Western countries. Female homecare workers in Oregon reported a high frequency of physical assaults significantly associated with SPs (Hanson et al., 2015). Discrimination, workplace harassment, and incivilities were associated with shorter sleep duration and sleep difficulties in black, Hispanic, and white American adults (Slopen and Williams, 2014). Workplace bullying was strongly associated with SPs in the French working population, with an increased adjusted odds ratio in both men (aOR = 4.40; 95% CI = 3.35–5.78) and women (aOR = 3.83; 95% CI = 3.12–4.70; Niedhammer et al., 2009). A Danish longitudinal study showed that bullied subjects reported more SPs than those who were neither bullied nor witnesses to bullying at baseline (Hansen et al., 2014). A further Danish study on public and private office employees observed that poor sleep is among the health correlates of bullying (Bonde et al., 2016). The PRISME cohort study conducted in Denmark found that workplace bullying at baseline was associated with awakening problems and lack of restful sleep at follow-up, but not with overall SPs and disturbed sleep (Hansen et al., 2016). Bullying at work was associated with sleep disorders in Polish university workers (Ziemska et al., 2013). A Finnish Public Sector survey indicated that exposure to WV was associated with an increase in disturbed sleep (RR = 1.32; 95% CI = 1.15–1.52) that persisted also after exposure (RR = 1.26; 95% CI = 1.07–1.48; Gluschkoff et al., 2017). The Helsinki Health Study revealed that workers exposed to bullying at baseline reported SPs at follow-up (Lallukka et al., 2011). Workplace sexual harassment and sexual assaults have been associated with SPs in many studies (Zahid et al., 1999; Park et al., 2013; Ziemska et al., 2013; Hanson et al., 2015; Nabe-Nielsen et al., 2016; Yoo et al., 2016). Type 4 violence (e.g., stalking in the workplace), perpetrated by people who have a relationship with the worker, but not with the workplace (Magnavita and Magnavita, 2007), can also heavily interfere with sleep. Continual aggression on the part of the stalker leads to both physical and emotional effects in victims, the most frequent of which are sleep disorders (Acquadro Maran et al., 2017).

Finding 2: Factors Affecting the Association of WV With SP

Researchers have sought to identify the occupational factors that may mediate the association of WV with SPs. Due to its well-known interference with biorhythms, night shift work was the first factor to be taken into consideration. In this review, researchers hypothesize that permanent night work, or alternating shifts that also include night work, are more harmful to sleep than daytime work. However, studies from the Finnish Public Sector database demonstrated that permanent night workers manifest inconsistent differences in sleep quality compared to day and shift workers. Since a slightly longer average length of sleep, fewer problems in maintaining sleep, and more difficulties in falling asleep were observed in night workers, the authors concluded that the type of shift alone cannot explain the association between WV and SPs (Karhula et al., 2018).

The relationship between WV and SPs in health care workers is complex and undoubtedly involves many factors such as the type of work performed, the relationship with patients, the level of worker engagement, the organization of work, the level of social support, and staff cohesion, all of which greatly influence the resilience of workers (Magnavita and Fileni, 2012; Magnavita, 2017). Interestingly, our review included a Finnish study that demonstrates that psychiatric nurses exposed to violence maintain better psychiatric well-being and experience fewer SPs than non-psychiatric nurses with a similar exposure (Pekurinen et al., 2017). These complex associations between WV, SPs, and work organization are observed not only in health care employees, but also in all types of workers. The findings of the Korean Working Conditions Survey indicated that workers exposed to workplace injustice (e.g., discrimination, harassment, or violence) had an ∼2- to 3-fold increased risk for SPs (Min

et al., 2014). In these workers, the frequency of work-related SPs was 5.1%. WV and the threat of violence were significantly associated with SPs in another Korean study (Park et al., 2013). Other studies showed that psychological stress can act as a partial mediator in the relationship between violence and sleep quality (Zhang et al., 2018), while organizational justice may have a protective effect (Gluschkoff et al., 2017).

Our review indicated that SPs were not always the main outcome of studies, but merely one of the symptoms associated with violence or resulting from it. In most cases, researchers reported psychiatric disorders such as anxiety, depression or burnout, or other parameters, such as sick leave or musculoskeletal disorders as outcome variables. In more recent studies, SPs were reported as a collateral factor that plays a moderating role in the relationship between the main variables. For example, studies on absenteeism showed that disturbed sleep and awakening difficulties mediated the association between bullying and long-term sickness absence (Nabe-Nielsen et al., 2016). Studies on clinical nursing home workers in Massachusetts showed that both musculoskeletal pain (Miranda et al., 2011) and sleep disorders (Miranda et al., 2014) increased in assaulted workers.

Finding 3: Prevalence of SPs in Workers Experiencing Violence

In the studies selected, different types of WV were considered to be a causal factor. Some studies took into consideration only type 2, type 3, or type 4 violence, while some considered only physical or moral violence, and others focused on sexual violence. This heterogeneity may explain why WV prevalence ranges so widely from 3 to 96% in these studies. It follows that the overall prevalence of SPs in exposed workers also falls within a very large range extending from less than 5% (Yoo et al., 2016) to nearly 50% (Tutenges et al., 2015; Pekurinen et al., 2017). Although all the authors reported a high prevalence of SPs in workers exposed to violence, a number of researchers failed to make a comparison with non-exposed workers.

Some difficulty was encountered in comparing prevalence rates on account of the diversity of methods used to measure SPs. Using an *ad hoc* questionnaire, Atawneh et al. (2003) calculated the prevalence of insomnia in hospital nurses exposed to WV to be 73%, while a different *ad hoc* questionnaire administered by Arthur et al. (2003) indicated a 9.0% rate among mental health workers. According to Niedhammer et al. (2009), bullied subjects had a 4.6% rate of SPs, while Ziemska et al. (2013) found the rate to be 11%, and Bonde et al. (2016) reported a rate of 15%. In a study conducted by Vartia (2001), 13% of bullied workers were taking sleep-inducing drugs, while Acquadro Maran et al. (2017) observed that more than 50% of subjects exposed to workplace stalking had sleep disorders.

Finding 4: Meta-Analysis

Our meta-analysis included 7 studies that published the data needed to calculate odds ratios. Of these, the study of Bonde et al. (2016) presented a repeated cross-sectional design, with measurements at baseline and at 2 and 4 years. Since these three measurements were considered to be different studies, a total of 9 studies were obtained.

The quality of the studies included in the meta-analysis ranged from 2/10 (Ziemska et al., 2013) to 7/10 (Niedhammer et al., 2009). The average quality of prospective or case-control studies included in meta-analysis was 4.7 out of 9, that of the other studies 4 points out of 10. All studies were observational. Most cases involved a general population, although one study focused on nursing assistants and another regarded university employees. Bullying was the principal type of violence, although one case involved mobbing, another physical and verbal violence, and one further study concerned physical, verbal and sexual violence. The length of recall periods for WV varied: 1 month (one study), 3 months (one study), and 12 months (two studies). All the other studies failed to specify the recall period. The length of recall periods for SPs was 3 months (two studies) or 12 months (two studies), while other studies failed to specify these data.

The overall odds ratio of WV and SPs was 2.55 (95% CI: 1.77–3.66). A highly significant overall level of significance ($p < 0.001$) was found for the meta-analysis, and a high degree of heterogeneity ($I^2 = 96\%$, $p < 0.001$) was observed among the studies selected (**Figure 2**).

As usual in the workplace, no study was a randomized trial. A single study (Yoo et al., 2016) alone included about half of the observed sample. Since this was also the study that reported the lowest level of quality, this certainly reduces the reliability of the estimate. However, it is easy to see that all studies lead to similar results and that confidence intervals are not too wide.

The asymmetric funnel plot (**Figure 3**) indicated the presence of publication bias. In systematic reviews that select studies published in English, the exclusion of studies written in other languages leads to an obvious risk of bias. On the other hand, in reviews that include studies written in other languages, there is the risk of overestimating the contribution of the national literature. In this review, as only one study out of 34 was written in Italian, language bias can be considered negligible.

Overall, the studies agree that WV is associated with SPs, but the evidence of the strength of this association is low, due to inconsistency arising from methodological heterogeneity, low quality of studies and risk of bias.

DISCUSSION

The literature reviewed by the authors indicates, with low evidence, that WV is associated with an increased risk of SPs. All the studies included in this systematic review are concordant in reporting that workers exposed to violence manifest problems related both to the quantity of sleep (e.g., sleep loss) and the quality of sleep, i.e., difficulty in falling asleep, frequent interruptions, early awakenings, insomnia, nightmares. Different types of violence do not all result in the same degree of harmfulness. Verbal violence perpetrated by colleagues and superiors, known as lateral violence or bullying, appears to be the most harmful type. A consistently high prevalence of SPs in workers exposed to violence was found in the studies surveyed, and the risk for subjects who had experienced violence was

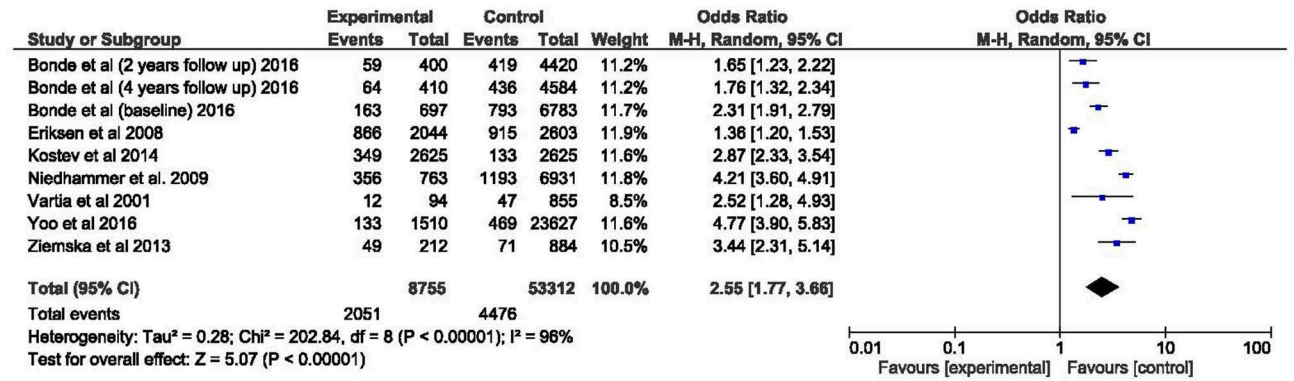

FIGURE 2 | Meta-analysis of the association of workplace violence and sleep problems. Forest plot.

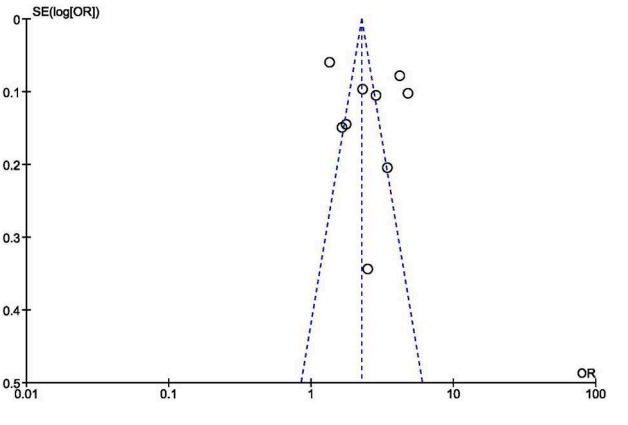

FIGURE 3 | Meta-analysis of the association of workplace violence and sleep problems. Funnel plot.

significantly higher than for other workers. The meta-analysis yielded a pooled odds ratio of >2.5 for subjects exposed to violence compared to other workers, although this estimate is limited on account of the great heterogeneity of the studies.

Study disparities were mainly due to the type of violence investigated and the length of the recall period. The authors investigated different periods with consequent variations in the degree of accuracy, since increasing the recall period provides more information but increases the likelihood of recall error. Moreover, since WV was investigated in a retrospective way in all the studies, when interpreting the results, the authors often attributed a causal role to the experience of violence, in some cases without ascertaining whether the same SPs were present also in subjects who had not undergone violence. A considerable disparity was also present in the definition of SPs; in fact, only one research group provided the definition of "sleep disorder" as envisaged by ICD-10. All other researchers defined the outcome in different ways, using generic terms such as sleep disturbances, difficulties, troubles, problems, and poor quality. Only a few studies used standardized questionnaires to define violence or sleep, while most researchers developed *ad hoc* questionnaires, sometimes composed of a single question. The quality of studies, assessed by the NOS and NOS-A scales, was not sufficiently high. It is well-known that information contained in published articles does not always ensure a perfect evaluation of the quality of the work; indeed, it has been shown that referees tend to overestimate quality. A methodological review that compared the assessments of reviewers and authors demonstrated that the overall NOS score in the assessments made by reviewers was significantly higher than those made by authors (Lo et al., 2014). This review found that the overall quality of the studies selected was poor and that the latter together with the marked heterogeneity constituted the main limitations. Our review puts forward the idea that violence should be systematically identified in the workplace and that further research should study the effect of WV on sleep, since alterations in sleep may be a predictor of occupational impairment, with relevant consequences on workers' safety and health.

Our findings confirm and extend what has been shown in previous review studies. A review of the research conducted in Latin American countries underlined the association between WV and SPs, without being able to quantify the association, since the studies were descriptive, with insufficient analytical nature (Ansoleaga et al., 2015). In 2013, the Swedish Council on Health Technology Assessment (SBU) concluded that people who experience bullying at work also have more sleep disturbances than those who are not subjected to such exposure at work (SBU, 2013). Our study has expanded this statement, indicating that non-bullying forms of violence are also associated with SPs. An interesting review of the literature aimed at identifying future SPs in workers exposed to various psychosocial risk factors has been conducted in 2015 within the framework of the SBU (Linton et al., 2015). The authors identified 24 studies, only two of which had studied prospectively the relationship between bullying and SPs. Authors concluded that many psychosocial work factors have an impact on SPs, and this might be utilized in the clinic as well as for planning work environments. We confirm this statement and are confident that future, well-designed studies, will help in elucidating the relationships between WV and SPs, clarifying the underlying mechanisms.

Neurophysiological Mechanisms

The studies included in this systematic review do not address the issue of neurophysiological mechanisms activated by WV. However, these mechanisms can be hypothesized on the basis of current neurophysiological literature. WV could be considered and experienced as a stressful life event. The significant individual differences in the consequences of stress exposure highlight the moderating influence of endogenous psychophysiological vulnerabilities (Rosenthal, 1970). Epigenetic regulation is essential for neural and brain functioning, and putative epi-mutations may play a role in the etiopathogenesis of many sleep and psychiatric diseases (Agorastos et al., 2019). Maintenance of DNA methylation and histone modifications is crucial for normal neurodevelopment and functioning of the brain (Ptak and Petronis, 2010). The stress response is highly complex, as can clearly be seen by the fact that identical stressors of equal strength elicit different reactions in different individuals. It is well-known that a stressful event (cognitive, physiological, etc.) can disrupt the sleep system, due to what has been described as sleep reactivity (Drake et al., 2014). Sleep reactivity plays a key aetiological role in vulnerability to insomnia and possibly other SPs. Physiologically and cognitive-emotionally induced hyper-arousal can interfere with sleep in a subset of the population (Kalmbach et al., 2018b) that is prone to experiencing excessively strong sleep responses to a wide range of environmental (workplace and work organization) and psychosocial stressors such as WV. Responses to WV that are related to sleep reactivity may be neurobiologically supported in autonomic dysregulation with parasympathetic activity as a potential autonomic marker of SPs. Persistent symptoms of hyper-arousal (not present before WV) include difficulty falling or staying asleep, irritability or outbursts of anger, difficulty concentrating, hypervigilance, and extreme startle response (Kalmbach et al., 2018a). Mood and anxiety disorders commonly co-occur with SP, resulting in more severe clinical impairment than does either disorder alone. Indeed, SP is a core feature of both depression and anxiety disorders (Motomura et al., 2013; Goldstein-Piekarski et al., 2019).

The basic mechanisms that link violence-related stress, SP, and neuro-psychiatric mechanisms are not fully elucidated. The default mode circuit (DMN), including the anterior medial prefrontal cortex (PFC), the posterior cingulate cortex, the angular gyrus (Greicius et al., 2009), and the negative affective circuit (NA), including amygdala, hippocampus, insula, and the dorsal and ventral portions of the PFC (Robinson et al., 2014) may play a role. DMN is genetically heritable and is observed when the brain is probed under task-free conditions, and typically when participants are instructed to reflect on their own spontaneously generated thoughts. Connectivity between nodes of the DMN and other networks implicated in mood and anxiety disorders fluctuate as a function of sleep stage. Profiles of DMN connectivity have been associated with sleep debt, fatigue, and tiredness, core features of anxiety and depression. Hypo-connectivity of the DMN and poor sleep quality are both relevant for mood and anxiety. The most compelling findings with respect to insomnia are a relative lack of deactivation of the DMN when compared to healthy controls, hyper-reactivity of the DMN in response to sleep-related stimuli, and hyper-connectivity of the DMN under task-free conditions. It has been hypothesized that the lack of disengagement may be reflective of increased self-reflective thought, rumination, and worry that may keep individuals from falling asleep. Mirroring the DMN profiles seen in insomnia, depression has been associated with over-activation and hyper-connectivity within the DMN.

The dorsal prefrontal sub-circuit has been preferentially implicated in appraisal and expression of emotion, and may be considered an "aversive amplification" sub-network of the negative affective circuits that serve to boost the processing of signals of potential threat. Complementing this function, the ventral sub-circuit has been implicated in automatic regulation of negative emotion. There is a striking overlap between the pattern of NA network dysfunction, SP, and anxiety and depression. Indeed, both hyper-reactivity of the amygdala and hypo-connectivity of medial prefrontal cortex-amygdala are theorized to contribute to the development and maintenance of emotional distress that underlies the maladaptive behaviors commonly observed in anxiety disorders, including increased negative bias, increased threat responsivity, and poor emotional regulation. Moreover, the degree of reactivity and regulation in these nodes correlates with subjective experiences of emotional distress as well as emotional behaviors (Goldstein-Piekarski et al., 2019).

SP has been shown experimentally to induce negative mood states, as well as a negative affective network profile mimicking that of anxiety and depression. The improvement of sleep quantity/quality may normalize these brain changes (Goldstein-Piekarski et al., 2019). These findings suggest that at least for some individuals, maladaptive negative affective network function may be an intermediate step between sleep disruption and anxiety and mood features, and that sleep is a modifiable target through which emotional distress can be reduced (**Figure 4**).

Long work hours, night-owl lifestyles, and extensive shift work are major contributors to sleep loss and a consequent increase in the risk for anxiety and depression (Abad and Guilleminault, 2005). Cheung et al. performed a cross-sectional observational study showing how acute occupational sleep deprivation and a frequently disrupted sleep cycle induce DNA damage and changes in antioxidant capacity (Cheung et al., 2019). These observations are concordant with findings of genotoxicity in sleep-deprived animals and elderly adults (Tenorio et al., 2013).

