Original Article

Insufficient sleep and suicidal ideation: a survey of 12,046 female adolescents

Woong-Sub Park [a], Kwang Ik Yang [b], Hyeyun Kim [c, *]

[a] Department of Preventive Medicine & Public Health Catholic Kwandong University College of Medicine, Gangwon, Republic of Korea
[b] Sleep Disorders Center, Department of Neurology, Soonchunhyang University College of Medicine, Cheonan Hospital, Cheonan, Republic of Korea
[c] Department of Neurology, Catholic Kwandong University College of Medicine, International St. Mary's Hospital, Incheon, Republic of Korea

A B S T R A C T

Objectives: Adolescence is a period of adaptation to social, hormonal, and physical changes. Because of these changes, adolescents are at risk for depression and suicidal thoughts. Female adolescents tend to be more sensitive to hormonal and emotional changes. Although the reciprocal relationship among depression, poor sleep quality, and suicide has been studied, whether decreased sleep time leads to depression-mediated suicide or induces suicide itself remains to be determined. Therefore, this study aimed to analyze (using a path analysis) the indirect (i.e., due to depression) and direct effects of sleep on suicidal ideation for female adolescents.
Methods: We use nationally representative data from the Korean juvenile health behavior online survey to analyze the sleep effects on suicidal ideation. A total of 12,046 Korean female adolescents were included in this study. We analyzed data from the juvenile health behavior online survey (2017) conducted by the Korea Centers for Disease Control and Prevention and identified variables that could affect the mental health of female adolescents. A path analysis was performed to determine the direct role of sleep in suicidal ideation.
Results: Decreased sleep was one of the several risk factors for suicidal ideation. Unexpectedly, after controlling for other risk factors including depression and socioeconomic factors, insufficient sleep was found to have direct effects on suicidal ideation. The indirect effect of insufficient sleep on suicidal ideation was mediated by depression.
Conclusion: Sleep is a modifiable factor that could reduce the suicide rate among female adolescents and could be targeted through public health prevention efforts.

© 2018 Elsevier B.V. All rights reserved.

1. Introduction

Adolescence is a time of adaptation to social, hormonal, and physical changes. During this critical time, adolescents develop self-identity and can experience mental instability. Emotional development during this period often affects adulthood. Depression that begins during adolescence has been reported to be more severe and long-lasting [1]. Also, external factors, such as the use of multimedia devices, playing video games, drinking alcohol, smoking, and consuming caffeine, have become threats to the mental health of adolescents [2].

As menarche begins, female adolescents experience rapid hormonal changes that could affect mental health. Several studies have reported that the mental health of female adolescents is more fragile than that of male adolescents [3]. Adolescents' mental health could be affected by the quality and amount of sleep, for example, excessively short or long sleep hours are known to have negative effects on mental health among adolescents [4]. Proper sleep is an essential component of mental health during adolescence; research has shown that sleep deprivation adversely affects adolescents' emotional control and predisposes them to suicidal ideation [5]. Furthermore, adequate sleep during adolescence is essential for mental health development and school performance [6].

Korean children and adolescents have the lowest satisfaction with life, and Korea has the highest suicide rates [7] among the countries that are part of the Organization for Economic Cooperation and Development. Among Korean students, one in every five respondents indicated that they experienced suicidal thoughts (17.7% for elementary school students, 22.6% for middle school students, and 26.8% for high school students), and annual increases in these rates (3.4% for elementary school students, 3.1%

* Corresponding author. Catholic Kwandong University College of Medicine, International St. Mary's Hospital, Simgokro 100gil 25 SeoGu, Incheon City, Republic of Korea.
E-mail address: imkhy77@gmail.com (H. Kim).

for middle school students, and 2.8% for high school students) have been reported [8].

Previous studies have demonstrated that depression is the strongest risk factor for suicide [9,10]. The reciprocal relationship among depression, poor sleep quality, and suicide has been studied. However, whether decreased sleep time leads to depression-mediated suicide or induces suicide itself remains to be determined. Therefore, this study was designed to analyze (using a path analysis) the indirect (ie, due to depression) and direct effects of sleep on suicidal ideation among female adolescents.

