

# Insufficient Sleep and Suicidality in Adolescents

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**Study Objectives:** To investigate the association between the behaviorally induced insufficient sleep and suicidality among adolescents.

**Design:** A population-based, cross-sectional survey.

**Setting:** General community.

**Participants:** A sample of 8,530 students (grades 7-11) was recruited in the Republic of Korea. The participants were 8,010 students who completed all questionnaires.

**Intervention:** N/A.

**Measurements:** The survey included the Beck Scale for Suicidal Ideation (SSI), the Beck Depression Inventory (BDI), a modified Epworth Sleepiness Scale (ESS), and questionnaires about sleep (weekday/weekend sleep schedule/duration, insomnia and snoring).

**Results:** Adolescents with behaviorally induced insufficient sleep syndrome (BISS) had higher SSI scores than those who slept  $\geq 7$  hours on weekdays, even after controlling for age, sex, and BDI score ( $F = 11.71$ ,  $P < 0.001$ ). After controlling for age and sex, longer weekend oversleep and shorter weekday sleep duration predicted a higher SSI score ( $\beta = 0.19$ ,  $P < 0.001$ ;  $\beta = 0.37$ ,  $P < 0.001$ ). The association between weekend oversleep and SSI score remained significant even after additionally controlling for BDI and ESS scores and presence of insomnia and snoring ( $\beta = 0.07$ ,  $P < 0.01$ ).

**Conclusion:** BISS was found to be associated with increased suicidality. Weekend oversleep was associated with suicidality independently of depression, daytime sleepiness, snoring, and insomnia. The study findings suggest that chronic sleep restriction among adolescents may increase suicidal risk.

**Keywords:** Suicide, adolescent, insufficient sleep

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## INTRODUCTION

Sleep plays an important role in the reparative and integrative processes of the brain, especially during adolescence when the sleep-wake cycle changes rapidly. Adolescents are recommended to sleep at least 8.5 hr per day.<sup>1</sup> However, many adolescents in modern society do not get enough sleep and suffer from chronic partial sleep deprivation, such as behaviorally induced insufficient sleep syndrome (BISS).<sup>2</sup>

Suicide is one of the leading causes of death and its incidence begins to increase rapidly during adolescence. As both suicide and insufficient sleep are key health issues for adolescents, several investigations have explored the possible association between these 2 problems, and short sleep duration has now been identified as a potential risk factor of suicidality among adolescents.<sup>3-4</sup>

The most commonly suggested cause of short sleep duration among adolescents is self-induced sleep restriction or wake extension,<sup>5</sup> which is referred to as BISS. Individuals with BISS persistently fail to obtain the sleep required for normal alertness because they curtail sleep voluntarily, albeit unintentionally. However, although short sleep duration may be a proxy measure of insufficient sleep, it represents a construct distinct from sleep restriction. Sleep duration may also be shortened by

an inability to sleep despite efforts to do so, as in adolescent insomnia or depression.<sup>6,7</sup> Moreover, a “natural” short sleeper may tend to sleep less without any complaint, because there are large individual variations in the need for sleep. Sleep restriction, insomnia, and individual variations in sleep need have independent effects on sleep duration. BISS differs from insomnia or naturally short sleep duration in that the ability to sleep is unimpaired and daytime sleepiness is usually excessive. However, to our knowledge, the association between behaviorally induced sleep insufficiency and suicidality has not been addressed in adolescents.

Korean adolescents have been shown to have shorter sleep durations and longer weekend oversleeps, as compared with their peers in other countries.<sup>8</sup> In Korea, middle and high schools start approximately at 07:00-08:30 and close at 16:00-18:30, and there are 6-10 classes (of 45-50 min/class) daily. In most classes, students sit at their desks and passively attend lectures. Furthermore, almost all Korean adolescents attend private educational institutions or go to night school for after-school extra tuition, usually until 21:00-24:00. In addition, because Korean adolescents are under strong socio-cultural/familial/psychologic pressure to perform well on their college entrance examinations, many of them respond by sacrificing sleep and studying for longer periods of time. Because of this unusual situation, Korea provides an exceptional opportunity for investigations of BISS in adolescents.

The specific aims of the current study were to examine the association between behaviorally induced sleep insufficiency and suicidality or depression in a large, community-based Korean adolescent sample. We hypothesized that adolescents with BISS would have higher suicidality than those without BISS and that weekend oversleep would independently predict suicidality among adolescents.