Therefore, ensuring an adequate amount of sleep is an important lifestyle factor that should be given greater attention to the management of mental health and WV. Sleep deprivation weakens the ability to inhibit aggression and enhances impulsivity (Kahn-Greene et al., 2006) with delay discounting, risk-taking, sensation-seeking, and a lack of behavioral response inhibition to negative emotional circumstances. The latter mediates the relationship between SPs and unwanted or context-inappropriate aggressive responses. Sleep restriction or deprivation mainly affects sleep-wake rhythms in shift and night workers, but it may also often alter or disrupt daily rhythms of activity, light exposure, eating patterns, drinking, body temperature, physiological activity, smoking,

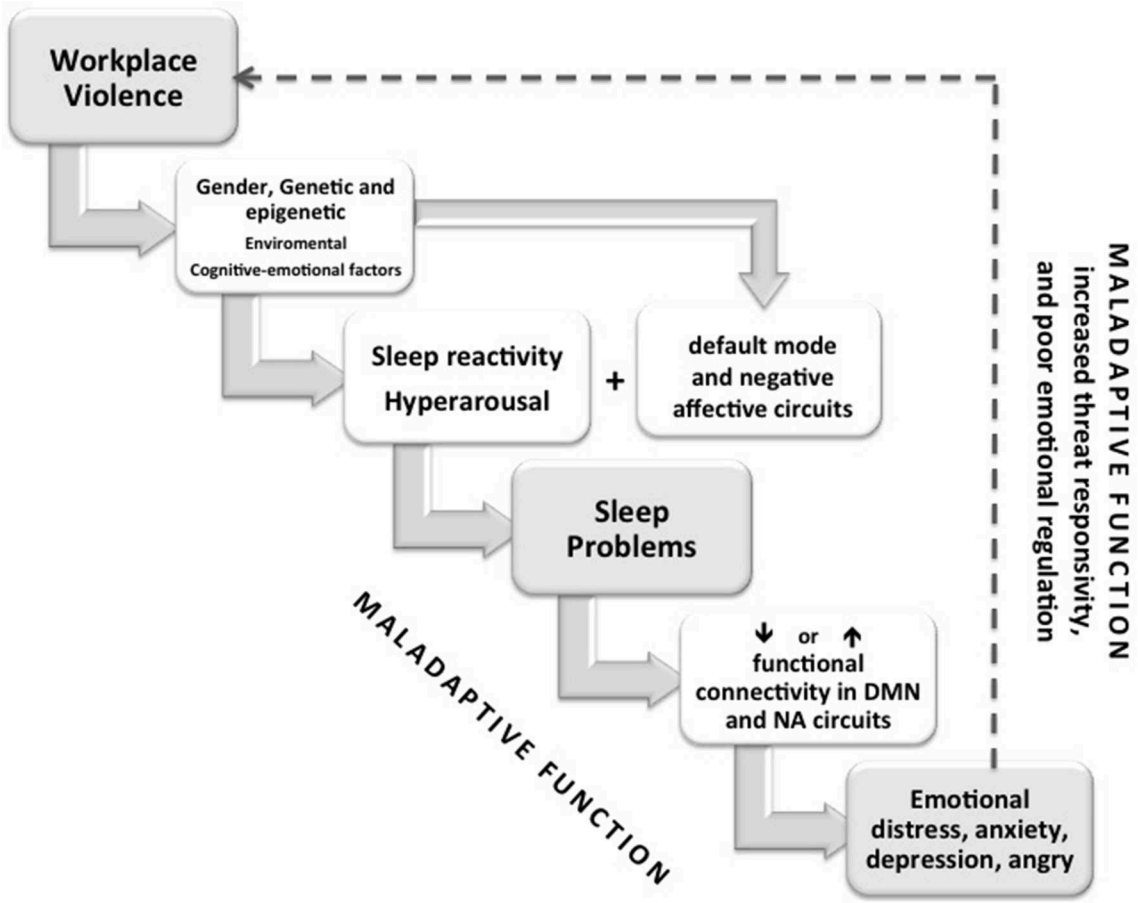

FIGURE 4 | Conceptual diagram depicting the effect of WV stress on sleep problems across individual features (gender, genetic, environmental) with sleep reactivity, hyperarousal, and the alterations of two brain circuits genetically heritable (default mode circuit—DMN and the negative affective circuits—NA). Connectivity between nodes of the DMN, NA and other networks implicated in mood and anxiety disorders fluctuate as a function of sleep stage. Different sleep problems could induce hyper-reactivity or hypo-connectivity of different nodes of circuits manly mPFC-amygdala that, in turn, contribute to the development and maintenance of emotional distress that underlies the maladaptive behaviors commonly observed in anxiety disorders, including increased negative bias, increased threat responsivity, and poor emotional regulation. Moreover, subjects with sleep problems, with a genetic predisposition and an epigenetic modification could be involved in hostile and aggressive behavior (maladaptive behaviors) at workplace for a loss of emotional control and regulation of aggression (dashed line).

and sleep-wake dependent neural and endocrine variables (Garbarino et al., 2002; Kecklund and Axelsson, 2016). These neuropathological mechanisms can partially explain a number of extreme conditions, but they do not appear to adequately interpret the long-term mechanisms by which low-grade WV alters sleep.

Almost all the studies included in our review have evaluated the potential effect of violence on both the quantity and the quality of sleep. However, very few attempts have been made to ascertain whether an inverse causality also exists between these two variables, namely that the presence of SPs promotes WV. In point of fact, violence at work can be considered a stress factor, and it is well-known that there is a close relationship between violence and stress (Chirico, 2015, 2017). Recent longitudinal studies have shown that violence and stress are in a cyclic relationship, i.e., violence increases stress in the worker, and the distressed worker is prone to violence (Magnavita, 2013a, 2014). This topic was addressed in the German Workplace Bullying and Harassment longitudinal study in which the authors evaluated the occurrence of SPs after exposure to different workplace stressors, and the reverse causation concluded that SPs might also prospectively predict subjective role stressors (Hansen et al., 2018). In this context, it is interesting to note that a case-control study reported a higher prevalence of diseases in general, and SPs in workers who had experienced mobbing (Kostev et al., 2014). However, further studies are needed to ascertain whether an inverse relationship exists between SPs and WV.

In recent years, our society has witnessed an increase in the productive and social conditions that interfere with sleep (Fischer et al., 2014). Workers are presumed to be the major victims of sleep deprivation epidemics and the 24/7 society, even if time-use studies have not always corroborated this hypothesis (Lamote de Grignon Pérez et al., 2019). Aging of the population and the workforce has also exposed older people who often

suffer from sleep disorders or have difficulty adapting their biorhythms to occupational risks (violence included; Flower et al., 2019). Furthermore, since the continual increase in violence in the workplace has recently been described as an "epidemic" (Rousseau et al., 2019), this study emphasizes the need to prevent violence in the workplace and improve sleep hygiene in workers.

Only a few countries in the world have included violence among the risks that must be prevented in the workplace and have consequently introduced appropriate health and safety regulations (Chirico et al., 2019). The quantity and quality of sleep are often not included among the occupational parameters to be monitored, and no widespread systems have been introduced for managing the risk of sleepiness at work (Costa et al., 2013; Magnavita, 2013b).

Strengths and Limitations of This Study

A limitation of this systematic review and meta-analysis of the literature on the relationship between occupational violence and sleep problems is due to the heterogeneous nature of the selected studies that are not always of the highest quality. The principal strength of our research lies in the fact that it is the first attempt to systematize the relationships between WV and SPs. The secondary objective of our study, which was to analyse the neurophysiological mechanisms underlying the association found, could only be carried out in part, because the studies surveyed did not directly address the topic. The current limitations of our knowledge on this relationship should encourage researchers to conduct further higher quality studies.

CONCLUSIONS

In conclusion, the association observed between common forms of workplace violence and changes in the sleep of a significant number of workers suggests that a concerted effort should be made to address all types of WV and to identify early alterations in workers' sleep patterns before these lead to harmful effects.

Researchers, physicians and managers share responsibility for promoting these efforts, even in countries where occupational safety and health standards do not compel the employer to prevent WV. Sleep health promotion campaigns should be introduced in conjunction with environmental, organizational and individual measures to prevent violence in the workplace.

The importance of this study lies above all in stressing that WV and SPs in workers are strongly connected. Subsequent studies may clarify to what extent particular forms of violence, for example, bullying or physical aggression, are correlated with sleep and therefore with safety and health in the workplace. Meanwhile, managers, physicians, and all stakeholders should engage in preventive measures to adequately control the phenomenon.

DATA AVAILABILITY

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

AUTHOR CONTRIBUTIONS

FC selected the studies and drafted the manuscript. NM selected the studies and revised the manuscript. IC and EL extracted data. SG evaluated the neurophysiologic data. ED performed statistical analyses.

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REFERENCES

Abad, V. C., and Guilleminault, C. (2005). Sleep and psychiatry. *Dialogues Clin. Neurosci.* 7, 291–303.

Acquadro Maran, D., Varetto, A., Zedda, M., and Franscini, M. (2017). Health care professionals as victims of stalking: characteristics of the stalking campaign, consequences, and motivation in Italy. *J. Interpers. Violence* 32, 2605–2625. doi: 10.1177/0886260515593542

Agorastos, A., Pervanidou, P., Chrousos, G. P., and Baker, D. G. (2019). Developmental trajectories of early life stress and trauma: a narrative review on neurobiological aspects beyond stress system dysregulation. *Front. Psychiatry* 10:118. doi: 10.3389/fpsyt.2019.00118

Ansoleaga, E., Gómez-Rubio, C., and Mauro, A. (2015). Workplace violence in Latin America: a review of the scientific evidence. *Vertex* 26, 444–452.

Arthur, G. L., Brende, J. O., and Quiroz, S. E. (2003). Violence: incidence and frequency of physical and psychological assaults affecting mental health providers in Georgia. *J. Gen. Psychol.* 130, 22–45. doi: 10.1080/00221300309601272

Atawneh, F. A., Zahid, M. A., Al-Sahlawi, K. S., Shahid, A. A., and Al-Farrah, M. H. (2003). Violence against nurses in hospitals: prevalence and effects. *Br. J. Nurs.* 12, 102–107. doi: 10.12968/bjon.2003.12.2.11049

Balshem, H., Helfand, M., Schünemann, H. J., Oxman, A. D., Kunz, R., Brozek, J., et al. (2011). GRADE guidelines: 3. Rating the quality of evidence. *J. Clin. Epidemiol.* 64, 401–406. doi: 10.1016/j.jclinepi.2010.07.015

Bambi, S., Becattini, G., Pronti, F., Lumini, E., and Rasero, L. (2013). Lateral hostilities among emergency and critical care nurses. Survey in five hospitals of the Tuscany Region. *Assist. Inferm. Ric.* 32, 213–222. doi: 10.1702/1381.15359

Banfi, T., Coletto, E., d'Ascanio, P., Dario, P., Menciassi, A., Faraguna, U., et al. (2019). Effects of sleep deprivation on surgeons dexterity. *Front. Neurol.* 10:595. doi: 10.3389/fneur.2019.00595

Bonde, J. P., Gullander, M., Hansen, Å. M., Grynderup, M., Persson, R., Hogh, A., et al. (2016). Health correlates of workplace bullying: a 3-wave prospective follow-up study. *Scand. J. Work Environ. Health* 42, 17–25. doi: 10.5271/sjweh.3539

Borenstein, M., Hedges, L. V., Higgins, J. P. T., and Rothstein, H. R. (2011). *Introduction to Meta-Analysis*. Chichester: Wiley.

Cheung, V., Yuen, V. M., Wong, G. T. C., and Choi, S. W. (2019). The effect of sleep deprivation and disruption on DNA damage and health of doctors. *Anaesthesia* 74, 434–440. doi: 10.1111/anae.14533

Chirico, F. (2015). La valutazione del rischio psicosociale: solo "stress lavoro-correlato" o altro? *medlav* 106, 65–66. Available online at: http://www.mattioli1885journals.com/index.php/lamedicinadellavoro/article/view/3861 (accessed September 10, 2019).

Chirico, F. (2017). The forgotten realm of the new and emerging psychosocial risk factors. *J. Occup. Health* 59, 433–435. doi: 10.1539/joh.17-0111-OP

Chirico, F., Heponiemi, T., Pavlova, M., Zaffina, S., and Magnavita, N. (2019). Psychosocial risk prevention in a global occupational health perspective. A descriptive analysis. *Int. J. Environ. Res. Public Health* 16:2470. doi: 10.3390/ijerph16142470

Clarke, P., Crawford, C., Steele, F., and Vignoles, A. (2010). *The Choice Between Fixed and Random Effects Models: Some Considerations for Educational Research*. IZA Discussion Paper No. 5287. Available online at: http://ftp.iza.org/dp5287.pdf (accessed July 15, 2019).

Costa, G., Accattoli, M. P., Garbarino, S., Magnavita, N., and Roscelli, F. (2013). I disturbi del sonno in ambito lavorativo: indirizzi di sorveglianza sanitaria, prevenzione e gestione del rischio/Sleep disorders and work: guidelines for health surveillance, risk management and prevention. *medlav*. 104, 251–266. Available online at: http://www.mattioli1885journals.com/index.php/lamedicinadellavoro/article/view/2833 (accessed September 10, 2019).

Cousins, J. N., and Fernández, G. (2019). The impact of sleep deprivation on declarative memory. *Prog. Brain Res.* 246, 27–53. doi: 10.1016/bs.pbr.2019.01.007

De Almeida, R. M., Cabral, J. C., and Narvaes, R. (2015). Behavioural, hormonal and neurobiological mechanisms of aggressive behaviour in human and nonhuman primates. *Physiol. Behav.* 143, 121–135. doi: 10.1016/j.physbeh.2015.02.053

Deeks, J. J., Dinnes, J., D'Amico, R., Sowden, A. J., Sakarovitch, C., Song, F., et al. (2003). International stroke trial collaborative group; european carotid surgery trial collaborative group. *Health Technol. Assess.* 7, 1–173. doi: 10.3310/hta7270

Drake, C. L., Pillai, V., and Roth, T. (2014). Stress and sleep reactivity: a prospective investigation of the stress-diathesis model of insomnia. *Sleep* 37, 1295–1304. doi: 10.5665/sleep.3916

Duval, S., and Tweedie, R. (2000). Trim and fill: a simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics* 56, 455–463. doi: 10.1111/j.0006-341X.2000.00455.x

Eriksen, W., Bjorvatn, B., Bruusgaard, D., and Knardahl, S. (2008). Work factors as predictors of poor sleep in nurses' aides. *Int. Arch. Occup. Environ. Health* 81, 301–310. doi: 10.1007/s00420-007-0214-z

Eurofound Sixth European Working Conditions Survey (2017). *Eurofound Sixth European Working Conditions Survey –Overview Report*. Luxembourg: Publications Office of the European Union (2017 update). Available online at: https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef1634en.pdf (accessed February 2, 2019).

FGCU Library (2019). *Evidence Based Practice (NUR 4169): PICO*. Available online at: https://fgcu.libguides.com/EBP/pico (accessed August 6, 2019).

Fischer, F. M., Puttonen, S., and Skene, D. J. (2014). 21st International symposium on shiftwork and working time: the 24/7 society–from chronobiology to practical life. *Chronobiol. Int.* 31, 1093–1099. doi: 10.3109/07420528.2014.979600

Fischer, F. M., Silva-Costa, A., Griep, R. H., Smolensky, M. H., Bohle, P., and Rotenberg, L. (2019). Working Time Society consensus statements: psychosocial stressors relevant to the health and wellbeing of night and shift workers. *Ind. Health* 57, 175–183. doi: 10.2486/indhealth.SW-3

Flower, D. J. C., Tipton, M. J., and Milligan, G. S. (2019). Considerations for physical employment standards in the aging workforce. *Work* 63, 509–519. doi: 10.3233/WOR-192962

Garbarino, S., De Carli, F., Nobili, L., Mascialino, B., Squarcia, S., Penco, M. A., et al. (2002). Sleepiness and sleep disorders in shift workers: a study on a group of italian police officers. *Sleep* 25, 648–653.

Garbarino, S., Durando, P., Guglielmi, O., Dini, G., Bersi, F., Fornarino, S., et al. (2016a). Sleep apnea, sleep debt and daytime sleepiness are independently associated with road accidents. A cross-sectional study on truck drivers. *PLoS ONE* 11:e0166262. doi: 10.1371/journal.pone.0166262

Garbarino, S., Guglielmi, O., Sanna, A., Mancardi, G. L., and Magnavita, N. (2016b). Risk of occupational accidents in workers with obstructive sleep apnea: systematic review and meta-analysis. *Sleep* 39, 1211–1218. doi: 10.5665/sleep.5834

Garbarino, S., Lanteri, P., Durando, P., Magnavita, N., and Sannita, W. G. (2016c). Co-morbidity, mortality, quality of life and the healthcare/welfare/social costs of disordered sleep. *Int. J. Environ. Res. Public Health* 13:E831. doi: 10.3390/ijerph13080831

Garbarino, S., Magnavita, N., Guglielmi, O., Maestri, M., Dini, G., Bersi, F. M., et al. (2017). Insomnia is associated with road accidents. Further evidence from a study on truck drivers. *PLoS ONE* 12:e0187256. doi: 10.1371/journal.pone.0187256

Garbarino, S., and Sannita, W. G. (2017). Poor sleeping has underrepresented medical, healthcare, and social costs? *Eur. J. Intern. Med.* 38, e15–e16. doi: 10.1016/j.ejim.2016.10.020

Gluschkoff, K., Elovainio, M., Hintsa, T., Pentti, J., Salo, P., Kivimäki, M., et al. (2017). Organisational justice protects against the negative effect of workplace violence on teachers' sleep: a longitudinal cohort study. *Occup. Environ. Med.* 74, 511–516. doi: 10.1136/oemed-2016-104027

Goldstein-Piekarski, A. N., Holt-Gosselin, B., O'Hora, K., and Williams, L. M. (2019). Integrating sleep, neuroimaging, and computational approaches for precision psychiatry. *Neuropsychopharmacology*. doi: 10.1038/s41386-019-0483-8. [Epub ahead of print].

Greicius, M. D., Supekar, K., Menon, V., and Dougherty, R. F. (2009). Resting-state functional connectivity reflects structural connectivity in the default mode network. *Cereb. Cortex* 19, 72–78. doi: 10.1093/cercor/bhn059

Hafner, M., Stepanek, M., Taylor, J., Troxel, W. M., and van Stolk, C. (2017). Why sleep matters-the economic costs of insufficient sleep: a cross-country comparative analysis. *Rand. Health Q* 6:11. doi: 10.7249/RB9962

Hansen, Å. M., Grynderup, M. B., Rugulies, R., Conway, P. M., Garde, A. H., Török, E., et al. (2018). A cohort study on self-reported role stressors at work and poor sleep: does sense of coherence moderate or mediate the associations? *Int. Arch. Occup. Environ. Health* 91, 445–456. doi: 10.1007/s00420-018-1294-7

Hansen, Å. M., Gullander, M., Hogh, A., Persson, R., Kolstad, H. A., Willert, M. V., et al. (2016). Workplace bullying, sleep problems and leisure-time physical activity: a prospective cohort study. *Scand. J. Work Environ. Health* 42, 26–33. doi: 10.5271/sjweh.3537

Hansen, Å. M., Hogh, A., Garde, A. H., and Persson, R. (2014). Workplace bullying and sleep difficulties: a 2-year follow-up study. *Int. Arch. Occup. Environ. Health* 87, 285–294. doi: 10.1007/s00420-013-0860-2

Hanson, G. C., Perrin, N. A., Moss, H., Laharnar, N., and Glass, N. (2015). Workplace violence against homecare workers and its relationship with workers health outcomes: a cross-sectional study. *BMC Public Health* 15:11. doi: 10.1186/s12889-014-1340-7

Hart, R., and Heybrock, D. (2017). Workplace violence and components of a psychologically healthy workplace. *Benefits Q.* 33, 8–12.

Hudson, A. N., Van Dongen, H. P. A., and Honn, K. A. (2019). Sleep deprivation, vigilant attention, and brain function: a review. *Neuropsychopharmacology* 8. doi: 10.1038/s41386-019-0432-6. [Epub ahead of print].