2. Methods

This study was conducted by the Korea Centers for Disease Control and Prevention (KCDC). Date of the 13th juvenile health behavior online survey regarding sleep time in 2017 were analyzed. This online survey was an anonymous, self-enforced survey for students in middle school and high school that aimed to understand youth health behaviors such as smoking, alcohol consumption, obesity, diet, and physical activity in Korea. This government-approved (approval no. 117058) and KCDC institutional review board-approved (2014-06EXP-02-P-A) statistical survey has been conducted annually since 2005. All subjects provided consent to participate in the study. The 2017 survey comprised 123 items from 15 categories, including smoking, alcohol consumption, obesity, diet, and physical activity. Overall, 107 indicators were calculated. The questionnaire items and indicators were developed with the help of expert advisory committees.

The sampling of online health behaviors was conducted using a stratified cluster analysis. First, data were extracted according to school, and then according to class. During the first data extraction, a list of the population was sorted, the sampling interval was calculated, and the sample school was selected using the systematic sampling method. During the second data extraction, data were randomly selected from the selected sample schools (one class per grade). Of 64,991 students surveyed from 800 schools (400 middle schools and 400 high schools), 62,276 students participated in the survey (95.8%). In Korea, the public school system consists of six years of elementary school, three years of middle school, and three years of high school. This study analyzed 15,233 girls in middle school. The definition of each variable was similar to that of the 2017 Youth Health Behavior Online Survey (http://yhs.cdc.go.kr). The main variables were depressive experience (ie, Have you ever felt sadness or despair that affected activities of daily living for two consecutive weeks during the past 12 months?) and suicidal ideation (ie, Have you ever seriously considered suicide during the last 12 months?). The average sleep duration per night was categorized as <6 h, >6 h but <7 h, >7 h but <8 h, and >8 h, analyzed as an independent variable. The variables that could affect the mental health of female adolescents were perceived economic status (upper class, middle class, or lower class); living with one parent, both parents, or neither parent; current smoking status (ie, smoking more than one cigarette per day during the past 30 days); current alcohol consumption (ie, consuming more than one drink during the past 30 days); and perceived health status. Smartphone use per day during weekdays, except for academic purposes, was categorized as <1 h, >1 h but <2 h, >2 h but <4 h, and >4 h. Sleep duration, smartphone use, and caffeine consumption were analyzed as continuous variables.

The sample was designed as a composite sample with weighted values to represent Korean adolescents. The KCDC provided guidelines for the raw data to analyze the weighted value and to reflect the sample design information appropriately. Therefore, all analyses used a method provided by the KCDC that considered the weight of the composite sample. We used the SAS version 9.4 statistical program to perform a bivariate analysis of the general characteristics, depressive experiences, and suicidal ideation. Next, we analyzed the mediating effects of depressive experiences on the influence of sleep duration on suicidal ideation using the M-plus version 5.2 statistical package. M-plus was not only used to perform a path analysis of the categorical variables but also to analyze continuous variables and categorical variables simultaneously. Most structural equations, including AMOS, were analyzed using the maximum likelihood method. However, if nominal variables were specified, then M-plus was used as the maximum likelihood method and could only be used for continuous variables. To evaluate the fit of the model, the Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI) were used, and the root mean square error of appreciation (RMSEA) index was determined as follows: <0.05, good fit; 0.05–0.08, normal fit; 0.08–0.10, weak fit; and >0.10, inappropriate fit.

3. Results

3.1. General analysis

Of all students sampled, 90% had middle to high and 10% and low economic status; and 0.7% were not living with their parents. The current smoking rate was 1.8%, the current alcohol consumption rate was 6.7%, and 27.8% reported that their health condition was not good. 25.4% indicated that they slept <6 h per night, 26.9% slept 6–7 h per night, 28.0% slept 7–8 h per night, and 19.7% slept >8 h per night. Moreover, 52.2% of the respondents spent >4 h per day using a smartphone, excluding the time spent for study purposes. Approximately 20% of the respondents consumed caffeinated beverages more than once per week, 28.9% of the respondents experienced depression, and 16.4% of respondents had suicidal thoughts (Table 1).

Risk factor analysis results regarding depression/suicidal ideation are shown in Table 2. The rates of depression/suicidal ideation were significantly higher for those with low economic status, those who currently smoked, those who currently consumed alcohol, and those with perceived poor health status. The prevalence of depression and suicidal ideation increased with increased duration of smartphone use, increased caffeine consumption per week, and decreased sleep duration (Table 2).