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## METHODS

### Subjects

We recruited subject schools in 3 different areas of South Korea by sending a document to schools asking for participation. All schools that agreed to participate were selected as subject schools and consisted of 18 high schools and 5 middle schools. Six were boys' schools, 8 were girls' schools, and 9 were coeducational schools. Among the coeducational schools, a school for arts and a school for domestic science showed female predominance. All students in the selected grades (8,530 students, 3,431 males, 5,099 females, mean age  $16.73 \pm 1.09$  yr, grades 7-11) were requested to complete the questionnaires. However, 520 students (6.10%; 297 males, 223 females, mean age:  $16.75 \pm 1.08$  years) did not complete the questionnaires and were excluded. The remaining 8,010 students (93.90%; 3,234 males, 4,876 females, mean age  $16.73 \pm 1.09$  yr) participated in the current study. The 8,010 participants and the 520 excluded candidates were not significantly different in age, but more males were excluded than females (8.66% versus 4.57%, respectively). The study protocol was approved by the Institutional Review Board of Gachon University of Medicine and Science.

### Questionnaires

Sleep duration and sleep schedules were assessed using a self-report questionnaire. The questionnaire included the following items: (1) "On average, how many hours do you sleep on weekdays?", (2) "On average, when do you go to bed on weekdays?", and (3) "On average, when do you rise from bed on weekdays?" Similar questions were asked for weekends. Participants were informed that sleep duration and time spent in bed could be different and time spent awake in bed should be excluded from sleep duration, but that time napping should be included. Weekend oversleep was defined as the additional time spent sleeping on weekends as compared with weekdays. Individual bedtime and rising time delays on weekends were also calculated. Five sleep variables (weekday sleep duration, weekend sleep duration, weekend oversleep, weekend bedtime delay, and weekend rise time delay) were used in the statistical analysis.

To measure the severity of suicidal intent, study participants were asked to complete the Korean version of the Beck 19-item Scale for Suicide Ideation (SSI).<sup>9,10</sup> The Korean version of the SSI has been shown to be highly correlated with the Suicidal Behavior Questionnaire and with suicide attempt history,<sup>10</sup> and to have good internal consistency (Cronbach  $\alpha = 0.74$ ).<sup>10</sup> The Korean version of the 21-item Beck Depression Inventory (BDI) was administered to assess depressive symptomatology.<sup>11,12</sup> A 7-item modified version of the Epworth Sleepiness Scale (ESS) was used to measure subjective daytime sleepiness. Because individuals younger than 20 yr are not allowed to drive in Korea, the last item of the ESS, which addresses driving, was omitted from the original 8-item Korean version.<sup>13,14</sup> The Korean Translation of the Composite Scale (KtCS), which consists of 13 items, was used to measure morningness-eveningness.<sup>15,16</sup>

The presence of insomnia in study participants was assessed based on self-reported experiences over the previous month in terms of (1) difficulty initiating sleep, (2) difficulty maintaining sleep, and (3) early awakening and difficulty resuming sleep. In

line with the diagnostic criteria in the International Classification of Diseases, 10<sup>th</sup> Revision, participants with at least 1 of the 3 types of insomnia (initial, maintenance, and terminal) with a frequency of  $\geq 3$  events/wk were classified as having significant insomnia. Similarly, participants who reported snoring  $\geq 3$  times/week were deemed to demonstrate significant snoring.

Based on 2 prior studies,<sup>2,17</sup> the presence of BISS was operationally defined as satisfying all of the following criteria: (1) a short sleep duration on weekdays ( $\leq 7$  hr); (2) a long weekend oversleep ( $\geq 2$  hr); (3) severe daytime sleepiness (ESS  $\geq 9$ ); and (4) the absence of significant insomnia.

### Statistical Analysis

Associations between weekend oversleep (or other sleep variables) and suicidality (or depression) were explored using 2 different multiple regression models (model 1 and model 2). In model 1, the dependent variable was either BDI or SSI score, and the independent variables were each of the sleep variables, age and sex. Because sleep variables are interrelated by definition and exhibit high multicollinearity, only 1 sleep variable entered into the separate regression model. In model 2, ESS scores and the presence of insomnia and snoring were included as 3 additional independent variables. When the association between SSI score and the sleep variables were examined, BDI score was also included as an independent variable in model 2.