Kahn-Greene, E. T., Lipizzi, E. L., Conrad, A. K., Kamimori, G. H., and Killgore, W. D. S. (2006). Sleep deprivation adversely affects interpersonal responses to frustration. *Pers. Indiv. Differ.* 41, 1433–1443. doi: 10.1016/j.paid.2006.06.002

Kalmbach, D. A., Anderson, J. R., and Drake, C. L. (2018a). The impact of stress on sleep: pathogenic sleep reactivity as a vulnerability to insomnia and circadian disorders. *J. Sleep Res.* 27:e12710. doi: 10.1111/jsr.12710

Kalmbach, D. A., Cuamatzi-Castelan, A. S., Tonnu, C. V., Tran, K. M., Anderson, J. R., Roth, T., et al. (2018b). Hyperarousal and sleep reactivity in insomnia: current insights. *Nat. Sci. Sleep* 10, 193–201. doi: 10.2147/NSS.S138823

Karhula, K., Hakola, T., Koskinen, A., Ojajärvi, A., Kivimäki, M., and Härmä, M. (2018). Permanent night workers' sleep and psychosocial factors in hospital work. A comparison to day and shift work. *Chronobiol. Int.* 35, 785–794. doi: 10.1080/07420528.2018.1466792

Kecklund, G., and Axelsson, J. (2016). Health consequences of shift work and insufficient sleep. *BMJ* 355:i5210. doi: 10.1136/bmj.i5210

Kostev, K., Rex, J., Waehlert, L., Hog, D., and Heilmaier, C. (2014). Risk of psychiatric and neurological diseases in patients with workplace mobbing

experience in Germany: a retrospective database analysis. *Ger. Med. Sci.* 12:doc10. doi: 10.3205/000195

Lallukka, T., Rahkonen, O., and Lahelma, E. (2011). Workplace bullying and subsequent sleep problems–the Helsinki Health Study. *Scand. J. Work Environ. Health* 37, 204–212. doi: 10.5271/sjweh.3137

Lamote de Grignon Pérez, J., Gershuny, J., Foster, R., and De Vos, M. (2019). Sleep differences in the UK between 1974 and 2015: Insights from detailed time diaries. *J. Sleep Res.* 28:e12753. doi: 10.1111/jsr.12753

Linton, S. J., Kecklund, G., Franklin, K. A., Leissner, L. C., Sivertsen, B., Lindberg, E., et al. (2015). The effect of the work environment on future sleep disturbances: a systematic review. *Sleep Med. Rev.* 23, 10–19. doi: 10.1016/j.smrv.2014.10.010

Litwiller, B., Snyder, L. A., Taylor, W. D., and Steele, L. M. (2017). The relationship between sleep and work: a meta-analysis. *J. Appl. Psychol.* 102, 682–699. doi: 10.1037/apl0000169

Lo, C. K., Mertz, D., and Loeb, M. (2014). Newcastle-Ottawa Scale: comparing reviewers' to authors' assessments. *BMC Med. Res. Methodol.* 14:45. doi: 10.1186/1471-2288-14-45

López-López, I. M., Gómez-Urquiza, J. L., Cañadas, G. R., De la Fuente, E. I., Albendín-García, L., and Cañadas-De la Fuente, G. A. (2019). Prevalence of burnout in mental health nurses and related factors: a systematic review and meta-analysis. *Int. J. Ment. Health Nurs.* 28, 1032–1041. doi: 10.1111/inm.12606

Magee, C., Gordon, R., Robinson, L., Reis, S., Caputi, P., and Oades, L. (2015). Distinct workplace bullying experiences and sleep quality: a person-centred approach. *Pers. Individ. Dif.* 87, 200–205. doi: 10.1016/j.paid.2015.08.004

Magnavita, N. (2011). Violence prevention in a small-scale psychiatric unit. Program planning and evaluation. *Int. J. Occup. Environ. Health* 17, 336–344. doi: 10.1179/107735211799041779

Magnavita, N. (2013a). The exploding spark. Workplace violence in an infectious disease hospital - A longitudinal study. *Biomed. Res. Int.* 2013:316358. doi: 10.1155/2013/316358

Magnavita, N. (2013b). The management of sleep disorders using the A.S.I.A. method. *G. Ital. Med. Lav. Ergon.* 35(4 Suppl.), 20–21. Available online at: http://hdl.handle.net/10807/51829

Magnavita, N. (2014). Workplace violence and occupational stress in health care workers: a chicken and egg situation - Results of a 6-year follow-up study. *J. Nurs. Scholarsh.* 46, 366–376. doi: 10.1111/jnu.12088

Magnavita, N. (2015). Work-related psychological injury is associated with metabolic syndrome components in apparently healthy workers. *PLoS ONE* 10:e0130944. doi: 10.1371/journal.pone.0130944

Magnavita, N. (2017). Productive aging, work engagement and participation of older workers. A triadic approach to health and safety in the workplace. *Epidemiol. Biostat. Public Health* 14:e12436. doi: 10.2427/12436

Magnavita, N., and Fileni, A. (2012). Violenza contro i radiologi. II: I fattori psicosociali. Violence against radiologists. II: psychosocial factors. *Radiol. Med.* 117, 1034–1043. doi: 10.1007/s11547-012-0824-8

Magnavita, N., and Garbarino, S. (2017). Sleep, health and wellness at work: a scoping review. *Int. J. Environ. Res. Public Health* 14:E1347. doi: 10.3390/ijerph14111347

Magnavita, N., Garbarino, S., and Winwood, P. C. (2015). Measuring psychological trauma in the workplace: psychometric properties of the Italian version of the Psychological Injury Risk Indicator (PIRI). A Cross-Sectional Study. *Sci. World J.* 2015: 720193. doi: 10.1155/2015/720193

Magnavita, N., and Heponiemi, T. (2011). Workplace violence against nursing students and nurses. An Italian experience. *J. Nurs. Scholarsh.* 43, 203–210. doi: 10.1111/j.1547-5069.2011.01392.x

Magnavita, N., and Heponiemi, T. (2012). Violence towards health care workers in a Public Health Care Facility in Italy: a repeated cross-sectional study. *BMC Health Serv. Res.* 12:108. doi: 10.1186/1472-6963-12-108

Magnavita, N., and Magnavita, G. (2007). Stalking in work environment. *G. Ital. Med. Lav. Ergon.* 29, 665–667.

Massar, S. A. A., Lim, J., and Huettel, S. A. (2019). Sleep deprivation, effort allocation and performance. *Prog. Brain Res.* 246, 1–26. doi: 10.1016/bs.pbr.2019.03.007

Min, J. Y., Park, S. G., Kim, S. S., and Min, K. B. (2014). Workplace injustice and self-reported disease and absenteeism in South Korea. *Am. J. Ind. Med.* 57, 87–96. doi: 10.1002/ajim.22233

Miranda, H., Punnett, L., Gore, R., and Boyer, J. (2011). Violence at the workplace increases the risk of musculoskeletal pain among nursing home workers. *Occup. Environ. Med.* 68, 52–57. doi: 10.1136/oem.2009.051474

Miranda, H., Punnett, L., Gore, R. J., and ProCare Research Team (2014). Musculoskeletal pain and reported workplace assault: a prospective study of clinical staff in nursing homes. *Hum. Factors* 56, 215–227. doi: 10.1177/0018720813508778

Modesti, P. A., Reboldi, G., Cappuccio, F. P., Agyemang, C., Remuzzi, G., Rapi, S., et al. (2016). ESH Working Group on CV risk in low resource settings. Panethnic differences in blood pressure in europe: a systematic review and meta-analysis. *PLoS ONE* 11:e0147601. doi: 10.1371/journal.pone.0147601

Motomura, Y., Kitamura, S., Oba, K., Terasawa, Y., Enomoto, M., Katayose, Y., et al. (2013). Sleep debt elicits negative emotional reaction through diminished amygdala-anterior cingulate functional connectivity. *PLoS ONE* 8:e56578. doi: 10.1371/journal.pone.0056578

Nabe-Nielsen, K., Grynderup, M. B., Lange, T., Andersen, J. H., Bonde, J. P., Conway, P. M., et al. (2016). The role of poor sleep in the relation between workplace bullying/unwanted sexual attention and long-term sickness absence. *Int. Arch. Occup. Environ. Health* 89, 967–979. doi: 10.1007/s00420-016-1136-4

Niedhammer, I., David, S., Degioanni, S., Drummond, A., and Philip, P. (2009). Workplace bullying and sleep disturbances: findings from a large-scale cross-sectional survey in the French working population. *Sleep* 32, 1211–1219. doi: 10.1093/sleep/32.9.1211

Nielsen, M. B., Pallesen, S., Harris, A., and Einarsen, S. V. (2018). Protocol for a systematic review and meta-analysis of research on the associations between workplace bullying and sleep. *Syst. Rev.* 7:232. doi: 10.1186/s13643-018-0898-z

Ovayolu, O., Ovayolu, N., and Karadag, G. (2014). Workplace bullying in Nursing. *Workplace Health Saf.* 62, 370–374. doi: 10.3928/21650799-20140804-04

Park, E., Lee, H. Y., and Park, C. S. (2018). Association between sleep quality and nurse productivity among Korean clinical nurses. *J. Nurs. Manag.* 26, 1051–1058. doi: 10.1111/jonm.12634

Park, J. B., Nakata, A., Swanson, N. G., and Chun, H. (2013). Organizational factors associated with work-related sleep problems in a nationally representative sample of Korean workers. *Int. Arch. Occup. Environ. Health* 86, 211–222. doi: 10.1007/s00420-012-0759-3

Pekurinen, V., Willman, L., Virtanen, M., Kivimäki, M., Vahtera, J., and Välimäki, M. (2017). Patient aggression and the wellbeing of nurses: a cross-sectional survey study in psychiatric and non-psychiatric settings. *Int. J. Environ. Res. Public Health* 14:E1245. doi: 10.3390/ijerph14101245

Pitney, W. A., Weuve, C., and Mazerolle, S. M. (2016). Experiences with and perceptions of workplace bullying among athletic trainers in the secondary school setting. *J. Athl. Train.* 51, 709–716. doi: 10.4085/1062-6050-51.10.14

Ptak, C., and Petronis, A. (2010). Epigenetic approaches to psychiatric disorders. *Dialogues Clin. Neurosci.* 12, 25–35.

Rathbone, J., Albarqouni, L., Bakhit, M., Beller, E., Byambasuren, O., Hoffmann, T., et al. (2017). Expediting citation screening using PICo-based title-only screening for identifying studies in scoping searches and rapid reviews. *Syst. Rev.* 6:233. doi: 10.1186/s13643-017-0629-x

Reknes, I., Notelaers, G., Magerøy, N., Pallesen, S., Bjorvatn, B., Moen, B. E., et al. (2017). Aggression from patients or next of kin and exposure to bullying behaviors: a conglomerate experience? *Nurs. Res. Pract.* 2017:1502854. doi: 10.1155/2017/1502854

Robinson, O. J., Krimsky, M., Lieberman, L., Allen, P., Vytal, K., and Grillon, C. (2014). The dorsal medial prefrontal (anterior cingulate) cortex–amygdala aversive amplification circuit in unmedicated generalised and social anxiety disorders: an observational study. *Lancet Psychiatry* 1, 294–302 doi: 10.1016/S2215-0366(14)70305-0

Rodriguez-Munoz, A., and Notelaers, G. (2011). Workplace bullying and sleep quality: the mediating role of worry and need for recovery. *Behav. Psychol.* 19, 453–468.

Rosenthal, D. (1970). *Genetic Theory and Abnormal Behavior*. New York, NY: McGraw-Hill.

Rousseau, C., Hassan, G., and Frounfelker, R. (2019). The role of physicians in the violence epidemic. *CMAJ* 191:E644. doi: 10.1503/cmaj.72017

SBU (2013). *Occupational Exposures and Sleep Disturbances*. SBU report no. 216.77. Stockholm: Swedish Council on Health Technology Assessment (SBU).

Slopen, N., and Williams, D. R. (2014). Discrimination, other psychosocial stressors, and self-reported sleep duration and difficulties. *Sleep* 37, 147–156. doi: 10.5665/sleep.3326

Sun, T., Gao, L., Li, F., Shi, Y., Xie, F., Wang, J., et al. (2017). Workplace violence, psychological stress, sleep quality and subjective health in Chinese doctors: a large cross-sectional study. *BMJ Open* 7:e017182. doi: 10.1136/bmjopen-2017-017182

Takaki, J., Taniguchi, T., Fukuoka, E., Fujii, Y., Tsutsumi, A., Nakajima, K., et al. (2010). Workplace bullying could play important roles in the relationships between job strain and symptoms of depression and sleep disturbance. *J. Occup. Health* 52, 367–374. doi: 10.1539/joh.L10081

Tenorio, N. M., Ribeiro, D. A., Alvarenga, T. A., et al. (2013). The influence of sleep deprivation and obesity on DNA damage in female Zucker rats. *Clinics* 68, 385–389. doi: 10.6061/clinics/2013(03)OA16

The National Institute for Occupational Safety and Health (NIOSH) Centers for Disease Control and Prevention (CDC) Workplace Violence Prevention for Nurses (2013). Available online at: https://wwwn.cdc.gov/wpvhc/Course.aspx/Slide/Unit1_5 (accessed February 2, 2019).

Thurston, R. C., Chang, Y., Matthews, K. A., von Kanel, R., and Koenen, K. (2019). Association of sexual harassment and sexual assault with midlife women's mental and physical health. *JAMA Intern. Med.* 179, 48–53. doi: 10.1001/jamainternmed.2018.4886

Tutenges, S., Sogaard, T. F., Kroll, L. T., Bloomfield, K., and Hesse, M. (2015). Violent work environments. A survey of bouncers and their experiences of violence, stress and other work-related problems. *Int. J. Workplace Health Manage.* 8, 129–141. doi: 10.1108/IJWHM-06-2014-0023

van Geel, M., Goemans, A., and Vedder, P. H. (2016). The relation between peer victimization and sleeping problems: a meta-analysis. *Sleep Med. Rev.* 2016, 89–95. doi: 10.1016/j.smrv.2015.05.004

Vartia, M. A. (2001). Consequences of workplace bullying with respect to the well-being of its targets and the observers of bullying. *Scand. J. Work Environ. Health* 27, 63–69. doi: 10.5271/sjweh.588

Vedaa, O., Krossbakken, E., Grimsruld, I. D., Bjovatn, B., Sivertsen, B., Mageroy, N., et al. (2016). Prospective study of predictors and consequences of insomnia: personality, lifestyle, mental health, and work-related stressors. *Sleep Med.* 20, 51–58. doi: 10.1016/j.sleep.2015.12.002

Vleeshouwers, J., Knardahl, S., and Christensen, J. O. (2015). Effects of psychological and social work factors on self-reported sleep disturbance and difficulties initiating sleep. *Sleep* 39, 833–846. doi: 10.5665/sleep.5638

Wells, G. A., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M., et al. (2012). *The Newcastle-Ottawa Scale (NOS) for Assessing the Quality of Nonrandomised Studies in Meta-Analyses*. Available online at: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp (accessed January 24, 2019).

Xie, W., Berry, A., Lustig, C., Deldin, P., and Zhang, W. (2019). Poor sleep quality and compromised visual working memory capacity. *J. Int. Neuropsychol. Soc.* 2019, 1–12. doi: 10.1017/S1355617719000183

Yang, B., Wang, Y., Cui, F., Huang, T., Sheng, P., Shi, T., et al. (2018). Association between insomnia and job stress: a meta-analysis. *Sleep Breath* 22, 1221–1231. doi: 10.1007/s11325-018-1682-y

Yoo, T., Ye, B., Kim, J. I., and Park, S. (2016). Relationship of workplace violence and perpetrators on sleep disturbance. Data from the 4th Korean working conditions survey. *Ann. Occup. Environ. Med.* 28:59. doi: 10.1186/s40557-016-0142-z

Zahid, M. A., Al-Sahlawi, K. S., Shahid, A. A., Awadh, J. A., and Abu-Shammah, H. (1999). Violence against doctors: 2. Effects of violence on doctors working in accident and emergency departments. *Eur. J. Emerg. Med.* 6, 305–309. doi: 10.1097/00063110-199912000-00006

Zhang, S. E., Liu, W., Wang, J., Shi, Y., Xie, F., Cang, S., et al. (2018). Impact of workplace violence and compassionate behaviour in hospitals on stress, sleep quality and subjective health status among Chinese nurses: a cross-sectional survey. *BMJ Open* 8:e019373. doi: 10.1136/bmjopen-2017-019373

Ziemska, B., Klimberg, A., and Marcinkowski, J. T. (2013). Psychosocial factors and health status of employees at the Poznan University of Medical Sciences. *Ann. Agric. Environ. Med.* 20, 539–543.

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Facilitators and Barriers for a Good Night's Sleep Among Adolescents

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Background: Sleep deprivation among adolescents is a major public health issue. Although previous studies have described their sleep habits and the consequences thereof, the voices of adolescents themselves are rarely heard. The aim of this study was to investigate adolescents' experiences regarding what they perceived as facilitators and barriers for a good night's sleep.

Methods: A qualitative focus group study with Swedish adolescents (n = 45) aged 16–18 years was performed with seven focus groups and analyzed using qualitative content analysis.

Results: Three categories were identified in the analysis regarding facilitators and barriers for achieving a good night's sleep: (1) Striving for a sense of well-being, (2) Tiring yourself out, and (3) Regulating electronic media availability. The adolescents thought that sleep was important in order to be able to cope with everyday life and to allow physical recovery. Overall, the adolescents were knowledgeable regarding commonly recommended strategies for improving sleep, but they had trouble finding a balance between sleep and other activities. Electronic media was used to obtain a sense of belonging and to communicate with others, which in itself was described as important for the adolescents' well-being. However, communicating with friends and family during the night conflicted with achieving a good night's sleep. Parental behaviors (late work habits, internet rules) were also perceived as important for adolescents' sleep habits.

Conclusions: An understanding of the dilemma of finding a balance between sleep and other activities may aid future sleep-promoting interventions for adolescents, incorporating the impact from social factors' on the adolescents' sleep.

Keywords: adolescents, electronic media use, focus group interviews, health, sleep, qualitative content analysis

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FACILITATORS AND BARRIERS FOR A GOOD NIGHT'S SLEEP AMONG ADOLESCENTS

Population-based studies indicate that approximately 25–35% of adolescents get insufficient sleep, and these estimates are increasing (Gradisar et al., 2011). The sleep recommendations for adolescents are 8–10 h, and below this range, lack of sleep may affect health and well-being (Hirshkowitz et al., 2015). It has been found that 61% of adolescents in North America are tired during school. Sleep length among adolescents from North America, Europe and Asia, range from

7.4–8.4 h (Gradisar et al., 2011). In an interview study with 14-year-old adolescents, Gruber et al. (2017) highlighted facilitators for sleep as physical, as well as relaxing activities before sleep. Barriers to sleep were stress, anxiety, and the use of electronic media before sleep. Adolescents were aware of the negative consequences of poor sleep (Gruber et al., 2017). During recent decades, sleep patterns have changed among Swedish adolescents toward later bedtimes (Norell-Clarke and Hagquist, 2017), yet few studies have investigated the opinions of adolescents regarding what affects their sleep. This study therefore aims to better understand how adolescents perceive facilitators and barriers for a good night's sleep.

Adequate sleep duration is associated with better attention, behavior, cognitive functioning, emotional regulation, and physical health among children and adolescents (Paruthi et al., 2016). Conversely, insufficient sleep has been associated with health problems as well as sleepiness in class, concentration difficulties, difficulties in school and poorer grades (Paruthi et al., 2016). Electronic media use has been found to be one reason for insufficient sleep (Cain and Gradisar, 2010). Adolescents who had inadequate sleep across the school week also reported problematic levels of sleepiness, fatigue, depressed mood, and anxiety (Short et al., 2013). Limited sleep and lack of sleep during adolescence can affect sleep later in life (Robotham, 2011). Adolescence and its developmental periods are characterized by many changes, and some problems during these developmental periods include problematic sleep habits (Wolfson and Carskadon, 2003). Besides this, Wolfson and Carskadon (2003) concluded that adolescents who have insufficient sleep are more likely to use stimulants like caffeine and nicotine to get through the day. Also, late bedtimes, as defined as 12:00 AM and later on a weekday, may be a risk factor for the prevalence of diabetes mellitus (Yan et al., 2019).

One way to change problematic sleep habits may be to gain a better understanding of the target population's perception of sleep and what promotes and hinders a good night's sleep. In this perspective, a salutogenic approach that emphasizes health promoting resources (Bauer et al., 2006) by inquiring about sleep promoting factors appears appropriate (Antonovsky and Sagy, 2017). The aim of this study was to investigate Swedish adolescents' experiences regarding what they perceived as facilitators and barriers for a good night's sleep.

MATERIALS AND METHODS

A qualitative focus group design was chosen to capture the experiences of adolescents.

Ethical approval for the study was obtained from the Regional Ethical Review Board in Lund, Sweden (EPN 2017/600). Focus group interviews were conducted to capture the various experiences of the adolescents as they provide the opportunity for a group of persons to describe and share their experiences on the selected topics. Focus group interviews are useful when trying to understand how a target group perceives and reasons regarding a phenomenon, because the format promotes reflection and differing opinions (Krueger and Casey, 2009).

Sample

The study was conducted in seven upper secondary schools in rural and urban areas of southern and middle Sweden, and included public and private tuition free schools offering vocational as well as college preparatory tracks. In total, nine schools were contacted, but two of them declined participation due to lack of time. The participants (n = 45) comprised 28 girls and 17 boys in upper secondary school. The age of the adolescents were 16 years (n = 42) and 18 years (n = 3). The participants lived with their families (n = 38) or by themselves (in boarding schools or own apartments) during weekdays and with their families during weekends (n = 7).

Data Collection

The schools distributed written information about the study to the students and their guardians. Thereafter, the teachers informed the students about the study orally and noted those who volunteered to participate, who then received written information about the study and its voluntary nature. All focus group interviews (n = 7 groups) were conducted during school days, between October 2018 and May 2019. About 3–8 people from each class participated in the study, so there were about 15 in each class who declined participation. The adolescents in each group were somewhat acquainted with one another since they were enrolled from the same classes. Both girls and boys participated in mixed groups that were led by the first, second, and/or last authors. The last author participated as an observer during the initial three focus group interviews. In order to increase the credibility of the study, the moderator fostered an open environment among the adolescents to ensure that all of the participants who wanted to talk were allowed to speak.

The time and place for the interviews was determined in consultation with school administrations and the students. The authors of this study developed a semi-structured interview guide (**Appendix 1**). Ten external experts (researchers) in the field of adolescent health, reviewed and gave feedback on the interview guide to optimize its purposefulness (Krueger and Casey, 2009). Following minor revisions, the interview guide was pilot tested in the first focus group interview. This did not lead to any further modifications, and the pilot interview was included in the final data set. Key questions in the interview guide included: "Could you please give examples of a good night's sleep?", "What are the challenges for a good night's sleep?" and "How do you handle these challenges?" (**Appendix 1**). The focus group interviews lasted between 70 and 90 min in six cases, and one focus group interview lasted 45 min. All interviews were audio-recorded and transcribed verbatim. In studies that use semi-structured interviews and are analyzed using qualitative content analysis, the sample size is often justified based on interviewing participants until "data saturation" is reached (Francis et al., 2010). The interviews varied in duration due to the same reason.

Analysis

The transcribed texts were analyzed using qualitative content analysis (Graneheim and Lundman, 2004). This technique makes it possible to analyse relatively large amounts of data while

also focusing on variations within the data. Qualitative content analysis is composed of descriptions of the concrete content and interpretations of the abstracted content while focusing on subjects' experiences (Graneheim and Lundman, 2004). The Nvivo Plus software, version 12 was used to organize and sort the text.

First, the transcripts were read several times to obtain a general sense of the information. The transcripts were then condensed and coded. Next, the codes were grouped into subcategories, which, in turn, were abstracted into categories. Then, categories and subcategories were discussed among the authors until consensus was reached. To strengthen the consistency of the analysis process across all of the transcripts, five members of the research team extracted a random sample of the data to evaluate the analysis at regular intervals during the analysis process. This was done in accordance with Guba (1981), since establishing credibility enhances the trustworthiness of the study.