3.2. Path analysis results

Examination of the fitness index revealed a CFI of 1.000 and TLI of 1.000 (RMSEA <0.001), which satisfied all of the model criteria. Depression was significantly influenced by sleep duration, economic status, current smoking status, current alcohol consumption status, perceived health status, caffeine consumption per week, and duration of smartphone use (except for academic purposes). Suicidal ideation was significantly influenced by sleep duration, economic status, current smoking status, current alcohol consumption status, perceived health status, and depression (Table 3).

The total standardized effect and the standardized direct effect of sleep duration on suicidal ideation were −0.105 and −0.044, respectively. The indirect standardized effect of sleep duration on depression-mediated suicidal ideation was −0.061 (Table 4). The direct effects of short sleep duration on suicidal ideation were more statistically significant than the indirect effects of depression (Fig. 1).

4. Discussion

In the path analysis of the present study, the major finding was that short sleep duration had direct effects on suicidal ideation after

Table 1
General characteristics.

Variables		N	Weighted (%)	S.E. of %
Grade	1	5011	32.9	0.48
	2	5105	34	0.56
	3	5117	33.1	0.63
Economic status	Middle–High	13,611	90.0	0.34
	Low	1622	10.0	0.34
Living with parents	No	113	0.7	0.08
	Yes	14,932	99.3	0.08
Current smoking status	No	14,970	98.2	0.14
	Yes	263	1.8	0.14
Current alcohol consumption status	No	14,215	93.3	0.25
	Yes	1018	6.7	0.25
Perceived health status	Poor	4230	27.8	0.44
	Good	11,003	72.2	0.44
Smartphone use (per day)	≤1 h	2318	15.0	0.34
	1–2 h	2000	13.4	0.37
	2–4 h	2855	19.0	0.36
	4 h ≤	8060	52.5	0.61
Caffeine consumption (per week)	No	12,140	79.9	0.37
	1–2	2245	14.4	0.30
	3–4	544	3.6	0.16
	5 ≤	304	2.1	0.15
Sleep duration	<6 h	3336	25.4	0.58
	6–7 h	3581	26.9	0.47
	7–8 h	3834	28.0	0.49
	≥8 h	2668	19.7	0.50
Depression	No	10,854	71.1	0.45
	Yes	4379	28.9	0.45
Suicidal ideation	No	12,770	83.6	0.36
	Yes	2463	16.4	0.36

Table 2
Risk factors for depression and suicidal ideation.

		Depression			Suicidal ideation		
		Weighted (%)	S.E. of %	p	Weighted (%)	S.E. of %	p
Grade	1	24.41	0.74	<0.001	13.45	0.59	<0.001
	2	30.00	0.73		18.38	0.69	
	3	32.12	0.80		17.34	0.60	
Economic status	Middle–High	27.44	0.48	<0.001	15.00	0.37	<0.001
	Low	41.69	1.32		29.15	1.20	
Living with parents	No	38.34	5.73	0.07	16.70	3.78	0.91
	Yes	28.66	0.45		16.26	0.36	
Current smoking status	No	28.29	0.44	<0.001	15.98	0.36	<0.001
	Yes	60.80	3.45		40.55	3.60	
Current alcohol consumption status	No	27.40	0.43	<0.001	15.21	0.37	<0.001
	Yes	49.05	1.73		33.06	1.57	
Perceived health status	Poor	41.03	0.83	<0.001	28.00	0.74	<0.001
	Good	24.18	0.50		11.95	0.34	
Smartphone use (per day)	≤1 h	25.97	1.16	<0.001	14.72	0.79	<0.001
	1–2 h	23.43	0.99		14.54	0.85	
	2–4 h	24.23	0.89		12.93	0.74	
	4 h≤	32.76	0.57		18.63	0.51	
Caffeine consumption (per week)	No	26.77	0.48	<0.001	15.18	0.40	<0.001
	1–2	33.05	1.08		18.90	0.94	
	3–4	44.23	2.31		25.57	2.01	
	5≤	53.62	3.04		30.76	2.96	
Sleep duration	<6 h	38.51	0.88	<0.001	23.97	0.90	<0.001
	6–7 h	28.72	0.88		16.31	0.72	
	7–8 h	24.72	0.91		13.30	0.62	
	≥8 h	21.23	0.87		10.96	0.69	

controlling for other factors that could influence suicidal ideation. Short sleep duration played a critical role in increasing suicidal ideation for female adolescents. Several studies have shown a close relationship between sleep and suicide for those at risk for mental health problems [10–12]. One study indicated that high school students in a suicide risk group had worse sleep quality than those in the non-suicide risk group [11]. Another study indicated short sleep duration and suicide attempts were closely related for children with depressive disorders [12]. It was reported that sleep quality was significantly correlated with mental health, but that sleep duration was not significantly correlated with mental health when sleep quality was controlled [13]. After controlling for depression, our study indicated that suicidal ideation increased significantly as sleep duration decreased. Unlike previous studies, short sleep duration was a significant independent risk factor for suicidal ideation among female adolescents. Therefore, to decrease

Table 3
Factor loading of the pathway analysis.