Relationships between other continuous variables were assessed using Pearson correlation coefficients. Group differences in continuous variables were explored using independent *t*-tests or analysis of covariance (covariates: age and sex). Between-group comparisons of categorical data were performed using the chi-square test. Statistical significance was defined at an  $\alpha$  of  $< 0.05$  (2-tailed), and SPSS Version 15.0 (SPSS Inc, Chicago, Ill) was used for all computations.

## RESULTS

### Demographic Data and Between-Group Comparisons

Summary statistics regarding the demographic characteristics and the questionnaire data of all 8,010 participants are presented in Table 1. Females (mean age  $16.66 \pm 1.11$  yr) were younger than males (mean age  $16.82 \pm 1.07$  yr) ( $t = 6.52$ ,  $P < 0.001$ ). For all study subjects, age was found to be negatively correlated with sleep duration both on weekdays and on weekends ( $r = -0.36$ ,  $P < 0.001$ ;  $r = -0.08$ ,  $P < 0.001$ , respectively), and age positively correlated with weekend oversleep ( $r = 0.16$ ,  $P < 0.001$ ) and weekend rise time delay ( $r = 0.14$ ,  $P < 0.001$ ). Females slept less on weekdays ( $t = 15.34$ ,  $P < 0.001$ ) and more on weekends ( $t = 7.01$ ,  $P < 0.001$ ), overslept for longer at weekends ( $t = 16.90$ ,  $P < 0.001$ ), and had greater rise time delays at weekends than males ( $t = 13.31$ ,  $P < 0.001$ ). On the other hand, males had larger bedtime delays on weekends ( $t = 7.25$ ,  $P < 0.001$ ).

### Daytime Sleepiness, Insomnia and Snoring

ESS scores were found to be positively correlated with age ( $r = 0.09$ ,  $P < 0.001$ ), and females had a higher mean ESS score than males ( $7.37 \pm 3.13$  versus  $7.06 \pm 3.10$ ,  $t = 4.24$ ,  $P < 0.001$ ). For all study subjects, ESS scores were negatively correlated with sleep duration on weekdays ( $r = -0.07$ ,  $P < 0.001$ ), positively correlated with sleep duration on week-

ends ( $r = 0.10$ ,  $P < 0.001$ ), weekend oversleep ( $r = 0.15$ ,  $P < 0.001$ ), rise time delay on weekends ( $r = 0.17$ ,  $P < 0.001$ ) and bedtime delay on weekends ( $r = 0.07$ ,  $P < 0.001$ ).

For all study subjects, mean KtCS score was  $32.58 \pm 5.73$ , and a lower KtCS score, which means more eveningness, was found to be correlated with a higher ESS score ( $r = 0.30$ ,  $P < 0.001$ ), shorter weekday sleep duration ( $r = 0.22$ ,  $P < 0.001$ ), longer weekend sleep duration ( $r = 0.18$ ,  $P < 0.001$ ) and longer weekend oversleep ( $r = 0.31$ ,  $P < 0.001$ ).

No significant differences were found between subjects with or without insomnia in terms of age or sex. Subjects with insomnia reported shorter weekday sleep duration ( $5.72 \pm 1.52$  hr versus  $6.08 \pm 1.26$  hr,  $t = 7.53$ ,  $P < 0.001$ ), longer weekend oversleep ( $2.96 \pm 2.30$  hr versus  $2.61 \pm 1.92$  hr,  $t = 4.14$ ,  $P < 0.001$ ) and greater weekend rise time delay ( $3.43 \pm 2.10$  hr versus  $2.98 \pm 1.79$  hr,  $t = 5.69$ ,  $P < 0.001$ ). Mean ESS score was greater for subjects with insomnia ( $8.51 \pm 3.56$  versus  $7.12 \pm 3.04$ ,  $t = 10.41$ ,  $P < 0.001$ ).

Although snoring was not found to be significantly related to age, it was more common in males ( $\chi^2 = 70.75$ ,  $P < 0.001$ ). Snorers had a longer mean weekday sleep duration ( $6.18 \pm 1.41$  hr versus  $6.04 \pm 1.28$  hr,  $t = 2.20$ ,  $P = 0.03$ ) and a larger weekend bedtime delay ( $0.78 \pm 1.26$  hr versus  $0.61 \pm 1.18$  hr,  $t = 2.86$ ,  $P < 0.01$ ). Furthermore, snorers had a higher mean ESS score ( $8.22 \pm 3.48$  versus  $7.19 \pm 3.09$ ,  $t = 6.01$ ,  $P < 0.001$ ) and were found to be more likely to meet the criteria for insomnia ( $\chi^2 = 5.77$ ,  $P = 0.02$ ).