RESULTS

Overall, the adolescents thought that sleep was important in order to be able to cope with everyday life and to allow physical recovery. Three categories emerged, which describe the adolescents' experiences of facilitators and barriers for a good night's sleep: (1) Striving for a sense of well-being, (2) Tiring yourself out, and (3) Regulating electronic media availability (**Table 1**). The three categories interactively affect nighttime sleep according to (**Figure 1**).

Striving for Sense of Well-Being

The adolescents described a striving for a sense of well-being linked with a good night's sleep. This meant engaging in relaxing activities and dealing with strains.

The engagement in relaxing activities was described as beneficial for sleep. When they relaxed, they felt a sense of well-being. Relaxation meant different things to the adolescents, but some of them suggested that mental and bodily self-care was helpful. One common strategy to relax was to nap for a few hours after school. The adolescents stated that this napping routine was crucial after an exhausting day at school. However, they also described how this routine made it more difficult to relax later when it was time to fall asleep. Other reported relaxing activities included reading books or listening to audiobooks, podcasts, or music. A cold and dark bedroom was regarded as relaxing before sleep. Some preferred taking a warm bath and bodily self-care with massage or mediation. Others stated that they could go to sleep without any special routine.

> "Just stop thinking and shut everything out and imagine that you're sinking into the bed like into a cloud and relax. Then it is much easier to fall asleep." (female)

Another aspect was that the adolescents felt relaxed while being with family and friends, experiencing togetherness, which was a facilitator for sleep. Lastly, some adolescents described that going outside to smoke was a strategy to promote relaxation. They mentioned that smoking was not good for their health, but said that it felt good and relaxing in the moment. Also hanging out with friends while they smoked – even if they did not smoke themselves – was relaxing.

Dealing with strains could mean school stress, worries, and pain. The adolescents described that during school terms, they always had a lot of homework to finish. In addition, some of the adolescents participated in music programs, amateur theater or other leisure activities. Overall, stress, anxiety, and thoughts about school and friends and family all had negative impacts on sleep. Some of the adolescents experienced a great deal of stress and anxiety. The interviews demonstrated that both boys and girls considered negative thoughts, stress, and anxiety as barriers for a good night's sleep.

Anxieties due to conflicts with family members and peers could originate on the Internet. Negative comments on social media could cause severe anxiety, especially if the adolescents did not know who the sender was. Those who were exposed to these comments and conflicts stated that their sleep was greatly affected due to difficulties to relax. The targets were very tired the next day and sometimes even felt anxious.

> "If someone writes *mmm*. in a message, then I can stay awake for several hours at night and think about it. Is the person angry, annoyed or what does *mmm*. mean"? (female)

Adolescents also reported that pain and anxiety directly affected their sleep. For example, one of the adolescents had chronic pain.

> "I'm in constant pain. So, how good I sleep or if I sleep at all, depends on how bad it is, and what I did during the day." (male)

The adolescents also felt that some strains were outside their control—for example, they reported that taking care of younger siblings negatively affected their sleep, and they stated that friends who sent text messages or called at night also negatively affected their sleep. Parents were described as having an impact on sleep in different ways. Some parents worked a lot during the evenings and nights, and therefore it seemed natural for the adolescents to also stay up late to complete their homework. This led to compromised sleep and tiredness the next day. Another dimension was parental rules. Although the adolescents vividly explained that it could be rather annoying when their parents had opinions about their sleep habits, they also admitted that parental advice and discussions were supportive in creating healthy sleep habits.

> "When my parents are nagging me to go to sleep, I get really annoyed, though I know that I need to sleep to not be exhausted the day after." (male)

Tiring Yourself Out

The adolescents described tiring yourself out as exhausting oneself physically and being mentally wound up.

Exhausting oneself physically was described as having a positive impact on sleep. The type of physical activity was of little significance. The frequency of engagement in physical activities varied from one to seven days a week. Some examples of exercise included going to the fitness center, riding horses, playing

TABLE 1 | Categories, subcategories, and codes based on focus group interviews with adolescents regarding what they perceive as facilitators and barriers for a good night's sleep.

Category	Sub-category	Codes
Striving for a sense of well-being	Engagement in relaxing activities	Bodily self-care, mentally self-care, supporting friends
	Dealing with strains	Pain, worries, thoughts about life, conflicts with peers and family, stress in school, solving problems
Tiring yourself out	Exhausting oneself physically	Being engaged in sports, daily activities, and physical activities in school
	Being mentally wound up but sedentary	Being trapped with electronic media, schoolwork, leisure time
Regulating electronic media availability	Sense of relief	Sense of control, parental responsibility, technical solutions
	Feeling of losing control	Stress, difficult to find balance, letting other people down

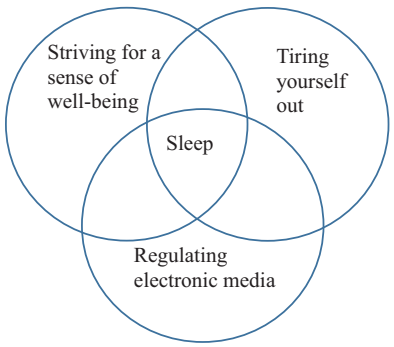

FIGURE 1 | The three categories that interactively affect nighttime sleep according to Swedish adolescents.

football, and walking or bicycling for transportation. While most exercise was undertaken outside their homes, some of the adolescents also mentioned participating in physical activity at home, such as running up and down the stairs or juggling. The adolescents stated that it was easier to settle down after physical activity, irrespectively of its intensity or how long it had lasted. The adolescents stated that they were simply exhausted when it was time to sleep they fell asleep without any effort, and it felt good.

> "I sleep better, fall asleep more easily because I've used the body physically and it makes me feel good and tired." (male)

The adolescents described that they felt an inner calm after physical activity, an absence of anxiety and that they slept better. The adolescents also reported that they liked physical activity during school. Some participated in physical activities very late in the evenings, and this led to late bedtimes. Therefore, they suggested more physical activity to be scheduled during school hours. The adolescents specifically reported that they needed physical activity or else they would easily become sedentary during the day and have difficulties falling asleep at night.

> "You get motivated together with your friends to get physically active and you get tired in the evening, so you fall asleep more easily at night. Then you wake up completely rested and do not feel tired in school the next day." (male)

Being mentally wound up but sedentary was something the adolescents experienced as barriers for a good night's sleep. However, the most common barrier was that they became captivated in electronic media use and succumbed to sedentary behaviors. The effect of adolescents captivated in electronic media was that the adolescents felt tired during the day. They tried to solve the fatigue by sleeping after school, which meant that schoolwork and leisure time were postponed until later in the evening.

Regulating Electronic Media Availability

The adolescents expressed that it is important to be inaccessible during the night as interruptions can prevent a good night's sleep. They reported that they had different strategies to make themselves inaccessible during nighttime, and this helped them to feel in control.

To switch off the sound on their smartphones or leave the smartphone outside the bedroom, and instead engage in activities such as reading books could give a *sense of relief.*

> "I go to bed early and I just lay there. No screen, I just lay there and try to sleep. I did not fall asleep immediately but after a few nights I fell asleep quite quickly without looking at the smartphone." (female)

Other adolescents used their smartphones to listen to relaxing music and audiobooks, receive calls, watch shows, and participate on social media. They reported that watching comics and scrolling through social media for a short time before falling asleep was calming. The adolescents expressed different opinions on parental involvement. Some said that their parents had no idea about their activities on social media and how frequently they engaged with it during the night. They felt that they were in control, but at the same time, they mentioned that they were tired during the day and that they had difficulties putting their smartphone away. Some of the adolescents mentioned that they wished that their parents had more rules about the media use, because then it would be easier to put the smartphone away, and they would not have to make the decision for themselves. They felt that this would also help them to feel relief. One of the adolescents stated that his parents shut down their wireless internet connection at a certain time in the evening and that this had helped him to sleep better.

> "It is good that they turn off the internet at a certain time, because then I will not have any chance to get stuck with the smartphone for too long at night." (male)

However, the adolescents mentioned that it was difficult to find a balance between being uninterrupted and yet be available for their friends and family at night. The adolescents described a *feeling of losing control* as a feeling of responsibility to be available for friends and family. For example, adolescents who had a driving license felt a responsibility to be available during the night in case a friend needed to be picked up urgently. Particularly adolescents in boarding schools expressed that family members expected them to be accessible in case of urgent family issues or if they wanted to check on them.

> "Imagine if I would switch off the smartphone at night and when I wake up in the morning and something horrible has happened that I missed just because I prioritized my sleep. No, it is not acceptable to do something like that." (female)

Some of the adolescents expressed that their smartphone use was addictive, meaning that they were unable to stop looking at the display.

> "The experience of having trouble sleeping can vary, but I find it difficult to fall asleep if I use social media before bedtime." (female)

DISCUSSION

The aim of this study was to investigate what adolescents perceive as facilitators and barriers to a good night's sleep. Historically, in the public discourse about adolescent sleep habits, there has been a moralistic attitude where adolescents are seen as hedonistic in their evening and night habits and unaware of what is best for them (Matricciani et al., 2012). Our findings suggest that today's adolescents are aware of the importance of sleep for their well-being and that they have access to different strategies to achieve a good night's sleep. However, they also described internal and external barriers that interfered with their sleep, some of which were on a relational level, which goes against the implicit assumption in sleep promotion that states that sleep is mostly affected by individual factors that one can control (Thorleifsdottir et al., 2002).

Besides Gruber et al.'s (2017) interview study with 18 adolescents (14 years old) in Canada, our study is one of few, to our knowledge, where adolescent voices have been directly heard regarding facilitators and barriers for sleep. The two studies are consistent regarding the importance of physical and relaxing activities for sleep, as well as the negative consequences of electronic media, stress, and anxiety before sleep"? A surprising finding was that altruistic relationship-related values had an influence on sleep habits, for example, in decisions to be electronically available in case of needing to help a friend or in case of urgent family news. The former may be understood from a developmental perspective as peer relationships become increasingly important during adolescence (Knoll et al., 2015). The latter was more surprising as the relationship to parents during adolescence is usually found to be characterized by a strive for autonomy. Similarly, it was also notable that some adolescents sought more rules from their parents regarding sleep habits.

If the parents imposed more boundaries (e.g., not allowing smartphones in some places or after certain times), the adolescents were unburdened of making that decision for themselves. This result indicates that parents might place too much responsibility on adolescents when it comes to electronic media use. The importance of parental influence was also demonstrated in a study that showed children and adolescents are more likely to follow parental regulations than advice from social media (Hiniker et al., 2016). This might not specific be to adolescents' sleep behavior but indicates that parental behavior affects adolescents' sleep. Another finding related to parental influence in the present study was that the adolescents described how they would stay up later if their parents also stayed up late. Taken together, our findings suggest that parental behavior is an important influence on adolescents' sleep.

One barrier to a good night's sleep was social media use. Our participants expressed mixed feelings about their use of social media. Some became anxious about missing out if they were not connected all of the time, and many described how they would be online for longer than they intended, which had a negative influence on sleep and the next day's performance. Also, the adolescents found it difficult to find a balance between being sufficiently inaccessible for sleep and being available to stay connected with friends and family. Nowadays, a large part of social interactions take place over social media, and anyone who makes themselves inaccessible (for the purpose of relaxing or avoiding disturbances) risks missing important events or contact attempts to a point where prioritizing yourself by "turning off" was considered selfish. Even though social media engagement was perceived as beneficial for relationships in this study, there are studies that show its negative effects on health. Specifically, social media use has a negative impact on aggression, drug use, eating disorders, and school performance (Strasburger et al., 2010).

This brings us to another finding: the importance of being physically active during the day to be able to fall asleep. The adolescents said that their electronic media use led to sedentary behaviors and a mentally active mind, both which interfered with their quality of sleep. Various forms of physical exercise were mentioned as facilitators for sleep, which is in concordance with other studies that have demonstrated that exercise has beneficial effects on sleep duration [e.g., (Kredlow et al., 2015]. Another benefit of physical activity was that it allowed the adolescents to be together with their friends. Regrettably, exercise was difficult to prioritize after school hours, as homework was time consuming.

Despite their insights in what promotes and disturbs sleep, the adolescents also used some strategies that are counter-productive for sleep. They mentioned that smoking was a relaxation strategy and that they napped for a few hours directly after school: both which decrease sleepiness later in the night (Boehm et al., 2016).

Strengths and Limitations

The focus group design was well suited for capturing the adolescent's views and experiences regarding sleep. The place where the interviews took place could have affected the groups' openness, even if the school and participants choose the place. In this case, all participants were interviewed within the schools. In order to increase the trustworthiness of the study, several of the

authors participated in the analysis process, and we used the same questions in all focus groups. A clear strength of this study is its focus on adolescents' own perceptions of facilitators and barriers to a good night's sleep.

The study was conducted in schools in southern and middle Sweden, and the question of transferability remains. Background information about socio-economic status, sleep disturbance, or psychiatric history among adolescents is not available in this study. Therefore, we do not know how generalizable the findings are to a broader adolescent population. In qualitative content analysis according to Graneheim and Lundman (2004), the goal is not to obtain generalizability but to identify differences and similarities in the material. Study participation was voluntary and, therefore, it is difficult to know if the participating individuals differed from their peers in any particular way. It may be assumed that our results represent a broad variety of experiences. Further studies in other contexts are recommended.

In all but one focus group interview, the conversation progressed smoothly. In one interview, it was somewhat more difficult to achieve an active discussion climate, and this interview only lasted for 45 min. Individual interviews might have given more depth to the conversations. However, moderators were accustomed conversation leaders with experience working with children and young people and endeavored to foster a good conversation climate. Focus group interviews also have the advantage of capturing collective views in a dynamic environment that promotes reflection and differing opinions.

Clinical Implications

A surprising finding was that altruistic relationship-related values were perceived to have an influence on adolescent sleep habits. The adolescents also expressed a wish to communicate and obtain support from parents and significant others. Parents and health professionals need to be aware and informed of the great responsibility that adolescents take for their friends. If friends and family members feel distressed or need help during the night, adolescents feel a responsibility to be available. Yet, this is unreasonably great burden for a teenager to bear, therefore, in sleep education programs, parents should also be included in the intervention. Gruber (2013) points out the importance of preventive sleep education programs for children and adolescents regarding, for example, relaxing behaviors.

Relatively small efforts have a positive effect on young people's sleep habits (Bonnar et al., 2015). For example, limiting evening phone use among adolescents increased sleep duration by 21 min (Bartel et al., 2019). However, only a quarter of invited adolescents participated in the study by Bartel et al. (2019), which may indicate that many adolescents lack motivation to change their evening phone use. The adolescents in our study showed an interest and desire to discuss sleep and salutogenic strategies to cope with barriers to healthy sleep habits. The main findings suggest that adolescents are aware of the importance of sleep for their well-being and that they have access to different strategies to achieve a good night's sleep. The focus group methodology in this study was appreciated by the adolescents, as they were afforded the opportunity to discuss a highly relevant topic with peers in a safe and non-judgmental way. Therefore, discussing such strategies and supporting adolescents in finding strategies to improve sleep habits is recommended.

CONCLUSION

Our findings suggest that adolescents are aware of different strategies to facilitate sleep and that they perceive factors outside their control as barriers to their sleep, such as social demands, family habits, and difficulties prioritizing physical exercise. An implicit assumption in sleep promotion has been that sleep is mostly affected by individual factors. Thus, advice is given to the individual on how to change their habits. Our study highlights the relational aspects of sleep, in that the behaviors and expectations from friends and parents as well as parental rules are all perceived as influential for adolescents' sleep habits. Continued research on the sleep patterns of adolescents and the associated facilitators and barriers is needed from a public health perspective. Ultimately, the results of this study may form a basis for future sleep interventions among adolescents, incorporating the social factors' impact on the adolescents' possibility to achieve a good night's sleep.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Etikprövningsnämnden, Lund. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

GH, PG, PH, AN-C, and AW designed research and analyzed the data. GH, PG, and AN-C Performed the research. GH wrote the first draft of the manuscript. GH, PG, PH, AN-C, AW, and HT revised the manuscript and approved the final version.

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REFERENCES

Antonovsky, A., and Sagy, S. (2017). "Aaron antonovsky, the scholar and the man behind salutogenesis," in *The Handbook of Salutogenesis*, eds M. B. Mittelmark, S. Sagy, M. Eriksson, G. F. Bauer, J. M. Pelikan, B. Lindstrom, et al. (Cham: Springer), 15–23. doi: 10.1007/978-3-319-04600-6_3

Bartel, K., Scheeren, R., and Gradisar, M. (2019). Altering Adolescents' Pre-bedtime phone use to achieve better sleep health. *Health Commun.* 34, 456–462. doi: 10.1080/10410236.2017.1422099

Bauer, G., Davies, J. K., and Pelikan, J. (2006). The EUHPID Health Development Model for the classification of public health indicators. *Health Promot Int.* 21, 153–159. doi: 10.1093/heapro/dak002

Boehm, M. A., Lei, Q. M., Lloyd, R. M., and Prichard, J. R. (2016). Depression, anxiety, and tobacco use: overlapping impediments to sleep in a national sample of college students. *J. Am. Coll. Health* 64, 565–574. doi: 10.1080/07448481.2016.1205073

Bonnar, D., Gradisar, M., Moseley, L., Coughlin, A. M., Cain, N., and Short, M. A. (2015). Evaluation of novel school-based interventions for adolescent sleep problems: does parental involvement and bright light improve outcomes? *Sleep Health* 1, 66–74. doi: 10.1016/j.sleh.2014.11.002

Cain, N., and Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: a review. *Sleep Med.* 11, 735–742. doi: 10.1016/j.sleep.2010.02.006

Francis, J. J., Johnston, M., Robertson, C., Glidewell, L., Entwistle, V., Eccles, M. P., et al. (2010). What is an adequate sample size? Operationalising data saturation for theory-based interview studies. *Psychol. Health* 25, 1229–1245. doi: 10.1080/08870440903194015

Gradisar, M., Gardner, G., and Dohnt, H. (2011). Recent worldwide sleep patterns and problems during adolescence: a review and meta-analysis of age, region, and sleep. *Sleep Med.* 12, 110–118. doi: 10.1016/j.sleep.2010.11.008

Graneheim, U. H., and Lundman, B. (2004). Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Educ. Today* 24, 105–112. doi: 10.1016/j.nedt.2003.10.001

Gruber, R. (2013). Making room for sleep: the relevance of sleep to psychology and the rationale for development of preventative sleep education programs for children and adolescents in the community. *Can. Psychol.* 54:62. doi: 10.1037/a0030936

Gruber, R., Somerville, G., Paquin, S., and Boursier, J. (2017). Determinants of sleep behavior in adolescents: a pilot study. *Sleep Health* 3, 157–162. doi: 10.1016/j.sleh.2017.03.004

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *ECTJ* 29:75.

Hiniker, A., Schoenebeck, S. Y., and Kientz, J. A. (2016). "Not at the dinner table: parents' and children's perspectives on family technology rules," in *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*, San Francisco, CA.

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., et al. (2015). National Sleep Foundation's updated sleep duration recommendations: final report. *Sleep Health* 1, 233–243. doi: 10.1016/j.sleh.2015.10.004

Knoll, L. J., Magis-Weinberg, L., Speekenbrink, M., and Blakemore, S. J. (2015). Social influence on risk perception during adolescence. *Psychol. Sci.* 26, 583–592. doi: 10.1177/0956797615569578

Kredlow, M. A., Capozzoli, M. C., Hearon, B. A., Calkins, A. W., and Otto, M. W. (2015). The effects of physical activity on sleep: a meta-analytic review. *J. Behav. Med.* 38:427449. doi: 10.1007/s10865-015-9617-6

Krueger, R. A., and Casey, M. A. (2009). *Focus Groups: A Practical Guide for Applied Research*. Los Angeles, CA: SAGE.