Pathway	Standardized factor loading	Unstandardized factor loading	Standard error	t-statistic	p-value
Sleep duration → Depression	−0.145	−0.116	0.010	−12.176	<0.001
Grade → Depression	0.012	0.016	0.018	0.856	0.392
Economic status → Depression	0.077	0.275	0.039	7.138	<0.001
Current smoking status → Depression	0.058	0.489	0.098	4.967	<0.001
Current alcohol consumption status → Depression	0.081	0.347	0.049	7.099	<0.001
Perceived health status → Depression	−0.171	−0.406	0.028	−14.607	<0.001
Living with parents → Depression	0.006	0.001	0.001	0.578	0.564
Caffeine consumption → Depression	0.090	0.058	0.006	9.217	<0.001
Smartphone use → Depression	0.079	0.026	0.004	6.627	<0.001
Sleep duration → Suicidal ideation	−0.044	−0.012	0.002	−5.108	<0.001
Grade → Suicidal ideation	−0.021	−0.009	0.005	−1.998	0.046
Economic status → Suicidal ideation	0.050	0.062	0.009	6.989	<0.001
Current smoking → Suicidal ideation	0.020	0.060	0.019	3.148	0.002
Current alcohol consumption → Suicidal ideation	0.043	0.064	0.011	5.828	<0.001
Perceived health status → Suicidal ideation	−0.097	−0.080	0.008	−10.514	<0.001
Living with parents → Suicidal ideation	0.008	0.000	0.000	1.411	0.158
Depression → Suicidal ideation	0.421	0.147	0.008	17.247	<0.001
Caffeine consumption → Suicidal ideation	0.013	0.003	0.002	1.768	0.077
Smartphone use → Suicidal ideation	0.005	0.001	0.001	0.636	0.525

Table 4
Decomposition of direct and indirect effects of sleep duration on suicidal ideation.

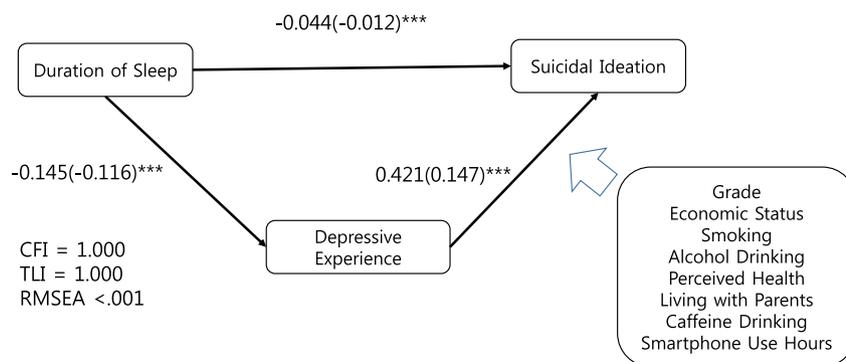|	Pathway	Standardized factor loading	Unstandardized factor loading	Standard error	t-statistic	p-value
Total	Sleep duration → Suicidal ideation	−0.105	−0.029	0.003	−9.397	<0.001
Direct	Sleep duration → Suicidal ideation	−0.044	−0.012	0.002	−5.108	<0.001
Indirect	Sleep duration → Depression → Suicidal ideation	−0.061	−0.017	0.002	−10.034	<0.001

Fig. 1. Standardized coefficients (unstandardized coefficients) of variables from the estimated structural equation model.

suicidal ideation, sleep duration should be increased, and education and care for female adolescents must be provided.