## Depression

BDI scores were found to be positively correlated with age ( $r = 0.05$ ,  $P < 0.001$ ) and ESS scores ( $r = 0.28$ ,  $P < 0.001$ ). Mean BDI score was higher for females ( $t = 9.36$ ,  $P < 0.001$ ), subjects with insomnia ( $t = 18.54$ ,  $P < 0.001$ ), and subjects who snored ( $t = 5.48$ ,  $P < 0.001$ ).

The results of multiple regression models 1 and 2 using BDI score as the dependent variable are summarized in Table 2.

In multiple regression model 1, which controlled for age and sex only, a higher BDI score was found to be predicted by shorter weekday sleep duration ( $P < 0.001$ ), longer weekend oversleep ( $P < 0.001$ ), a larger weekend bedtime delay ( $P < 0.001$ ), a larger weekend rise time delay ( $P < 0.001$ ), and a lower KtCS score ( $P < 0.001$ ).

The ESS scores, insomnia, and snoring were included as additional independent variables in multiple regression model 2, because correlation analysis showed that most of these variables were significantly related to both sleep variables and depressive symptoms. A comparison of the results of the models 1 and 2 showed that although a higher BDI score was predicted by a shorter weekday sleep time ( $P < 0.001$ ), a larger weekend rise time delay ( $P = 0.03$ ),

and a lower KtCS score ( $P < 0.001$ ) by both models, the significant associations between BDI and weekend oversleep or

**Table 1**—Characteristics of study participants ( $n = 8010$ )

	Mean $\pm$ SD (n, %)
Age	16.73 $\pm$ 1.09
Sex	
Male	3,134 (39.13 %)
Female	4,876 (60.87 %)
School	
High school (18)	6,374 (79.58 %)
Middle school (5)	1,636 (20.42 %)
Sleep time	
Weekday	
Sleep duration	6 hr 3 min ( $\pm$ 1 hr 18 min) [3 hr ~ 11 hr]
Bedtime	24:00 ( $\pm$ 1 hr 6 min) [23:00 ~ 03:00]
Rise time	06:40 ( $\pm$ 46 min) [05:00 ~ 11:30]
Weekend	
Sleep duration	8 hr 41 min ( $\pm$ 1 hr 52 min) [3 hr ~ 14 hr]
Bedtime	01:01 ( $\pm$ 1 hr 24 min) [23:00 ~ 05:00]
Rise time	09:41 ( $\pm$ 1 hr 47 min) [06:00 ~ 15:00]
Weekday-weekend difference	
Weekend oversleep	2 hr 38 min ( $\pm$ 1 hr 58 min) [-3 hr ~ 8 hr]
Bedtime delay	37 min ( $\pm$ 1 hr 11 min) [-3 hr 30 min ~ 4 hr]
Rise time delay	3 hr 1 min ( $\pm$ 1 hr 49 min) [-1 hr 6 min ~ 8 hr 55 min]
Suicidality and depression	
SSI	7.06 $\pm$ 5.46 [0~38]
BDI	10.36 $\pm$ 6.98 [0~27]
Sleep problem	
ESS	7.25 $\pm$ 3.12 [0~19]
KtCS	32.62 $\pm$ 5.74 [14~53]
Significant insomnia	
Initial insomnia	511 (6.38 %)
Maintenance insomnia	348 (4.34 %)
Terminal insomnia	113 (1.41 %)
Any insomnia	763 (9.53 %)
Significant snoring	433 (5.41 %)

BDI, Beck Depression Inventory; ESS, Epworth Sleepiness Scale; KtCS: Korean Translation of the Composite Scale; SD, standard deviation; SSI: Beck Scale for Suicidal Ideation.