Matricciani, L. A., Olds, T. S., Blunden, S., Rigney, G., and Williams, M. T. (2012). Never enough sleep: a brief history of sleep recommendations for children. *Pediatrics* 129, 548–556. doi: 10.1542/peds.2011-2039

Norell-Clarke, A., and Hagquist, C. (2017). Changes in sleep habits between 1985 and 2013 among children and adolescents in Sweden. *Scand. J. Public Health* 45, 869–877. doi: 10.1177/1403494817732269

Paruthi, S., Brooks, L. J., D'Ambrosio, C., Hall, W. A., Kotagal, S., Lloyd, R. M., et al. (2016). Recommended amount of sleep for pediatric populations: a consensus statement of the American Academy of Sleep Medicine. *J. Clin. Sleep Med.* 12, 785–786. doi: 10.5664/jcsm.5866

Robotham, D. (2011). Sleep as a public health concern: insomnia and mental health. *J. Public Mental Health* 10, 234–237. doi: 10.1108/17465721111188250

Short, M. A., Gradisar, M., Lack, L. C., Wright, H. R., and Dohnt, H. (2013). The sleep patterns and well-being of Australian adolescents. *J. Adolesc.* 36, 103–110. doi: 10.1016/j.adolescence.2012.09.008

Strasburger, V. C., Jordan, A. B., and Donnerstein, E. (2010). Health effects of media on children and adolescents. *Pediatrics* 125, 756–767. doi: 10.1542/peds.2009-2563

Thorleifsdottir, B., Bjornsson, J. K., Benediktsdottir, B., Gislason, T., and Kristbjarnarson, H. (2002). Sleep and sleep habits from childhood to young adulthood over a 10-year period. *J. Psychosom. Res.* 53, 529–537. doi: 10.1016/s0022-3999(02)00444-0

Wolfson, A. R., and Carskadon, M. A. (2003). Understanding adolescent's sleep patterns and school performance: a critical appraisal. *Sleep Med. Rev.* 7, 491–506. doi: 10.1016/s1087-0792(03)90003-7

Yan, B., Fan, Y., Zhao, B., He, X., Yang, J., Chen, C., et al. (2019). Association between late bedtime and diabetes mellitus: a large community-based study. *J. Clin. Sleep Med.* 15, 1621–1627. doi: 10.5664/jcsm.8026

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

APPENDIX 1

Interview Guide

Focus groups, adolescents in their first year of upper secondary school.

The aim of this study was to investigate Swedish adolescents' experiences regarding what they perceived as facilitators and barriers for a good night's sleep.

Key questions:	Could you please give examples of a good night's sleep.
	What are the challenges for a good night's sleep?
	How do you handle these challenges?
Closing questions and summary:	What resources do you think exist in your everyday life to meet your challenges regarding sleep?
	Is there something we have not asked about that you would like to add?

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Social Jetlag and Its Association With Screen Time and Nighttime Texting Among Adolescents in Sweden: A Cross-Sectional Study

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The discrepancy between social and biological clock due to sleep and wake up time difference across weekdays and weekends is referred as social jetlag. The overall aim of this study is to test whether there is an association between both screen time and nighttime texting and social jetlag among 13- to 15-year-old adolescents in Sweden. This study included a cross-sectional survey in which data were collected from all schools with grades 7 and 8 in four municipalities in southern Sweden. The sample consisted of 1518 students (72.7% response rate), among whom 50.7% were girls. Ages varied between 13 and 15 years (mean, 13.9; standard deviation (SD), 0.4). Social jetlag was defined as more than 2 h difference between bedtime and wake-up time on school days compared to weekends. The prevalence of social jetlag among this study population was 53.9%. After adjusting for age, sex, and economic status, the multivariate binary logistic regression analysis results showed that increased screen time ($p < 0.001$) and texting at night ($p = 0.002$) were significantly associated with social jetlag. Irregular bedtime and wake-up habits on school days and weekends are associated with nighttime texting and increased screen time. For future research, more focus should be given to identifying causality factors and gain an understanding of the effects of social jetlag, which will help in developing appropriate public health messages and intervention programs.

Keywords: sleep, screen time, nighttime texting, adolescents, social jetlag

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INTRODUCTION

The notion of adolescents as a genuinely healthy age group has contributed to them being neglected in public health research (Gore et al., 2011). Measuring adolescent health requires sound information, including social and environmental determinants (Patton et al., 2010). Adolescence and young adulthood are unique periods of life, and investments in adolescent health will contribute to a healthier start in life (Patton et al., 2016). Recent estimates suggest that one in five children and young adults have difficulties sleeping (Calhoun et al., 2014). There is a rapidly rising prevalence of sleep problems among adolescents, which is associated with poor functioning (Langberg et al., 2017). Therefore, the increasing prevalence of sleep problems has become a recognized international public health problem (Gradisar et al., 2011). Among children, insufficient sleep increases the risk of neuropsychological complications (Gregory et al., 2009). A literature review, including 36 papers on the relationship between sleep and

electronic media among adolescents has concluded that delayed bedtime and shorter total sleep time are consistently related to media use (Cain and Gradisar, 2010). Television viewing, use of the computer, internet, and electronic gaming, the use of mobile phones, and listening to music were identified as having a negative impact on sleep (both delayed and shortened sleep time) among adolescents (Cain and Gradisar, 2010). A study on sleep quality during early childhood found that independent use of different electronic media now begins at less than 3 years old, which is before the children have learned to read (Genuneit et al., 2018). Children learn to use electronic devices on their own, which are handed to them by their parents, resulting in a significant amount of screen time (from computer, television, and mobile device use) (Kabali et al., 2015). The frequent use of electronic media is generating a debate about to what extent this might have an adverse effect on health (Milde-Busch et al., 2010). Therefore, today's children are exposed to a greater amount of electronic media than ever before, which now requires constructive and in-depth research on how this affects their physiological and psychological well-being. Here, we investigated irregular sleep ("social jetlag"), screen time and nighttime texting among adolescents.

Humans have 24-h biological rhythms (referred to as circadian rhythms). Mammals express multiple biological rhythms structured into multiple complex interactions (Touitou and Haus, 2012). In humans, circadian rhythms are driven by endogenous (genetics) and exogenous (e.g., social life, light-dark cycle, and sleep-wake cycle) factors (Touitou and Haus, 2012). The internal time-keeping system or biological clock is represented by the suprachiasmatic nuclei (SCN) of the anterior hypothalamus, which controls the circadian system (Oginska and Pokorski, 2006; Touitou and Haus, 2012). Circadian rhythm refers to our daily synchronized rhythm, which is also known as our 24-h biological clock (Oginska and Pokorski, 2006; Touitou and Haus, 2012). Thus, a temporal dissociation can occur when the biological clock is not synchronized with the astronomical clock because of other factors, such as jetlag, night work, shift work, mood disorder, and the use of certain medications (Touitou et al., 1990; Reinberg and Ashkenazi, 2008). Sleep has a bidirectional relationship with the circadian system as not only insufficient sleep but also mistimed sleep that interrupts biological clock has an impact on the circadian system (Kryger et al., 2011). The discrepancy between social and biological clock due to sleep and wake up time difference across weekdays and weekends is referred as social jetlag (Wittmann et al., 2006). Social jetlag affects almost all of us throughout life, especially young adults (Wittmann et al., 2006). Today's adolescents and young people are at an increased risk of social jetlag because of electronic media habits (Cain and Gradisar, 2010). The negative effects on sleep (both delayed and shortened) because of inappropriate electronic media use among adolescents and young people is alarming (Cain and Gradisar, 2010).

Insufficient sleep among adolescents is significantly associated with negative physiological consequences, such as obesity, depression, anxiety, mood disturbance, suicidal ideation, and drug and alcohol use (Gupta et al., 2002; Chen et al., 2008; Stoner et al., 2018). Adolescents with poor sleep quality and decreased sleep duration tend to have a lower sense of well-being, poor academic results, and a decreased quality of life (Wittmann et al., 2006; Baert et al., 2015; Johansson et al., 2016). Moreover, chronic sleep loss in adolescents is associated with poor judgment and risk-taking behaviors, such as drinking and driving, smoking, and substance abuse (Calamaro et al., 2009; Catrett and Gaultney, 2009). In studies among adolescents, social jetlag has been found to be associated with an unhealthy dietary pattern, depressive symptoms, and multiple metabolic risks (Levandovski et al., 2011; Wong et al., 2015; Koopman et al., 2017; Almoosawi et al., 2018; Mota et al., 2019). Surprisingly, female participants with social jetlag had more depressive symptoms compared to men (Mathew et al., 2019).

For the development of adolescent health, sleep is a key element, and sleep (both psychologically and physiologically) is important (Touitou, 2013). However, the prevalence rate of sleep disorders is comparatively high among western countries, where the cumulative sleep debt has been associated with behavioral problems, poor school achievements, and fatigue (Touitou, 2013). Thus, the effects on sleep have been the object of many studies addressing the permanent social jetlag that is experienced by many adolescents, and this should be considered to be a matter of concern in public health (Touitou, 2013; Johansson et al., 2016).

Many variables have been investigated, although delayed bedtime and shorter total sleep time have been found to be most consistently related to electronic media use and nighttime texting with negative consequences (Gradisar et al., 2011; Pecor et al., 2016). Therefore, how electronic media use is associated with sleep and social jetlag among adolescents requires further study (Waterhouse et al., 2005).

PURPOSE

The overall aim of this study is to address the research question of whether there is an association between social jetlag and screen time and nighttime texting among adolescents aged 13–15 in Sweden. To address this aim, we opted for a cross-sectional study where the following research question is examined: Is there any association between social jetlag, screen time, and nighttime texting among adolescents?

The specific objectives are:

(1) To examine the associations between experienced social jetlag and the level of daily screen time among adolescents; and
(2) To examine the association between social jetlag and the frequency of nighttime texting among adolescents.

MATERIALS AND METHODS

This study was conducted using the quantitative data from a larger research project (ISRCTN17006300) that was performed as a cross-sectional survey that collected data from all schools with grades 7 and 8 in four municipalities in southern Sweden. Respondents came from schools that were located in both urban

and rural areas and from public as well as private schools. The sample consists of 1518 students (72.7% response rate), of whom 50.7% were girls. Ages varied between 13 and 15 years (mean, 13.9; standard deviation (SD), 0.4).

Ethical Considerations

Guardians and students were informed in writing about the purpose of the study and that it was voluntary to participate in the study. Written informed consent was obtained. The students were told that there were no correct or incorrect answers. The study was approved by the Regional Ethical Review Board in Lund, EPN 2015/113. All procedures were conducted in accordance with the Declaration of Helsinki.

Data Collection

In this cross-sectional study, each student in the four included municipalities in southern Sweden was invited to participate in this study. A survey questionnaire was distributed by the respective school nurses in connection with mandatory health interview (during school hours) in grades 7 and 8. The questionnaire was completed using paper and a pencil, and the school nurse was present to answer any questions related to the questionnaire.

Questionnaire

The survey was based on the Sleep and Media Habits Questionnaire (SMHQ), which is designed to track sleep and screen habits in school-aged children (Garmy et al., 2012a). The SMHQ consists of questions about the time (hours and minutes) spent in front of a TV/computer per day that is not related to schoolwork, as well as sleep duration (hours and minutes) on nights before school days as well as on weekends, time for going to bed and waking up on school days and weekends, tiredness in school (never, rarely, often, and every day), and the frequency of texting/other messages (e.g., Facebook and Instagram) at night (never, a few times a year, sometimes every month, sometimes every week) during the school week.

Description of Variables

Demographic Variables

Sex, age, and economic situation variables were considered to be the demographic information in this study. Age was a continuous variable, while sex was a dichotomized variable. The economic situation (self-assessed) variable had six options to answer, and, from those six options, a dichotomous variable was computed (very good or quite good economic situation/average or worse economic condition).

Social Jetlag

The major outcome variable in this study is social jetlag and it is defined and measured according to the theory and process presented by Wittmann et al. (2006). In this study, 93% of the participants had a sleep midpoint difference greater than or equal to 1 h. Thus, this study concluded that a midpoint difference of greater than or equal to 2 h is the social jetlag cut-off point, and it was coded as a dichotomized variable.

Screen Time

TV time and computer time (hours per day) were treated as continuous variables in the study. Total screen time was calculated based on the time spent using TV and computers. This continuous variable is categorized into three categorical variables of more or less than 2 h of screen time, more or less than 3 h of screen time and, more or less than 4 h of screen time.

Nighttime Texting

Another categorized variable is nighttime texting. The frequency of sending or receiving SMS/other messages (e.g., Facebook, Instagram, and Snap) during the night had four response options (never, yearly, monthly, and weekly), and a dichotomized variable for texting habit was generated (weekly/less than weekly).

Data Analysis

Descriptive and analytical statistics have been conducted. Data analysis is conducted using the SPSS version 24 (IBM Corp., IBM SPSS Statistics for Windows). The mean, median, and percentages of the descriptive statistics are presented for the continuous variables, and the frequencies with percentages are presented for the categorical variables. Bivariate analyses with Pearson Chi-square test were performed to observe the *p*-value between dependent and independent variables. Binary logistic regression was used to analyze the confidence interval (CI) and the odds ratio (OR) was used to represent the data. A *p*-value <0.05 was considered to be statistically significant. In the crude analysis, the association between categorized social jetlag (more than 2 h was determined to indicate the presence of social jetlag) and screen time, texting at night, and demographic variables were investigated using binary logistic regression analysis. Multivariate binary logistic regression was used to analyze the adjusted OR between the dependent and independent variables, thus controlling for the possible effect modifiers and potential confounders in the binary logistic regression models. Different kinds of electronic use and social jetlag have been shown to be significantly affected by socio-economic status, age, and sex in earlier studies (Thomas et al., 2010; Short and Louca, 2015; Komada et al., 2019; Mathew et al., 2019). Therefore, in this study, these three factors were adjusted in the multivariate binary logistic regression analysis model.

RESULTS

Sample Characteristics

The population sample consisted of approximately an equal number of male (49.3%) and female (50.7%) participants among the 1518 study participants. The mean participant age was 13.89 years, and the range was 13–15 years. For the self-reported economic situation, 1227 (80.8%) of the participants described their economic situation as good or very good (**Table 1**). Among the participants who answered the questions about sleep (n = 1425, 93.9%), 53.9% (n = 818) experienced social jetlag (a sleep midpoint difference greater than or equal to 2 h). Among the participants (n = 1354, 89.9%), the total screen time for using a computer and television was over 4 h for

TABLE 1 | Descriptive characteristics of the characteristics of the participants (*N* = 1518) from southern Sweden.

Variables	Male n (%)	Female n (%)	Total n (%)
Age (*N* = 1518)			
13 years	84 (5.5)	106 (7.0)	190 (12.5)
14 years	651 (42.9)	661 (43.5)	1312 (86.4)
15 years	13 (0.9)	3 (0.2)	16 (1.1)
Missing Data	–	–	–
Socio-economic situation (*N* = 1518)			
Very good or good economic situation	602 (39.7)	625 (41.2)	1227 (80.8)
Average or worse economic situation	146 (9.6)	145 (9.6)	291 (19.2)
Missing Data	–	–	–
Continuous variable	**Mean (hr:min) (SD)**	**Mean (hr:min) (SD)**	**Mean (hr:min) (SD)**
Bedtime			
Weekdays	22.20 (0.89)	22.15 (0.83)	22.20 (0.86)
Weekends	24.10 (1.40)	23.45 (1.24)	23.59 (1.34)
Wake up time			
Weekdays	6.41 (0.46)	6.58 (0.48)	6.52 (0.48)
Weekends	10.05 (1.43)	9.42 (1.19)	9.55 (1.33)
Sleep Duration			
Weekdays	8.13 (0.96)	8.01 (0.98)	8.07 (0.97)
Weekends	9.67 (1.31)	9.71 (1.14)	9.69 (1.23)
Screen time	3.72 (2.14)	3.06 (2.06)	3.38 (2.12)
Categorical variable	**n (%)**	**n (%)**	**n (%)**
Screen time (4 h cutoff)			
Less than 4 h	375 (57.2%)	498 (70.3%)	873 (64.0%)
4 h or more	281 (42.8%)	210 (29.7%)	491 (36.0%)
Night time texting			
Less than weekly	419 (75.2%)	445 (78.9%)	864 (77.1%)
Weekly	138 (24.8%)	119 (21.1%)	257 (22.9%)

36% (n = 491) of the participants, and males comprised 57.2% (n = 281) of these participants. Among the participants who reported on their nighttime texting habit (n = 1510, 99.5%), 37.6% (n = 568) reported never texting at night. A nighttime texting habit of sometimes every week was shown for 25.8% (n = 389) of these participants.

Bivariate Analysis (Pearson Chi-Square Test)

The bivariate analysis was performed in this study between the dependent variable social jetlag and the independent variables such as the demographic variables (**Table 2**). From the demographic variables of age, sex, and economic situation, only the participant's sex (p = 0.001) showed a statistically significant association with social jetlag. However, social jetlag is statistically significantly associated with nighttime texting (p = 0.001) and screen time [>2 h of screen time (p = 0.025), >3 h of screen time (p = 0.002), and >4 h of screen time (p < 0.001)]. Because the category for >4 h of screen time showed the highest significance in the analysis, this category was used for further analysis. Average sleep duration was not associated with social jetlag (p = 0.191).

TABLE 2 | Descriptive characteristics from the Chi-square test on association of social jetlag and independent variables of adolescent participants (*N* = 1518) from southern Sweden.

Variables	Social jetlag No n (%)	Social jetlag Yes n (%)	Total n	*P* value
Age (*N* = 1425)				
13 years	67 (37.9)	110 (62.1)	177	–
14 years	536 (43.4)	699 (56.6)	1235	0.259
15 years	4 (0.3)	9 (0.6)	13	–
Economic situation (*N* = 1425)				
Very good or good economic situation	499 (43.2)	657 (56.8)	1156	0.367
Average or worse economic situation	108 (40.1)	161 (59.9)	269	–
Sex (*N* = 1425)				
Male	264 (38.3)	426 (61.7)	690	**0.001***
Female	343 (46.7)	392 (53.3)	735	–
Nighttime texting (*N* = 1057)				
Less than Weekly	400 (49.0)	417 (51.0)	817	–
Weekly	88 (36.7)	152 (63.3)	240	**0.001***
Screen time (*N* = 1290)				
Less than 4 h of screen time	390 (47.0)	440 (53.0)	830	
4 h or more of screen time	161 (35.0)	299 (65.0)	460	**<0.001***

**Statistically significant ($p < 0.05$).*

Crude Analysis: Binary Logistic Regression Analysis

In **Table 3**, the crude analysis between social jetlag and independent variables for the unadjusted OR and a 95% CI has been presented with the sex-segregated value. The sex of the participants showed a significant OR (OR = 1.404), which means that male participants were 1.4 times more likely to experience social jetlag in this study. Nighttime texting also showed a significant OR (OR = 1.487), meaning that texting often at night was 1.5 times more likely to be associated with social jetlag. Four hours or more of screen time was also significant, indicating that screen time is 1.5 times more likely to be associated with social jetlag (OR = 1.547). However, age and economic situation did not show any significance in this crude analysis. Because the sex of the participants was significant in both bivariate and crude analyses for the adjusted analysis, the sex-segregated analysis is included.

Adjusted Analysis: Multivariate Binary Logistic Regression Analysis

The adjusted analysis is presented to determine the association between dependent and independent variables in sex-segregated and total data that was adjusting for age, sex, and socio-economic status (**Table 4**). After adjusting for age sex and economic status, screen time (p < 0.001) was statistically significantly

TABLE 3 | Sex-segregated crude analysis of the association between social jetlag and independent variables among 13–15 year old adolescents in southern Sweden.

Variables	Male OR (CI 95%)	Female OR (CI 95%)	Total OR (CI 95%)
Age			
13 years	1	1	1
14 years	0.658 (0.393–1.100)	0.875 (0.572–1.338)	0.710 (0.465–1.086)
15 years	0.639 (0.165–2.479)	(–)	0.912 (0.198–4.193)
Economic situation			
Very good or good economic situation	1	1	1
Average or worse economic situation	0.872 (0.592–1.283)	1.438 (0.985–2.099)	1.113 (0.775–1.598)
Sex			
Female	N/A	N/A	1
Male	N/A	N/A	1.404 (1.063–1.854)*
Nighttime texting			
Less than weekly	1	1	1
Weekly	1.375 (0.906–2.086)	1.916 (1.253–2.928)	1.487 (1.072–2.062)*
Screen time			
Less than 4 h of screen time	1	1	1
4 h or more of screen time	1.475 (1.056–2.060)	1.702 (1.214–2.385)	1.547 (1.155–2.072)*

**Statistically significant ($p < 0.05$). (–) The number of the respondents was too low to show the result.*

associated with social jetlag. In **Table 4**, the adjusted analysis is presented to determine the association between dependent and independent variables in overall and sex-segregated data adjusting for age, sex, and socio-economic status. After adjusting for age, sex, and economic status, texting at night ($p = 0.002$) was statistically significantly associated with social jetlag. According to the bivariate and crude analysis, it is assumed that sex can be a potential cofounder. However, in the multivariate regression model with and without the variable sex in the model, the effect size was not significantly affected, and thus, sex was not a confounding factor in this regression model.

DISCUSSION

Here, we report a statistically significant association between screen time and social jetlag among adolescents. This result is similar to other studies where screen time was negatively associated with sleep habits (Calamaro et al., 2009; Cain and Gradisar, 2010). A study conducted in the United States has shown an extreme prevalence of bedtime technology use and that this is strongly associated with sleep-related complications (Gradisar et al., 2013). This study claimed that nine out of ten Americans have reported using a technological device before sleeping and that the more interactive the device is (e.g., computer, laptop, cell phone, or video console), the greater the risk of reported sleep problems, including problems sleeping and unrefreshing sleep. Moreover, that study found that watching TV is popular (60% of the total population) before going to sleep (Gradisar et al., 2013). In a systematic review paper that assessed the scientific literature among school-aged children and adolescents regarding the association between screen time and sleep outcomes, 90% of the 67 articles included in the study claimed that screen time is adversely associated with sleep outcomes among adolescents (Hale and Guan, 2015).