Previous studies have demonstrated that short sleep duration has a direct effect on suicidal ideation by removing the protective function of sleep from emotional homeostasis. Proper sleep could promote brain homeostasis and physical restoration [14—16], but sleep deprivation could reduce emotional homeostasis and physical well-being. The protective effects of sleep on mental health are decreased with decreased sleep duration, which could negatively affect emotional homeostasis [17]. Moreover, emotional reactivity and psychological distress are closely related to suicidal ideation, especially in adolescents [18]. A previous study showed that healthy sleep is related to optimism whereas poor sleep is associated with increased negative emotions such as depression and anxiety [19]. Another study showed that sleep has a role in increasing positive emotional experiences for healthy young adults [20]. Therefore, positive emotions could be increased by the positive functions of sleep, thereby suggesting the direct effect of sleep on suicidal ideation.

Short sleep duration was found to exacerbate depression, and aggravated depressive moods could increase suicidal ideation. The mechanisms of the direct and indirect relationships between sleep, depression, and suicide could be explained by the neurotransmitters involved in these processes [21,22]. First, high cortisol levels represent a high-stress situation, indicating that the body is coping with external stress stimuli, which may interfere with sleep and may also increase cortisol secretion [23,24]. Second, serotonin, which is a major neurotransmitter affecting depression and suicide [25], also plays a role in the relationships between sleep, depression, and suicide. Several studies showed that serotonin levels are decreased in adults who have attempted suicide and that reduced serotonin levels influence the extreme behaviors associated with suicide attempts [26]. Serotonin is decreased in patients with decreased sleep duration. Third, prolactin, which exhibits increased secretion in those who have sufficient sleep, is decreased during depression. Serotonin promotes thyrotropin-releasing hormone (TRH) secretion, and TRH secretion stimulates prolactin release. Therefore, prolactin degradation could result from decreased

serotonin, further suggesting that prolactin is decreased during depression [27,28].

Poor sleep quality including unexpected short sleep duration could affect anxiety levels and attention in patients with depressive disorders [29—31], and sleep disturbances influence depressive mood. Short sleep duration may aggravate depressive moods, which could result in insomnia. Therefore, sleep duration could increase suicidal ideation indirectly through the aggravation of depression. During our study, the indirect effects of depression on suicidal ideation were stronger than the direct effects of short sleep duration. Therefore, controlling depression is an extremely powerful approach to preventing suicidal ideation.

This study had some limitations. First, sleep quality as used in this study was limited by the adequacy of the data, based on subjective satisfaction. Hence, a comparison with other sleep quality studies that considered various factors of sleep quality would be limited. Second, not all previously reported factors influencing suicidal ideation and depression were included in this study; therefore, careful interpretation of the effects of sleep time, both direct and indirect, on suicidal ideation is required. Third, Path analysis does not easily identify cause and effect; it only suggests the directionality of our model. Consequently, a longitudinal follow-up study is needed to identify a causal relationship between sleep time and suicidal ideation.

In conclusion, short sleep duration could increase suicidal ideation after controlling for depression. Currently, several efforts to prevent juvenile suicide are focused on reducing depression. However, because depression is influenced by various factors, including sleep duration, these factors should be considered in the effort to reduce depression. It is also necessary to consider the difficulty involved in providing standardized guidelines due to individual differences. Nevertheless, to reduce suicide rates, an extremely simple approach that is more powerful than other alternatives for decreasing depression involves improving sleep duration. Longer sleep duration could enhance mental health among adolescents.

Acknowledgements

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2018.08.025.