A study conducted in the United States suggested that technological device use before sleep is highly prevalent and this is also associated with sleep problems; 72% of the participating adolescents reported using a cell phone before going to sleep (Gradisar et al., 2013). In this study, we found similar results, that night time texting use of cell phones is significantly associated with social jetlag (Gradisar et al., 2013). Studies have identified a statistically significant association between social jetlag and health-related disorders, and they also showed that irregular sleep timing is associated with an unhealthy lifestyle (Roenneberg et al., 2019). Additionally, social jetlag and its association with adverse health outcomes are often studied as a sleep discrepancy, and there is currently no consensus on outcomes (Roenneberg et al., 2019). Therefore, in social jetlag studies, final outcomes are often described in terms of sleep habits. Here, we report a high prevalence of social jetlag and its association with screen time and nighttime texting. Similarly, other studies addressing adolescents and their sleep behavior showed that the use of multiple electronic media was associated with sleep.

In this study, we found a high prevalence of social jetlag, which suggests the need for further studies and the development

TABLE 4 | Multivariate logistic regression analysis between social jetlag with screen time and nighttime texting adjusting by age sex and economic status.

Variables	Male participants		Female participants		Total sample	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Total screen time						
Less than 4 h of screen time	Ref	Ref	Ref	Ref	Ref	Ref
4 h or more of screen time	1.534 (1.095–2.146)^{AE}	0.013	1.691 (1.205–2.373)^{AE}	**0.002***	1.596 (1.258–2.025)^{ASE}	**<0.001***
Nighttime texting						
Less than weekly	Ref	Ref	Ref	Ref	Ref	Ref
Weekly	1.386 (0.912–2.107)^{AE}	0.127	1.857 (1.210–2.848)^{AE}	**0.005***	1.609 (1.193–2.170)^{ASE}	**0.002***

**Statistically significant ($p < 0.05$). ^{A}Adjusted for age. ^{S}Adjusted for sex. ^{E}Adjusted for socio-economic status.*

of intervention/prevention strategies. In a cohort study, 43,880 subjects were followed for 13 years to address any possible association between mortality and both weekday and weekend sleep (Åkerstedt et al., 2019). The authors reported a significant association between mortality and weekday and weekend sleep (Åkerstedt et al., 2019). Short sleep duration during on weekdays had a higher mortality rate if there was no compensation with more sleep on the weekends (Åkerstedt et al., 2019). Here, we concluded that there is a high prevalence of social jetlag and that the study population compensates for their short sleep duration during the weekdays by sleeping more during the weekends. However, social jetlag is often not studied among adolescents, but it is also important to remember that social jetlag is something that affects most people at some point in their life, although adolescents are at relatively greater risk (Wittmann et al., 2006). In a study on sleep behavior among adolescents, after controlling for different emotional behaviors, nighttime use of any electronic device was associated with poorer sleep quality (Woods and Scott, 2016). Nighttime sleep and daytime functioning of adolescents are affected by technology use before sleep (Johansson et al., 2016). Similar studies have reported how nighttime texting habits are associated with disrupted sleep (Garmy and Ward, 2018) and that screen time (television and computer) is associated with sleep behavior (Garmy et al., 2012b) among young people.

Strengths and Limitations

This study focused on one of the newest areas of social epidemiology: adolescent health and technological behavior. Few studies have investigated electronic media use and its impact on social jetlag among adolescents.

This paper has emphasized adolescents and nighttime texting, acknowledging that it has an impact on young people, which is well-known but under-investigated. Moreover, as a cross-sectional study, it is a representative sample of the total population and it had a relatively high participation rate, which is a strength in this study.

In this study, the main aim was to investigate whether the association of inconsistent sleep during weekdays and weekends, known as social jetlag, is associated with screen time and nighttime texting. However, one of the main limitations of this study was that the cross-sectional study design. Thus, this study could not determine a causal relationship between the dependent and independent variables. Moreover, there is no data regarding screen time difference for weekdays and weekends. Another limitation is that this study does not include any data on chronotype which could include a significant aspect in the study. Lastly, the data on night-time texting the frequency of texting has low resolution and does not cover more frequent options.

Implications for Future Research

An in-depth literature review in this arena also showed a lack of research in developing countries. Although there has been some research on social jetlag focusing on ethnic minorities and social jetlag (Anothaisintawee et al., 2018), there have been no significant studies conducted in the developing countries, which should be addressed in future work. However, in developing countries, such research is complicated because electronic media use can be a potential confounding factor for social jetlag. In any future study regarding electronic media use, there should be a greater focus on the influence of social jetlag on eating behavior, composition of the daily diet, and mealtime among different age groups (Mota et al., 2019). Moreover, a detailed study including depressive symptoms and substance use (e.g., coffee or energy beverage consumption) should be included (Chen et al., 2008; Calamaro et al., 2009; Cain and Gradisar, 2010; Pecor et al., 2016). This study has focused on the association, and future studies on this topic should address the clinical significance, the magnitude of the association, and the causality of social jetlag. Future research requires a methodological approach to addressing the causal pathways between screen time, nighttime texting, and sleep. Future research should also focus on more characteristics related to screen-use that can potentially cause behavioral changes, such as timing, duration, screen size, volume, and closeness to face (Åkerstedt et al., 2019). In conclusion, future research needs to develop and measure the impact and magnitude of this problem to generate youth-appropriate public health messaging and interventions that will reduce the risk of screen time and nighttime texting before or during bed and their potential consequence on sleep, health, and well-being.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Regional Ethical Review Board in Lund, EPN 2015/113. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

PG designed the research. MH and PG analyzed the data. MH wrote the first draft of the manuscript. MH and PG revised the manuscript and approved the final version.

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REFERENCES

Åkerstedt, T., Ghilotti, F., Grotta, A., Zhao, H., Adami, H. O., Trolle-Lagerros, Y., et al. (2019). Sleep duration and mortality–Does weekend sleep matter? *J. Sleep Res.* 28:e12712. doi: 10.1111/jsr.12712

Almoosawi, S., Palla, L., Walshe, I., Vingeliene, S., and Ellis, J. (2018). Long sleep duration and social jetlag are associated inversely with a healthy dietary pattern in Adults: results from the UK National Diet and Nutrition Survey Rolling Programme Y1–4. *Nutrients* 10:E1131. doi: 10.3390/nu10091131

Anothaisintawee, T., Lertrattananon, D., Thakkinstian, A., and Reutrakul, S. (2018). The relationship among morningness-eveningness, sleep duration, social jet lag and body mass index in Asian patients with prediabetes. *Front. Endoctinol.* 9:435. doi: 10.3389/fendo.2018.00435

Baert, S., Omey, E., Verhaest, D., and Vermeir, A. (2015). Mister Sandman, bring me good marks! On the relationship between sleep quality and academic achievement. *Soc. Sci. Med.* 130, 91–98. doi: 10.1016/j.socscimed.2015.02.011

Cain, N., and Gradisar, M. (2010). Electronic media use and sleep in school-aged children and adolescents: a review. *Sleep Med.* 11, 735–742. doi: 10.1016/j.sleep.2010.02.006

Calamaro, C. J., Mason, T. B., and Ratcliffe, S. J. (2009). Adolescents living the 24/7 lifestyle: effects of caffeine and technology on sleep duration and daytime functioning. *Pediatrics* 123:e1005–10. doi: 10.1542/peds.2008-3641

Calhoun, S. L., Fernandez-Mendoza, J., Vgontzas, A. N., Liao, D., and Bixler, E. O. (2014). Prevalence of insomnia symptoms in a general population sample of young children and preadolescents: gender effects. *Sleep Med.* 15, 91–95. doi: 10.1016/j.sleep.2013.08.787

Catrett, C. D., and Gaultney, J. F. (2009). Possible insomnia predicts some risky behaviors among adolescents when controlling for depressive symptoms. *J. Genetic Psychol.* 170, 287–309. doi: 10.1080/00221320903218331

Chen, X., Beydoun, M. A., and Wang, Y. (2008). Is sleep duration associated with childhood obesity? A systematic review and meta−analysis. *Obesity* 16, 265–274. doi: 10.1038/oby.2007.63

Garmy, P., Jakobsson, U., and Nyberg, P. (2012a). Development and psychometric evaluation of a new instrument for measuring sleep length and television and computer habits of Swedish school-age children. *J. Sch. Nurs.* 28, 138–143. doi: 10.1177/1059840511420878

Garmy, P., Nyberg, P., and Jakobsson, U. (2012b). Sleep and television and computer habits of Swedish school-age children. *J. Sch. Nurs.* 28, 469–476. doi: 10.1177/1059840512444133

Garmy, P., and Ward, T. M. (2018). Sleep habits and nighttime texting among adolescents. *J. Sch. Nurs.* 34, 121–127. doi: 10.1177/1059840517704964

Genuneit, J., Brockmann, P. E., Schlarb, A. A., and Rothenbacher, D. (2018). Media consumption and sleep quality in early childhood: results from the Ulm SPATZ Health Study. *Sleep Med.* 45, 7–10. doi: 10.1016/j.sleep.2017.10.013

Gore, F. M., Bloem, P. J., Patton, G. C., Ferguson, J., Joseph, V., Coffey, C., et al. (2011). Global burden of disease in young people aged 10–24 years: a systematic analysis. *Lancet* 377, 2093–2102. doi: 10.1016/S0140-6736(11)60512-6

Gradisar, M., Gardner, G., and Dohnt, H. (2011). Recent worldwide sleep patterns and problems during adolescence: a review and meta-analysis of age, region, and sleep. *Sleep Med.* 12, 110–118. doi: 10.1016/j.sleep.2010.11.008

Gradisar, M., Wolfson, A. R., Harvey, A. G., Hale, L., Rosenberg, R., and Czeisler, C. A. (2013). The sleep and technology use of Americans: findings from the National Sleep Foundation's 2011 Sleep in America poll. *J. Clin. Sleep Med.* 9, 1291–1299. doi: 10.5664/jcsm.3272

Gregory, A. M., Caspi, A., Moffitt, T. E., and Poulton, R. (2009). Sleep problems in childhood predict neuropsychological functioning in adolescence. *Pediatrics* 123, 1171–1176. doi: 10.1542/peds.2008-0825

Gupta, N. K., Mueller, W. H., Chan, W., and Meininger, J. C. (2002). Is obesity associated with poor sleep quality in adolescents? *Am. J. Hum. Biol.* 14, 762–768. doi: 10.1002/ajhb.10093

Hale, L., and Guan, S. (2015). Screen time and sleep among school-aged children and adolescents: a systematic literature review. *Sleep Med. Rev.* 21, 50–58. doi: 10.1016/j.smrv.2014.07.007

Johansson, A. E., Petrisko, M. A., and Chasens, E. R. (2016). Adolescent sleep and the impact of technology use before sleep on daytime function. *J. Pediatr. Nurs.* 31, 498–504. doi: 10.1016/j.pedn.2016.04.004

Kabali, H. K., Irigoyen, M. M., Nunez-Davis, R., Budacki, J. G., Mohanty, S. H., Leister, K. P., et al. (2015). Exposure and use of mobile media devices by young children. *Pediatrics* 136, 1044–1050. doi: 10.1542/peds.2015-2151

Komada, Y., Ikeda, Y., Sato, M., Kami, A., Masuda, C., and Shibata, S. (2019). Social jetlag and menstrual symptoms among female university students. *Chronobiol. Int.* 36, 258–264. doi: 10.1080/07420528.2018.1533561

Koopman, A. D., Rauh, S. P., van 't Riet, E., Groeneveld, L., Van Der Heijden, A. A., Elders, P. J., et al. (2017). The association between social jetlag, the metabolic syndrome, and type 2 diabetes mellitus in the general population: the New Hoorn study. *J. Biol. Rhythm* 32, 359–368. doi: 10.1177/0748730417713572

Kryger, M., Roth, G., Eloni, D., and Dement, W. (2011). *Principles and Practice of Sleep Medicine*. Canada: Elsevier.

Langberg, J. M., Molitor, S. J., Oddo, L. E., Eadeh, H.-M., Dvorsky, M. R., and Becker, S. P. (2017). Prevalence, patterns, and predictors of sleep problems and daytime sleepiness in young adolescents with ADHD. *J. Attention Dis.* 24:1087054717690810. doi: 10.1177/1087054717690810

Levandovski, R., Dantas, G., Fernandes, L. C., Caumo, W., Torres, I., Roenneberg, T., et al. (2011). Depression scores associate with chronotype and social jetlag in a rural population. *Chronobiol. Int.* 28, 771–778. doi: 10.3109/07420528.2011.602445

Mathew, G. M., Hale, L., and Chang, A.-M. (2019). Sex moderates relationships among school night sleep duration, social jetlag, and depressive symptoms in adolescents. *J. Biol. Rhythm.* 34, 205–217. doi: 10.1177/0748730419828102

Milde-Busch, A., von Kries, R., Thomas, S., Heinrich, S., Straube, A., and Radon, K. (2010). The association between use of electronic media and prevalence of headache in adolescents: results from a population-based cross-sectional study. *BMC Neurol.* 10:12. doi: 10.1186/1471-2377-10-12

Mota, M. C., Silva, C. M., Balieiro, L. C. T., Gonçalves, B. F., Fahmy, W. M., and Crispim, C. A. (2019). Association between social jetlag food consumption and meal times in patients with obesity-related chronic diseases. *PLoS ONE* 14:e0212126. doi: 10.1371/journal.pone.0212126

Oginska, H., and Pokorski, J. (2006). Fatigue and mood correlates of sleep length in three age−social groups: school children, students, and employees. *Chronobiol. Int.* 23, 1317–1328. doi: 10.1080/07420520601089349

Patton, G. C., Sawyer, S. M., Ross, D. A., Viner, R. M., and Santelli, J. S. (2016). From advocacy to action in global adolescent health. *J. Adolesc. Health.* 59, 375–377. doi: 10.1016/j.jadohealth.2016.08.002

Patton, G. C., Viner, R. M., Linh, L. C., Ameratunga, S., Fatusi, A. O., Ferguson, B. J., et al. (2010). Mapping a global agenda for adolescent health. *J. Adolesc. Health* 47, 427–432. doi: 10.1016/j.jadohealth.2010.08.019

Pecor, K., Kang, L., Henderson, M., Yin, S., Radhakrishnan, V., and Ming, X. (2016). Sleep health, messaging, headaches, and academic performance in high school students. *Brain Dev.* 38, 548–553. doi: 10.1016/j.braindev.2015.12.004

Reinberg, A., and Ashkenazi, I. (2008). Internal desynchronization of circadian rhythms and tolerance to shift work. *Chronobiol. Int.* 25, 625–643. doi: 10.1080/07420520802256101

Roenneberg, T., Pilz, L. K., Zerbini, G., and Winnebeck, E. C. (2019). Chronotype and social jetlag: a (self-) critical review. *Biology* 8:E54. doi: 10.3390/biology8030054

Short, M. A., and Louca, M. (2015). Sleep deprivation leads to mood deficits in healthy adolescents. *Sleep Med.* 16, 987–993. doi: 10.1016/j.sleep.2015.03.007

Stoner, L., Beets, M. W., Brazendale, K., Moore, J. B., and Weaver, R. G. (2018). Social jetlag is associated with adiposity in children. *Global Ped. Health* 5:2333794X18816921.

Thomas, S., Heinrich, S., Kühnlein, A., and Radon, K. (2010). The association between socioeconomic status and exposure to mobile telecommunication networks in children and adolescents. *Bioelectromagnetics* 31, 20–27. doi: 10.1002/bem.20522

Touitou, Y. (2013). Adolescent sleep misalignment: a chronic jet lag and a matter of public health. *J. Physiol-Paris.* 107, 323–326. doi: 10.1016/j.jphysparis.2013.03.008

Touitou, Y., and Haus, E. (2012). *Biologic Rhythms in Clinical and Laboratory Medicine*. Berlin: Springer Science.

Touitou, Y., Motohashi, Y., Reinberg, A., Touitou, C., Bourdeleau, P., Bogdan, A., et al. (1990). Effect of shift work on the night-time secretory patterns of melatonin, prolactin, cortisol and testosterone. *Eur. J. Appl. Physiol. Occupat. Physiol.* 60, 288–292. doi: 10.1007/bf00379398

Waterhouse, J., Nevill, A., Finnegan, J., Williams, P., Edwards, B., Kao, S. Y., et al. (2005). Further assessments of the relationship between jet lag and some of its symptoms. *Chronobiol. Int.* 22, 121–136. doi: 10.1081/cbi-200036909

Wittmann, M., Dinich, J., Merrow, M., and Roenneberg, T. (2006). Social jetlag: misalignment of biological and social time. *Chronobiol. Int.* 23, 497–509. doi: 10.1080/07420520500545979

Wong, P. M., Hasler, B. P., Kamarck, T. W., Muldoon, M. F., and Manuck, S. B. (2015). Social jetlag, chronotype, and cardiometabolic risk. *J. Clin. Endocrinol. Metab.* 100, 4612–4620. doi: 10.1210/jc.2015-2923

Woods, H. C., and Scott, H. (2016). # Sleepyteens: social media use in adolescence is associated with poor sleep quality, anxiety, depression and low self-esteem. *J. Adolesc.* 51, 41–49.

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Impact of Cumulative Unhealthy Sleep Practices in Adolescence on Substance Use in Young Adulthood Estimated Using Marginal Structural Modeling

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Objectives: The purpose of this study was to identify the impact of chronic, unhealthy sleep practices in adolescence on substance use in young adulthood. Unhealthy sleep practices in adolescent samples exhibit a bidirectional relationship with substance use. The relationship is further complicated if we consider that confounders such as depression vary over time and are often in response to adolescents' prior poor sleep practice, which can be addressed by a counterfactual approach using a marginal structural model.

Methods: Data in this study are from the Taiwan Youth Project, a longitudinal study that started in 2000 and surveyed 2,690 7th grade students at age 13. Outcomes include frequency of cigarette smoking and alcohol drinking at age 21. Three unhealthy sleep practices were included in this study: short sleep, social jetlag, and sleep disturbance. We used a marginal structural model with stabilized inverse probability-of-treatment weights to address time-varying confounders in each wave and a total sample of 1,678 adolescents with complete information for this study.

Results: Accumulated waves of sleep disturbance and social jetlag in adolescence were significantly associated with cigarette use in young adulthood. Accumulated social jetlag but not sleep disturbance was also associated with alcohol use in adulthood. Accumulated waves of short sleep were not associated with later alcohol use, but were negatively correlated with cigarette use.

Conclusion: Interventions that aim to reduce the likelihood of substance use in young adulthood should consider confronting unhealthy sleep practices, in particular the discrepancy between bedtimes on school days and weekends and sleep disturbance.

Keywords: insufficient sleep, cigarette use, alcohol use, adolescent, marginal structural model

INTRODUCTION

Unhealthy sleep practices, such as sleep insufficiency and social jetlag, are common problems in adolescents related to adverse consequences such as depression, mood disturbances, obesity, and risk-taking behaviors by causing poor judgment and decision-making skills, lack of motivation, and inattention (Owens and Group, 2014; Shochat et al., 2014; Diaz-Morales and Escribano, 2015). Factors that contribute to poor sleep practices in adolescents include but are not limited to increasing media screen time (Twenge et al., 2017), mental health (Lund et al., 2010), and school start time (Gradisar et al., 2011). The definition and measurement of sleep practices relied on using sleep schedule and sleep time to calculate sleep duration (Nascimento-Ferreira et al., 2016). Sleep insufficiency is often defined by short sleep durations, and is sometimes complemented by daytime sleepiness such as daytime napping or weekend oversleeping (Owens and Group, 2014). It is often recommended that adolescents should have 8 h or more for getting sufficient sleep (Owens and Group, 2014). Social jetlag refers to the differences in the timing of sleep that has been interfered with by social schedules, such as the discrepancy between school and free days (Diaz-Morales and Escribano, 2015). The negative impact of poor sleep practices among adolescents is receiving more global attention due to the alarmingly low average sleep time (i.e., less than 8 h) and poor sleep quality (Mesquita and Reimao, 2010; Gradisar et al., 2011; Chen and Gau, 2016; Zhang et al., 2017; Lima and Silva, 2018), especially in Asian samples (Yang et al., 2005; Chung and Cheung, 2008; Liu et al., 2008; Xu et al., 2012).

The initiation of substance use often occurs during adolescence (Montes et al., 2019), which makes adolescence a critical intervention period for substance use. Distinguishing the potential influence of unhealthy sleep practices on substance use can provide insights to reduce substance use among adolescents. Several cross-sectional studies have shown an association between insufficient sleep and substance use in adolescents (O'Brien and Mindell, 2005; Yen et al., 2010; McKnight-Eily et al., 2011). Sleeping less than 8 h per night was associated with smoking and alcohol consumption in a U.S. adolescent sample (McKnight-Eily et al., 2011). Sleep duration at night below the 15th percentile of the study population was associated with high odds of alcohol drinking among Taiwanese adolescents (Yen et al., 2008). Further evidence of the impact of unhealthy sleep practices on substance use was provided by longitudinal studies. For example, a recent longitudinal study identified that erratic sleep/wake and more daytime sleepiness were associated with higher levels of lifetime use of all substances, and that higher evening chronotype tendencies were associated with lower cigarette and higher alcohol use (Nguyen-Louie et al., 2018). Another study found that shorter sleep duration and greater daytime sleepiness were associated with higher odds of later alcohol use (Miller et al., 2017).

Although some longitudinal evidence exists to understand the effect of unhealthy sleep practices on substance use, such a longitudinal relationship, cannot be teased out without considering time-dependent confounders such as depression (Robins et al., 2000). For example, depression in adolescents is also associated with later substance use (Conway et al., 2016) and can be affected by prior poor sleep practice (Owens and Group, 2014). Other confounders such as academic performance and self-rated health were also associated with both sleep practices and substance use (Diego et al., 2003; Curcio et al., 2006; Ortiz-Hernandez et al., 2009; Conklin et al., 2019). A failure to control for confounders, which are affected by prior treatment, and a risk factor for the outcome such as substance use in our study, would introduce a biased estimate of the association (Robins et al., 2000).

In this study, we used a marginal structural model to address the issue of time-varying confounders. Marginal structural models were used for observational data to estimate the causal effects of an exposure that changes with time. The covariates in this model also changed with time and could play a role both as confounders and mediators (Robins et al., 2000). The application of a marginal structural model has been used in several research fields such as epidemiology, criminology, and medicine (Petersen et al., 1983; Yi et al., 2009; Lin and Yi, 2015). We aim to examine the impact of cumulative sleep insufficiency in adolescence on cigarette smoking or alcohol drinking in young adulthood in a sample of Taiwanese adolescents that have been followed for 17 years. A hypothesized conceptual framework is depicted in **Figure 1** denoting the relationships between cumulative unhealthy sleep practices and the frequency of smoking and drinking at age 21. We also tested various types of unhealthy sleep practices that resulted in sleep insufficiency, including short duration of sleep, social jetlag, and sleep disturbance. We hypothesized that chronic, unhealthy sleep practices have an impact on cigarette smoking and alcohol drinking in young adulthood after adjusting for time-varying confounders such as depression, academic achievement, and self-rated health. We also compared the estimates from conventional regression analyses with marginal structural models.

MATERIALS AND METHODS

Participants

Data in this study were from the Taiwan Youth Project (TYP) (Yi et al., 2009). TYP was a longitudinal study that started in 2000 and surveyed two cohorts of 7th (J1) and 9th (J3) grade students from northern Taiwan (Yi et al., 2009). TYP used a multistage-stratified and class-clustered method to randomly select 40 schools and 81 classes in each grade (Yi et al., 2009). Only the J1 cohort, 2,690 7-grade participants, was used for this study. For this study, we used data from waves 1 (year 2000, age = 13, n = 2,690), 2 (year 2001, age = 14, n = 2,683), 3 (year 2002, age = 15, n = 2,664), 6 (year 2005, age = 18, n = 1,826), 8 (year 2007, age = 20, n = 1,739) and 9 (year 2009, age = 21, n = 1,875). We excluded students who had ever smoked or drank alcohol in 1st wave (n = 206) and those who failed to complete the questions about frequency of cigarette use and alcohol use at wave 9 (n = 806). Finally, the sample used for analysis in the present study was 1,678 participants. The excluded sample was not statistically different in gender, level of urbanization of school, township type of school location and father's ethnic origin compared to the 1,678 participants used

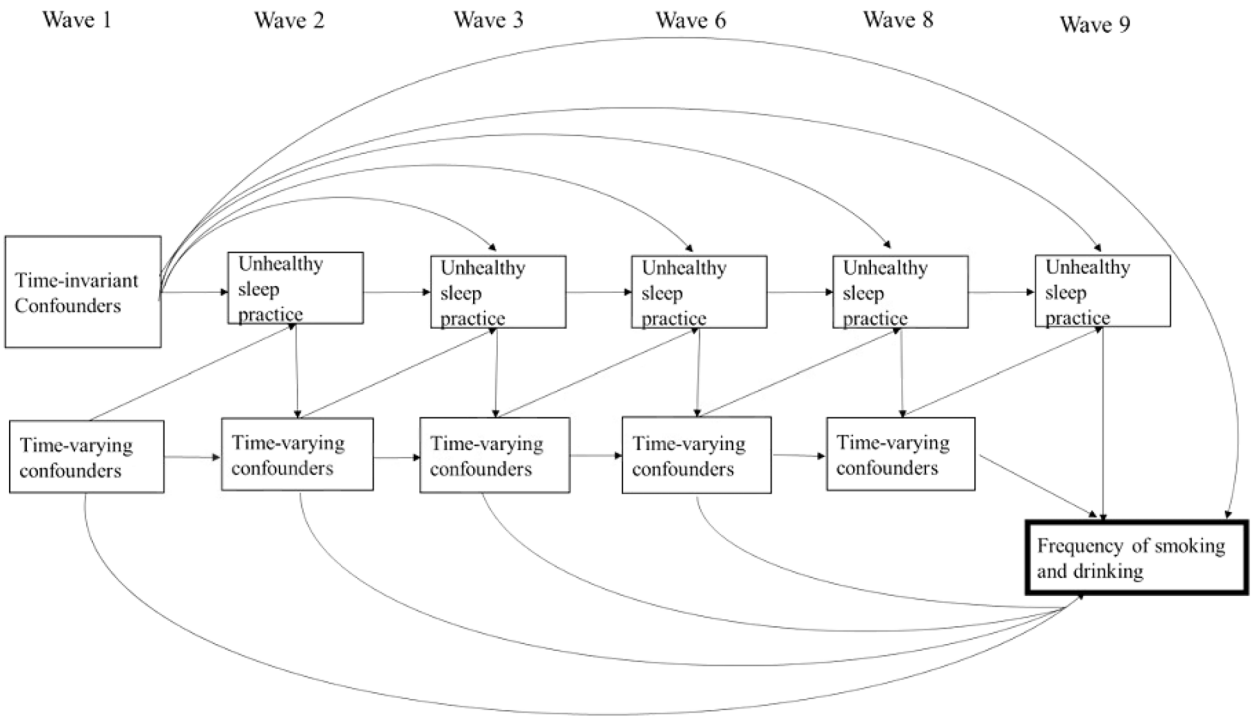

FIGURE 1 | Conceptual framework denoting the relationships between cumulative unhealthy sleep practices in wave 2 to 9 and frequency of smoking and drinking at age 21. Sleep practices of adolescents were affected by sleep practices and time-varying confounders in the previous waves. Time-invariant confounders included gender, level of urbanization of school, township type of school location, pubertal timing, expected academic achievement, and father's ethnic origin. Time-varying confounders included depression, self-related health, academic achievement, attending cram school, smoking and drinking status, and living with parents or not. Time-varying confounders not only affect unhealthy practice for the next wave, but also the following wave, which were omitted for the clarity of the graph.

for the analysis in this study. The study protocol was approved by the Human Ethics Committee at the National Cheng Kung University Hospital (B-ER-107-028).

Measures

Dependent Variables (Cigarette and Alcohol Use at Wave 9)

Participants were asked how many packs of cigarettes they smoked in the past week on a scale from never to at or above 7 packs and how many times they drank alcohol in the past month on a scale from never to at or above 7 times at age 21. The frequency of substance use was treated as a continuous variable.

Independent Variable (Unhealthy Sleep Practices)

Three unhealthy sleep practices were assessed in this study: short sleep, social jetlag, and sleep disturbance; all of these were measured at wave 2, 3, 6, 8, and 9. In each wave, the participants were asked what time they went to bed and got up on weekdays and what time they went to bed and got up on weekends. A weekly average was calculated first by adding up the total hours of sleep within a week and then dividing by seven. We defined short sleep as less than an average of 8, 7, or 6 h per night in a week. We used various cutoffs because the definition of sleep insufficiency varies by culture and time period (Nascimento-Ferreira et al., 2016). Although it is often recommended to have 8 h or more for getting sufficient sleep for adolescents (Owens and Group, 2014), since the average sleep time was quite low in several Asian samples (Yang et al., 2005; Chung and Cheung, 2008; Liu et al., 2008; Xu et al., 2012), we decided that the cutoff should not only consider the recommended 8-h but also included other cutoffs, such as 7- and 6-h, in the analysis. Cumulative short sleep was the sum of waves of short sleep from wave 2 to 9. Social jetlag was calculated by subtracting weekday bedtime from weekend bedtime, a definition used by previous studies (Lin and Yi, 2015; Jankowski, 2017). A positive score indicated that students went to bed later on the weekends. Dichotomized social jetlag was defined with three cutoffs: at or above 2, 1, or 0.5 h. Cumulative social jetlag was a sum of waves of social jetlag from wave 2 to 9. Finally, we used three items to capture the students' sleep disturbance: insomnia or difficulty falling asleep, waking early and unable to go back to sleep, and disturbed night sleep or waking up often during the night. The response categories ranged from "it does not happen" (0) to "it happens to me and is very serious" (4). The sleep disturbance items were similar to those described in the Sleep Quality Index (SIQ) (Cronbach's α = 0.60–0.71) (Yi et al., 2009; Lin and Yi, 2015). Sleep disturbance for each wave was indicated by a sum score. Cumulative sleep disturbance was the sum of waves of sleep disturbance from waves 2 to 9.

Time-Invariant Covariates (Wave 1)

Gender

Students were either male or female.

Level of urbanization of school
There are geographical and urbanity differences in Taiwan in prevalence of substance use behavior (Chen et al., 2017). School location was on a scale of 1 (rural/Yilan County) to 3 (urban/Taipei City) based on the stratification of Taiwan administrative districts (Yi et al., 2009).

Township type of school location
The township type of school location was classified on a scale of seven types of townships: core city, general city, emerging towns, traditional industrial towns, general towns, aging towns, or remote area (Yi et al., 2009).

Pubertal timing
The Pubertal Development Scale (PDS) was used to measure the participants' pubertal timing (Petersen et al., 1983). The PDS used five items: height spurt, body hair development, skin changes, breast growth/deepening of voice, and menarche/facial hair development. Except for menarche, which was a dichotomous item ("yes" or "no"), all other items were rated using a 4-point Likert scale. The internal consistency of the PDS is acceptable in boys (α = 0.68–0.78) and girls (α = 0.76–0.83) (Petersen et al., 1988), and α = 0.681 for boys and α = 0.713 for girls in Taiwan sample, which included 1,378 boys and 1,312 girls (Tsai et al., 2015b). Based on standardized same-gender PDS scores, the participants were classified into three pubertal timing groups: early puberty (more than 1 standard deviation [SD] above), on-time puberty (within 1 SD either way), and late-puberty (more than 1 SD below) (Negriff et al., 2011; White et al., 2012; Tsai et al., 2015a,b).

Expected academic achievement
Expected academic achievement may indicate the level of parental monitoring (Pinquart, 2016), which may affect adolescents' bedtime (Gunn et al., 2019) and substance use (Smith et al., 2017). Students were asked the educational level they desired if there were no restrictions. We dichotomized the answers into "college graduate or above" and "below college."

Father's ethnic origin
Father's ethnicity was categorized as Weinan Islanders, Hakka, mainlanders, original residents, or others.

Time-Varying Covariates

Depression (waves 1, 2, 3, 6, and 8)
A short version of the Symptom Checklist-90-Revised (SCL-90-R) consisted of seven items: headache, lonely, depressed, weakness in certain parts of the body, numbness/tingling pain in certain parts of the body, feeling like the throat is clogged, and insomnia (Derogatis, 1983; Lin and Yi, 2015). Adolescents were asked whether they had experienced these symptoms in the past week and how serious the experience was in the past week on a scale of 0 (no) to 4 (yes, very serious). An average score of 6 items (not including insomnia) divided the adolescents into four groups: 0, at or less than 1, at or less than 2, and more than 2.

Self-related health (waves 1, 2, 3, 6, and 8)
Adolescents were asked how they felt about their health; response categories ranged from 1 (excellent) to 5 (very bad). We classified them as "good" when they chose excellent, very good or good, and "bad" when they chose not very good or very bad.

Academic achievement (waves 1, 2, 3, and 6)
Students were asked to self-report their ranking in class. We divided them into two group: rank 1st to 5th and others.

Attended cram school (waves 1, 2, 3, and 6) or had a job (waves 6 and 8)
Cram schools are private after-school programs for students to achieve better academic performance. Students were asked whether they were attending cram school or had been working in the past year.

Self smoking and drinking status (waves 2, 3, 6, and 8)
Students were asked whether or how often they smoked or drank in the past year. Answers were categorized as yes if they have smoked or drank and no if not.

Peer smoking and drinking status (waves 2, 3, 6, and 8)
Students were asked whether or how often their peers smoked or drank in the past year. Answers were categorized as yes if they have smoked or drank and no if not.

Living with parents (waves 1, 2, and 3)
Answers were categorized as living with parents or not.

Statistical Analysis

We first used conventional linear regression analyses, controlling for the confounders (includes time-invariant covariates and time-varying covariates at wave 1, and the other two sleep variables) to analyze the relationship between accumulated waves of unhealthy sleep practices and the frequency of cigarette and alcohol use in wave 9 (Model 1).

We then conducted an analysis using marginal structural logistic regression models to examine the frequency of cigarette smoking and alcohol use in young adulthood (21 years) as a function of cumulative unhealthy sleep practices during adolescence and time-invariant covariates. Adjustment for time-varying covariates was achieved through the use of inverse probability-of-treatment weights (IPW) (Robins et al., 2000). We calculated the probability of the unhealthy sleep practices in subsequent waves by using logistic regression. The inverse of this probability was used to weight each respondents' contribution to a pseudo-population in which time-varying covariates were balanced in expectation across the healthy sleep practices.

Because the variables were either nominal or ordinal, we used "indicator variable analysis" to deal with item non-response missing data (Faries et al., 2014). We substituted these missing data with a number to represent an additional category of each variable. We considered participants who were lost-to-follow-up as exposed to another treatment. In wave 1 and wave 9, there were 1,678 students; 5, 15, 353, and 295 students were attritions in wave 2, 3, 6, and 8, respectively. Using inverse probability attrition weighted (IPAW) estimation, the probability of lost-to-follow-up was considered the same (Goldstein, 2009).

We used marginal structural models to estimate the effects of each additional wave of unhealthy sleep practices on the frequency of cigarette smoking and alcohol use in wave 9

(**Figure 1**). That is, we used stabilized IPWs (Model 2) and further added the other two sleep variables as the time-varying covariates to calculate adjusted stabilized IPWs (Model 3). The IPTWs were multiplied by IPAWs to get a correct weight, and the marginal structural models were fitted using a conventional linear regression model that did not include the time-varying covariates as controls. All of the analyses were computed by SAS Enterprise Guide, version 9.4, computer software.

RESULTS

Tables 1, **2** present descriptive statistics for the time-invariant and time-varying sample characteristics. Half of the participants were male and at wave 1 when they aged 13, 58.6% were at late puberty and 34.6% were categorized as on-time puberty (**Table 1**). At wave 9, when they aged 21, participants smoked 0.57 packs of cigarettes per week on average and drank 0.92 times per month (**Table 2**). The majority of participants did not smoke or drink: 85.2% did not smoke and 60.1% did not drink alcohol at wave 9.

At wave 1, sleep disturbance was significantly correlated with social jetlag and short duration of sleep; short duration of sleep was not correlated with social jetlag. There are similar proportions of participants suffering sleep disturbance in waves 2, 3, 6, 8, and 9 (43.4–59.9%). In most waves, half of the participants had short sleep defined as less than 8 h. Participants (ranging from 14% to 34.5%) had short sleep defined as less than 7 h. About half of the participants had social jetlag greater than or equal to 1 h (46.9–64.7%).

TABLE 1 | Time-invariant sample characteristics.

	At Wave 1 (n = 1678)
Variables	%
Gender	
Male	50.4
Female	49.6
Level of urbanization of school	
Taipei City	37.7
New Taipei City	37.9
Yilan County	24.4
Township type of school location	
Core city	48.2
General city	27.5
Emerging towns	13.5
General towns	8.1
Aging towns	2.6
Pubertal timing	
Early puberty	6.8
On-time puberty	34.6
Late-puberty	58.6
Expected academic achievement	
At or under junior college	24.3
At or above college	74.3
Father's ethnic origin	
Weinan Islanders	77.5
Hakka	8.1
Mainlanders	11.9
Original residents	0.8
Others	1.6

Sleep Disturbance

In the conventional linear regression model (Model 1 in **Table 3**), accumulated waves of sleep disturbance could increase the times of alcohol use per month (β = 0.071, 95% CI = 0.020, 0.122), but they were not associated with the frequency of cigarette smoking. In the marginal structural models, sleep disturbance significantly increased the packs of cigarettes smoked per week (stabilized weights in Model 2: β = 0.076, 95% CI = 0.019, 0.133; adjusted stabilized weights in Model 3: β = 0.074, 95% CI = 0.017, 0.130), but were not associated with times of alcohol use per month (**Table 3**).

Short Duration of Sleep

In the conventional linear regression model (Model 1 in **Table 4**), accumulated waves of short sleep—no matter whether the sleep duration was less than 8, 7, or 6 h—were not associated with the frequency of cigarette smoking and alcohol use. However, using IPTW, when the sleep duration was less than 8 h, each additional wave had decreased packs of cigarette smoking per week (stabilized weights in Model 2: β = −0.106, 95% CI: −0.17, −0.042; adjusted stabilized weights in Model 3: β = −0.107, 95% CI: −0.171, −0.043), but had no significant effect on alcohol use. When the sleep duration was less than 7 h, each additional wave had decreased packs of cigarette smoking per week (stabilized weights in Model 2: β = −0.081, 95% CI: −0.159, −0.002), but had no significant effect on alcohol use. Sleep duration less than 6 h for each additional wave increased the times of alcohol use per month after adjusting for the other two unhealthy sleep practices as time-varying confounders (adjusted stabilized weights in Model 3: β = 0.196, 95% CI = 0.035, 0.357), but had no significant effect on cigarette smoking (**Table 4**).

Social Jetlag

By the marginal structural models, accumulated waves of social jetlag increased the packs of cigarette smoking per week and the times of alcohol use per month, regardless of whether the differences of bedtime between weekday and weekend were longer than 0.5, 1, or 2 h. However, some of the effects could not be observed in the conventional linear regression analysis. We also found that the larger social jetlag was, the higher the frequency of cigarette smoking and alcohol use (**Table 5**).

DISCUSSION

Using IPTWs in marginal structural model analyses, we found that accumulated waves of sleep disturbance and social jetlag in adolescence were significantly associated with an increase of cigarette use in young adulthood. Accumulated social jetlag—but not sleep disturbance—was also associated with an increase of alcohol use in adulthood. Accumulated waves of short sleep were not associated with a later increase of alcohol use unless it was less

TABLE 2 | Time-varying sample characteristics.

	Wave 1 (*n* = 1,673)	Wave 2 (*n* = 1,673)	Wave 3 (*n* = 1,663)	Wave 6 (*n* = 1,325)	Wave 8 (*n* = 1,383)	Wave 9 (*n* = 1,678)
		%	%	%	%	Mean ± SE or %
Independent variables						
Sleep disturbance (sum score > 0)		44.6	55.8	43.4	59.9	53.3
Short sleep						
<8 h		50.5	64.9	71.8	48.4	45.2
<7 h		14.5	27.5	34.5	18.6	15.3
<6 h		3.1	7.6	8.5	3.4	3.5
Social jetlag						
≥0.5 h		83.7	78.5	65.4	68.4	65.1
≥1 h		64.7	58.5	46.9	55.8	49.7
≥2 h		26.1	21.4	15.3	18.8	16.0
Dependent variables						
Cigarette smoking (packs/week)						0.57 ± 1.63
Alcohol use (times/month)						0.92 ± 1.49
Time-varying covariates						
Depression, %						
0	33.2	27.6	21.5	24.7	22.0	
At or less than 1	58.1	62.2	61.3	59.1	59.1	
At or less than 2	7.9	9.7	16.1	15.2	17.1	
More than 2	0.7	0.5	1.14	1.1	1.8	
Self-related health (bad, %)	13.6	6.2	6.6	7.0	14.8	
Academic achievement (within the top five grades, %)	17.0	17.4	17.9	17.0		
Attended cram school (Yes, %)	67.4	58.7	54.1	43.8		
SELF smoking and drinking status (Yes, %)		7.8	5.6	29.5	32.3	
PEER smoking and drinking status (Yes, %)		0.84		31.6	42.9	
Living with parents (Yes)	89.2	88.8	87.7			
Had a job (Yes, %)				14.8	46.0	

TABLE 3 | Accumulated waves of sleep disturbance and frequency of smoking and drinking.

	Packs of cigarette smoking per week	Times of alcohol use per month
	β (95% CI)	β (95% CI)
Model 1	0.043 (− 0.010, 0.095)	0.071 (0.020, 0.122)**
Model 2	0.076 (0.019, 0.133)**	0.045 (− 0.008, 0.097)
Model 3	0.074 (0.017, 0.130)*	0.045 (− 0.007, 0.097)

*Model 1: conventional linear regression analyses, controlling for the confounders including time-invariant covariates and time-varying covariates at wave 1, and the other two sleep variables. Model 2: used stabilized inverse probability attrition weighted (IPTW). Model 3: Model 2 further added the other two sleep variables as the time-varying covariates to calculate adjusted stabilized IPTW. *p < 0.05, **p < 0.01.*

than 6 h of sleep per night; however, in our sample, short sleep was associated with less likelihood of cigarette smoking at age 21. With careful consideration of time-varying confounders and the temporal ordering of relationships, our study showed that not all unhealthy sleep practices were associated with later substance use in Taiwanese adolescents.