References

[1] Wesselhoft RT. Childhood depressive disorders. Dan Med J 2016;63.
[2] Goodyear-Smith F, Martel R, Darragh M, et al. Screening for risky behaviour and mental health in young people: the YouthCHAT programme. Publ Health Rev 2017;38:20.
[3] Pabst SR, Negriff S, Dorn LD, et al. Depression and anxiety in adolescent females: the impact of sleep preference and body mass index. J Adolesc Health 2009;44:554—60.
[4] Bernert RA, Kim JS, Iwata NG, et al. Sleep disturbances as an evidence-based suicide risk factor. Curr Psychiatr Rep 2015;17:554.
[5] Wahlstrom KL, Berger AT, Widome R. Relationships between school start time, sleep duration, and adolescent behaviors. Sleep Health 2017;3:216—21.
[6] Wolfson AR, Carskadon MA. Understanding adolescents' sleep patterns and school performance: a critical appraisal. Sleep Med Rev 2003;7:491—506.
[7] Lee HY, Hahm MI, Park EC. Differential association of socio-economic status with gender- and age-defined suicidal ideation among adult and elderly individuals in South Korea. Psychiatr Res 2013;210:323—8.
[8] Kye SY, Kwon JH, Park K. Happiness and health behaviors in South Korean adolescents: a cross-sectional study. Epidemiol Health 2016;38, e2016022.
[9] Hawton K, Casanas ICC, Haw C, et al. Risk factors for suicide in individuals with depression: a systematic review. J Affect Disord 2013;147:17—28.
[10] Park JH, Yoo JH, Kim SH. Associations between non-restorative sleep, short sleep duration and suicidality: findings from a representative sample of Korean adolescents. Psychiatr Clin Neurosci 2013;67:28—34.
[11] Qian Y, Sun L, Zhou C, et al. The association between suicidal ideation and sleep quality in elderly individuals: a cross-sectional study in Shandong, China. Psychiatr Res 2017;256:453—7.
[12] Liu X. Sleep and adolescent suicidal behavior. Sleep 2004;27:1351—8.
[13] Wheaton AG, Jones SE, Cooper AC, et al. Short sleep duration among middle school and high school students - United States, 2015. MMWR Morb Mortal Wkly Rep 2018;67:85—90.
[14] van der Helm E, Yao J, Dutt S, et al. REM sleep depotentiates amygdala activity to previous emotional experiences. Curr Biol 2011;21:2029—32.
[15] Goldstein AN, Walker MP. The role of sleep in emotional brain function. Annu Rev Clin Psychol 2014;10:679—708.
[16] Gujar N, Yoo SS, Hu P, et al. Sleep deprivation amplifies reactivity of brain reward networks, biasing the appraisal of positive emotional experiences. J Neurosci 2011;31:4466—74.
[17] Haack M, Mullington JM. Sustained sleep restriction reduces emotional and physical well-being. Pain 2005;119:56—64.
[18] Wilburn VR, Smith DE. Stress, self-esteem, and suicidal ideation in late adolescents. Adolescence 2005;40:33—45.
[19] Lau EY, Hui CH, Lam J, et al. Sleep and optimism: a longitudinal study of bidirectional causal relationship and its mediating and moderating variables in a Chinese student sample. Chronobiol Int 2017;34:360—72.
[20] Tempesta D, Socci V, De Gennaro L, et al. Sleep and emotional processing. Sleep Med Rev 2018 Aug;40:183—95 [Epub 2017 Dec 22].
[21] Muller MJ, Olschinski C, Kundermann B, et al. Sleep duration of inpatients with a depressive disorder: associations with age, subjective sleep quality, and cognitive complaints. Arch Psychiatr Nurs 2017;31:77—82.
[22] Manceaux P, Jacques D, Zdanowicz N. Hormonal and developmental influences on adolescent suicide: a systematic review. Psychiatr Danub 2015;27(Suppl. 1):S300—4.
[23] Lewitzka U, Bauer M, Ripke B, et al. Impulsivity and saliva cortisol in patients with suicide attempt and controls. Neuropsychobiology 2017;75(4):162—8.
[24] Scharlau F, Pietzner D, Vogel M, et al. Evaluation of hair cortisol and cortisone change during pregnancy and the association with self-reported depression, somatization, and stress symptoms. Stress 2017:1—8.
[25] Peng L, Song D, Li B, et al. Astroglial 5-HT2B receptor in mood disorders. Expert Rev Neurother 2018:1—8.
[26] Murray NM, Buchanan GF, Richerson GB. Insomnia caused by serotonin depletion is due to hypothermia. Sleep 2015;38:1985—93.
[27] Gupta S, Mukherjee A, Biswas S, et al. Evaluation of endocrine parameters as predictor of major depressive disorder. Indian J Psychol Med 2017;39:766—9.
[28] Arana G, Boyd 3rd AE, Reichlin S, et al. Prolactin levels in mild depression. Psychosom Med 1977;39:193—7.
[29] Gadie A, Shafto M, Leng Y, et al. How are age-related differences in sleep quality associated with health outcomes? An epidemiological investigation in a UK cohort of 2406 adults. BMJ Open 2017;7, e014920.
[30] Suh SW, Han JW, Lee JR, et al. Sleep and cognitive decline: a prospective non-demented elderly cohort study. Ann Neurol 2018 Mar;83(3):472—82.
[31] Sit D, Luther J, Buysse D, et al. Suicidal ideation in depressed postpartum women: associations with childhood trauma, sleep disturbance and anxiety. J Psychiatr Res 2015;66—67:95—104.