We found consistent evidence that cumulative social jetlag was associated with increased cigarette and alcohol use, which is consistent with the literature (O'Brien and Mindell, 2005; Pasch et al., 2010). One of the reasons may be peer influence. Social network analysis has demonstrated that both poor sleep behavior and substance use behavior can be spread in adolescents' networks and that the two behaviors are correlated (Mednick et al., 2010). There may be social activities in peer groups that affect both adolescents' sleep schedules on weekends and their smoking and drinking behaviors such as hanging out in entertainment venues past average bedtime and substance use with peers. However, more studies were needed to verify whether sleep behavior and substance use behavior can be spread in adolescents in different samples. It may also be due to the biological mechanism: the disruption of adolescent's circadian rhythm may predispose them to more alcohol and cigarette use by altering the reward function in the brain development (Hasler et al., 2015). Social jetlag may negatively affect an individual's endocrine and behavioral risk profile such as being more physically inactive or having an increased resting heart rate (Rutters et al., 2014), which may later be associated with increased depression and substance use. Intervening for social jetlag in adolescent populations is likely to reduce the likelihood of substance use in young adulthood.

The significant impact of short sleep on the decrease of cigarette use is a major difference in our sample that contrasts

TABLE 4 | Accumulated waves of short sleep and frequency of smoking and drinking.

		Packs of cigarette smoking per week	Times of alcohol use per month
		β(95% CI)	β (95% CI)
<8 h	Model 1	−0.008 (− 0.063, 0.046)	0.018 (− 0.035, 0.071)
	Model 2	−0.106 (− 0.170, −0.042)**	−0.009 (− 0.067, 0.049)
	Model 3	−0.107 (− 0.171, −0.043)**	0.004 (− 0.055, 0.062)
<7 h	Model 1	0.010 (− 0.059, 0.079)	0.036 (− 0.031, 0.103)
	Model 2	−0.081 (− 0.159, −0.002)*	0.046 (− 0.028, 0.121)
	Model 3	−0.064 (− 0.146, 0.017)	0.053 (− 0.023, 0.129)
<6 h	Model 1	0.031 (− 0.103, 0.165)	0.020 (− 0.110, 0.149)
	Model 2	−0.056 (− 0.222, 0.111)	0.116 (− 0.037, 0.268)
	Model 3	−0.048 (− 0.227, 0.130)	0.196 (0.035, 0.357)*

*Model 1: conventional linear regression analyses, controlling for the confounders including time-invariant covariates and time-varying covariates at wave 1, and the other two sleep variables. Model 2 : used stabilized inverse probability attrition weighted (IPTW). Model 3: Model 2 further added the other two sleep variables as the time-varying covariates to calculate adjusted stabilized IPTW. *p < 0.05, **p < 0.01.*

TABLE 5 | Accumulated waves of social jetlag and frequency of smoking and drinking.

		Packs of cigarette smoking per week	Times of alcohol use per month
		β (95% CI)	β (95% CI)
≥0.5 hours	*Model*1	0.047 (− 0.015, 0.110)	0.018 (− 0.042, 0.079)
	*Model*2	0.141 (0.064, 0.218)***	0.095 (0.027, 0.163)**
	*Model*3	0.138 (0.061, 0.215)***	0.100 (0.031, 0.169)**
≥1 h	*Model*1	0.076 (0.019, 0.132)**	0.032 (− 0.023, 0.086)
	*Model*2	0.199 (0.134, 0.264)***	0.108 (0.047, 0.168)***
	*Model*3	0.203 (0.137, 0.269)***	0.114 (0.052, 0.175)***
≥2 h	*Model*1	0.216 (0.145, 0.288)***	0.121 (0.052, 0.191)***
	*Model*2	0.277 (0.197, 0.357)***	0.126 (0.051, 0.202)**
	*Model*3	0.284 (0.203, 0.364)***	0.135 (0.059, 0.211)***

*Model 1: conventional linear regression analyses, controlling for the confounders including time-invariant covariates and time-varying covariates at wave 1, and the other two sleep variables. Model 2: used stabilized inverse probability attrition weighted (IPTW). Model 3: Model 2 further added the other two sleep variables as the time-varying covariates to calculate adjusted stabilized IPTW. **p < 0.01. ***p < 0.001.*

with the literature. Previous studies have mostly demonstrated an association opposite of our findings (McKnight-Eily et al., 2011). This may be explained by the influence of sleep insufficiency on cognition, resulting in the increase of vulnerability to peer pressure (O'Brien and Mindell, 2005), and the correlation between poor sleep practices and substance use by adolescents' social networks and shared lifestyles (Mednick et al., 2010). However, the cause of short sleep may be different in an Asian context compared to Western culture and may be a result of a culture with a high priority for academic achievements rooted in Confucianism (Huang and Gove, 2015). Cultural differences in bedtime were noted in a review on worldwide sleep practices (Gradisar et al., 2011). Asian adolescents have significantly later bedtimes than European or North American adolescents (Gradisar et al., 2011). Reasons for restricted sleep time in school days in the Taiwan context could be for academic purposes. The emphasis on education in the society may influence the loading of homework and the attitude of parents to encourage spending more time on school work than in sleep. Hence, the mechanisms linking short sleep and smoking may be different from the Western context. It was hard to differentiate the academic-related factor when thinking about reasons why adolescents had short sleep in our dataset, such as spending lots of time studying instead of going to bed early. Future studies that include detailed reasons for short sleep in adolescents can further test the mediating effect of these reasons.

Our results showed different findings between conventional regression analysis and analysis using marginal structural models, such as in sleep disturbance; the significant effect in conventional regression analysis using the marginal structural model no longer exists. We used marginal structural models because conventional methods may give biased effect estimates when exposure affects a confounder or when exposure both affects and is affected by the study outcome, and also because marginal structural models have the ability to handle time-varying confounding and censoring (Robins et al., 2000). We interpreted the results of marginal structural models, instead of conventional models to avoid the above bias. One systematic review examined the publications in which marginal structural models and conventional analyses were used and found that few of the analyses (11%) showed opposite results between marginal structural models and conventional models. Among the rest of the studies that did not show opposite results, 40% showed that the marginal structural estimate differed by at least 20% from

the conventional estimate on the usual scale (Suarez et al., 2011). Our paper is in the latter category. Our study showed that the standard errors of the marginal structural models associations are greater than the conventional standard errors, consistent with the findings of the review (Suarez et al., 2011). This increase in standard error has been described as a trade-off between bias and precision (Cole and Hernán, 2008).

Our findings should be interpreted considering the following limitations. First, other unmeasured confounders may exist. We focused a lot on individual level factors. Although we included peer drinking/smoking status as a time-varying confounder, there may be more relational or socio-environmental factors to be considered, such as a peer network that is associated with both sleep behavior and substance use because of shared lifestyles, induction, or their social behaviors. Other psychiatric conditions also likely impact both sleep and substance use, such as anxiety and attention deficit hyperactivity disorder. Second, sleep practice measurements were self-reported in our study and adolescents were only asked to report a time in general, which might have resulted in recall bias and social desirability bias. Objective measurement should be used in future studies, such as actigraphy or other validated wearable devices to better capture timing for going to bed and waking up. Similarly, since alcohol drinking and cigarette smoking behaviors were also self-reported, it is possible that these behaviors were underreported.

This study adds to the understanding of the longitudinal impact of three different dimensions of poor sleep practice in adolescence on substance use using a large sample size with a long follow-up that spanned 9 years in the adolescents' life course. We highlighted that the effect of cumulative insufficient sleep on smoking and drinking may operate by different biological and social mechanisms, and that the cultural context should be taken into consideration. The use of marginal structural models provided an opportunity to evaluate the impact of insufficient sleep as time-dependent variables in the presence of time-dependent confounders, such as depression, which are affected by prior insufficient sleep. Mindfulness-based interventions and cognitive-behavioral therapy were effective to improve problematic sleep practices among adolescents (Blake et al., 2019). Interventions that aim to reduce the likelihood of substance use in young adulthood may consider incorporating such techniques to improve sleep practices in adolescents, particularly the discrepancy between bedtimes on school days and weekends and better quality of sleep.

DATA AVAILABILITY STATEMENT

The datasets for this study can be found: https://srda.sinica.edu.tw/index_en.php.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board at the National Cheng Kung University in Taiwan (B-ER-107-028). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

CS and C-YH conceptualized the structure of the study. C-YH conducted the formal analysis. C-YH and CS wrote the manuscript. S-HL monitored and validated the process of data analysis. M-CT and TY reviewed and edited the manuscript. CS, S-HL, M-CT, and TY acquired research funding.

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REFERENCES

Blake, M. J., Latham, M. D., Blake, L. M., and Allen, N. B. (2019). Adolescent-sleep-intervention research: current state and future directions. *Curr. Dir. Psychol. Sci.* 28, 475–482.

Chen, W. J., Wu, S. C., Tsay, W. I., Chen, Y. T., Hsiao, P. C., Yu, Y. H., et al. (2017). Differences in prevalence, socio-behavioral correlates, and psychosocial distress between club drug and hard drug use in Taiwan: results from the 2014 National Survey of Substance Use. *Int. J. Drug Policy* 48, 99–107. doi: 10.1016/j.drugpo.2017.07.003

Chen, Y. L., and Gau, S. S. F. (2016). Sleep problems and internet addiction among children and adolescents: a longitudinal study. *J. Sleep Res.* 25, 458–465. doi: 10.1111/jsr.12388

Chung, K. F., and Cheung, M. M. (2008). Sleep-wake patterns and sleep disturbance among Hong Kong Chinese adolescents. *Sleep* 31, 185–194.

Cole, S. R., and Hernán, M. A. (2008). Constructing inverse probability weights for marginal structural models. *Am. J. Epidemiol.* 168, 656–664. doi: 10.1093/aje/kwn164

Conklin, A. I., Yao, C. A., and Richardson, C. G. (2019). Chronic sleep disturbance, not chronic sleep deprivation, is associated with self-rated health in adolescents. *Prev. Med.* 124, 11–16.

Conway, K. P., Swendsen, J., Husky, M. M., He, J.-P., and Merikangas, K. R. (2016). Association of lifetime mental disorders and subsequent alcohol and illicit drug use: results from the National Comorbidity survey–adolescent supplement. *J. Am. Acad. Child Adoles. Psychiatry* 55, 280–288. doi: 10.1016/j.jaac.2016.01.006

Curcio, G., Ferrara, M., and De Gennaro, L. (2006). Sleep loss, learning capacity and academic performance. *Sleep Med. Rev.* 10, 323–337.

Derogatis, L. (1983). *SCL-90-R: administration, Scoring, and Procedural Manual-II*. Baltimore, MD: Clinical Psychometric Research.

Diaz-Morales, J. F., and Escribano, C. (2015). Social jetlag, academic achievement and cognitive performance: understanding gender/sex differences. *Chronobiol. Int.* 32, 822–831. doi: 10.3109/07420528.2015.1041599

Diego, M. A., Field, T. M., and Sanders, C. E. (2003). Academic performance, popularity, and depression predict adolescent substance use. *Adolescence* 38, 35–42.

Faries, D. E., Obenchain, R., Haro, J. M., and Leon, A. C. (2014). *Analysis of Observational Health Care Data Using SAS*. Cary, NC: SAS Institute.

Goldstein, H. (2009). Handling attrition and non-response in longitudinal data. *Longit. Life Course Stud.* 1, 63–72.

Gradisar, M., Gardner, G., and Dohnt, H. (2011). Recent worldwide sleep patterns and problems during adolescence: a review and meta-analysis of age, region, and sleep. *Sleep Med.* 12, 110–118. doi: 10.1016/j.sleep.2010.11.008

Gunn, H. E., O'Rourke, F., Dahl, R. E., Goldstein, T. R., Rofey, D. L., Forbes, E. E., et al. (2019). Young adolescent sleep is associated with parental monitoring. *Sleep Health* 5, 58–63. doi: 10.1016/j.sleh.2018.09.001

Hasler, B. P., Soehner, A. M., and Clark, D. B. (2015). Sleep and circadian contributions to adolescent alcohol use disorder. *Alcohol* 49, 377–387. doi: 10.1016/j.alcohol.2014.06.010

Huang, G. H., and Gove, M. (2015). Asian parenting styles and academic achievement: views from Eastern and Western perspectives. *Education* 135, 389–397.

Jankowski, K. S. (2017). Social jet lag: sleep-corrected formula. *Chronobiol. Int.* 34, 531–535. doi: 10.1080/07420528.2017.1299162

Lima, T. R., and Silva, D. A. S. (2018). Association of sleep quality with sociodemographic factors and lifestyle in adolescents from southern Brazil. *World J. Pediatrics* 14, 383–391. doi: 10.1007/s12519-018-0136-8

Lin, W. H., and Yi, C. C. (2015). Unhealthy sleep practices, conduct problems, and daytime functioning during adolescence. *J. Youth Adolesc.* 44, 431–446. doi: 10.1007/s10964-014-0169-9

Liu, X., Zhao, Z., Jia, C., and Buysse, D. J. (2008). Sleep patterns and problems among chinese adolescents. *Pediatrics* 121, 1165–1173. doi: 10.1542/peds.2007-1464

Lund, H. G., Reider, B. D., Whiting, A. B., and Prichard, J. R. (2010). Sleep patterns and predictors of disturbed sleep in a large population of college students. *J. Adolesc. Health* 46, 124–132. doi: 10.1016/j.jadohealth.2009.06.016

McKnight-Eily, L. R., Eaton, D. K., Lowry, R., Croft, J. B., Presley-Cantrell, L., and Perry, G. S. (2011). Relationships between hours of sleep and health-risk behaviors in US adolescent students. *Prev. Med.* 53, 271–273. doi: 10.1016/j.ypmed.2011.06.020

Mednick, S. C., Christakis, N. A., and Fowler, J. H. (2010). The spread of sleep loss influences drug use in adolescent social networks. *PloS One* 5:e9775. doi: 10.1371/journal.pone.0009775

Mesquita, G., and Reimao, R. (2010). Stress and sleep quality in high school Brazilian adolescents. *An. Acad. Bras Cienc.* 82, 545–551.

Miller, M. B., Janssen, T., and Jackson, K. M. (2017). The prospective association between sleep and initiation of substance use in young adolescents. *J. Adolesc. Health* 60, 154–160. doi: 10.1016/j.jadohealth.2016.08.019

Montes, K. S., Witkiewitz, K., Pearson, M. R., and Leventhal, A. M. (2019). Alcohol, tobacco, and marijuana expectancies as predictors of substance use initiation in adolescence: a longitudinal examination. *Psychol. Addict. Behav.* 33, 26–34. doi: 10.1037/adb0000422

Nascimento-Ferreira, M. V., Collese, T. S., de Moraes, A. C. F., Rendo-Urteaga, T., Moreno, L. A., and Carvalho, H. B. (2016). Validity and reliability of sleep time questionnaires in children and adolescents: a systematic review and meta-analysis. *Sleep Med. Rev.* 30, 85–96. doi: 10.1016/j.smrv.2015.11.006

Negriff, S., Ji, J., and Trickett, P. K. (2011). Exposure to peer delinquency as a mediator between self-report pubertal timing and delinquency: a longitudinal study of mediation. *Dev. Psychopathol.* 23, 293–304. doi: 10.1017/S0954579410000805

Nguyen-Louie, T. T., Brumback, T., Worley, M. J., Colrain, I. M., Matt, G. E., Squeglia, L. M., et al. (2018). Effects of sleep on substance use in adolescents: a longitudinal perspective. *Addict. Biol.* 23, 750–760. doi: 10.1111/adb.12519

O'Brien, E. M., and Mindell, J. A. (2005). Sleep and risk-taking behavior in adolescents. *Behav. Sleep Med.* 3, 113–133.

Ortiz-Hernandez, L., Tello, B. L., and Valdes, J. (2009). The association of sexual orientation with self-rated health, and cigarette and alcohol use in Mexican adolescents and youths. *Soc. Sci. Med.* 69, 85–93. doi: 10.1016/j.socscimed.2009.03.028

Owens, J., and Group, A. S. W. (2014). Insufficient sleep in adolescents and young adults: an update on causes and consequences. *Pediatrics* 134, e921–e932. doi: 10.1542/peds.2014-1696

Pasch, K. E., Laska, M. N., Lytle, L. A., and Moe, S. G. (2010). Adolescent sleep, risk behaviors, and depressive symptoms: are they linked? *Am. J. Health Behav.* 34, 237–248.

Petersen, A. C., Crockett, L., Richards, M., and Boxer, A. (1988). A self-report measure of pubertal status: reliability, validity, and initial norms. *J. Youth Adolesc.* 17, 117–133. doi: 10.1007/BF01537962

Petersen, A. C., Tobin-Richards, M., and Boxer, A. (1983). Puberty: its measurement and its meaning. *J. Early Adolesc.* 3, 47–62.

Pinquart, M. (2016). Associations of parenting styles and dimensions with academic achievement in children and adolescents: a meta-analysis. *Educ. Psychol. Rev.* 28, 475–493.

Robins, J. M., Hernan, M. A., and Brumback, B. (2000). Marginal structural models and causal inference in epidemiology. *Epidemiology* 11, 550–560.

Rutters, F., Lemmens, S. G., Adam, T. C., Bremmer, M. A., Elders, P. J., Nijpels, G., et al. (2014). Is social jetlag associated with an adverse endocrine, behavioral, and cardiovascular risk profile? *J. Biol. Rhythms* 29, 377–383. doi: 10.1177/0748730414550199

Shochat, T., Cohen-Zion, M., and Tzischinsky, O. (2014). Functional consequences of inadequate sleep in adolescents: a systematic review. *Sleep Med. Rev.* 18, 75–87. doi: 10.1016/j.smrv.2013.03.005

Smith, L. J., Aycock, C., Hook, K., Chen, P., and Rueger, S. Y. (2017). Parental monitoring moderates the relation between radio exposure and adolescent alcohol and tobacco use: preliminary findings from a national survey. *J. Child Adolesc. Substance Abuse* 26, 314–323.

Suarez, D., Borràs, R., and Basagaña, X. (2011). Differences between marginal structural models and conventional models in their exposure effect estimates: a systematic review. *Epidemiology* 22, 586–588. doi: 10.1097/EDE.0b013e31821d0507

Tsai, M. C., Hsieh, Y. P., Strong, C., and Lin, C. Y. (2015a). Effects of pubertal timing on alcohol and tobacco use in the early adulthood: a longitudinal cohort study in Taiwan. *Res. Dev. Disabil.* 36C, 376–383. doi: 10.1016/j.ridd.2014.10.026

Tsai, M. C., Strong, C., and Lin, C. Y. (2015b). Effects of pubertal timing on deviant behaviors in Taiwan: a longitudinal analysis of 7th- to 12th-grade adolescents. *J. Adolesc.* 42, 87–97. doi: 10.1016/j.adolescence.2015.03.016

Twenge, J. M., Krizan, Z., and Hisler, G. (2017). Decreases in self-reported sleep duration among US adolescents 2009–2015 and association with new media screen time. *Sleep Med.* 39, 47–53. doi: 10.1016/j.sleep.2017.08.013

White, R. M. B., Deardorff, J., and Gonzales, N. A. (2012). Contextual amplification or attenuation of pubertal timing effects on depressive symptoms among mexican American Girls. *J. Adolesc. Health* 50, 565–571.

Xu, Z., Su, H., Zou, Y., Chen, J., Wu, J., and Chang, W. (2012). Sleep quality of Chinese adolescents: distribution and its associated factors. *J. Paediatr. Child Health* 48, 138–145. doi: 10.1111/j.1440-1754.2011.02065.x

Yang, C. K., Kim, J. K., Patel, S. R., and Lee, J. H. (2005). Age-related changes in sleep/wake patterns among Korean teenagers. *Pediatrics*115 (Suppl.), 250–256.

Yen, C. F., King, B. H., and Tang, T. C. (2010). The association between short and long nocturnal sleep durations and risky behaviours and the moderating factors in Taiwanese adolescents. *Psychiatry Res.* 179, 69–74. doi: 10.1016/j.psychres.2009.02.016

Yen, C. F., Ko, C. H., Yen, J. Y., and Cheng, C. P. (2008). The multidimensional correlates associated with short nocturnal sleep duration and subjective insomnia among Taiwanese adolescents. *Sleep* 31, 1515–1525.

Yi, C. C., Wu, C.-I., Chang, Y. H., and Chang, M.-Y. (2009). The psychological well-being of taiwanese youth: school versus family context from early to late adolescence. *Int. Sociol.* 24, 397–429.

Zhang, J. H., Paksarian, D., Lamers, F., Hickie, I. B., He, J. P., and Merikangas, K. R. (2017). Sleep patterns and mental health correlates in US adolescents. *J. Pediatr.* 182, 137–143.

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