**Table 2**—The association between BDI score and sleep variables

	Regression Model 1 <sup>a</sup>		Regression Model 2 <sup>b</sup>	
	$\beta$	P	$\beta$	P
Sleep duration in weekday	-0.55	< 0.001	-0.41	< 0.001
Sleep duration in weekend	-0.02	0.72	-0.12	< 0.01
Weekend oversleep	0.20	< 0.001	0.05	0.23
Weekend bedtime delay	0.26	< 0.001	0.10	0.08
Weekend rise time delay	0.30	< 0.001	0.09	0.03
KtCS	-0.27	< 0.001	-0.17	< 0.001

<sup>a</sup>Multiple regression model 1: dependent variable: BDI; independent variables: each sleep variable, age, and sex. <sup>b</sup>Multiple regression model 2: dependent variable: BDI; independent variables: each sleep variable, age, sex, insomnia, snoring, and ESS. BDI, Beck Depression Inventory; ESS, Epworth Sleepiness Scale; KtCS, Korean Translation of the Composite Scale.

**Table 3**—The association between SSI score and sleep variables

	Regression Model 1 <sup>a</sup>		Regression Model 2 <sup>b</sup>	
	$\beta$	P	$\beta$	P
Sleep duration in weekday	-0.37	< 0.001	-0.05	0.14
Sleep duration in weekend	0.05	0.14	0.05	0.03
Weekend oversleep	0.19	< 0.001	0.07	< 0.01
Weekend bedtime delay	0.15	< 0.01	0.00	0.94
Weekend rise time delay	0.24	< 0.001	0.07	< 0.01
KtCS	-0.18	< 0.001	-0.03	< 0.001

<sup>a</sup>Multiple regression model 1: dependent variable: SSI; independent variables: each sleep variable, age, and sex. <sup>b</sup>Multiple regression model 2: dependent variable: SSI; independent variables: each sleep variable, age, sex, insomnia, snoring, ESS, and BDI. BDI, Beck Depression Inventory; ESS, Epworth sleepiness scale; KtCS, Korean Translation of the Composite Scale; SSI, Beck Scale for Suicidal Ideation.

weekend bedtime delay by model 1 were not significant in model 2. However, a new association was detected by model 2 between a shorter weekend sleep time and a higher BDI score ( $P < 0.01$ ). The different results obtained using models 1 and 2 were mainly driven by ESS scores, as the results of models 1 and 2 were similar when other additional independent variables of insomnia and snoring were excluded. When the sleep item of BDI was excluded, model 1 and 2 results were not significantly changed.

### Suicidality

SSI score was found to be positively correlated with age ( $r = 0.04$ ,  $P < 0.001$ ), and ESS ( $r = 0.22$ ,  $P < 0.001$ ) and BDI scores ( $r = 0.70$ ,  $P < 0.001$ ). Mean SSI score was higher in females than in males ( $t = 14.73$ ,  $P < 0.001$ ), and also in subjects with insomnia ( $t = 15.13$ ,  $P < 0.001$ ) and subjects who snored ( $t = 3.70$ ,  $P < 0.001$ ).

The results of the multiple regression models 1 and 2 using SSI score as the dependent variable are summarized in Table 3.

Multiple regression model 1 showed that a higher SSI score was associated with shorter weekday sleep duration ( $P < 0.001$ ), longer weekend oversleep ( $P < 0.001$ ), a larger weekend bedtime delay ( $P < 0.01$ ), a larger weekend rise time delay ( $P < 0.001$ ), and a lower KtCS score ( $P < 0.001$ ).

When BDI scores, the ESS scores, insomnia, and snoring were included as additional independent variables in model 2, longer weekend oversleep ( $P < 0.01$ ), larger weekend rise time delay ( $P < 0.01$ ) and lower KtCS score ( $P < 0.001$ ) were found to predict a higher SSI score, which indicates that weekend oversleep is an independent predictor of suicidality. Although weekday sleep duration and weekend bedtime delay were not found to significantly predict SSI score by model 2, a significant association between a longer weekend sleep duration and a higher SSI score ( $P = 0.03$ ) was found. The different results of models 1 and 2 were mainly driven by BDI score, as model 2 produced similar results when other additional variables of ESS score, insomnia, and snoring were excluded as independent variables. When the sleep and suicide items of BDI were excluded, model 2 results were not significantly changed.

### Behaviorally Induced Insufficient Sleep Syndrome

Of the 8,010 study participants, 1,504 (18.78%) were classified as having BISS, and 5,743 (71.70%) without BISS or significant insomnia were classified as not having BISS. Of subjects without BISS, 2,031 (25.51%) who slept  $\geq 7$  hr on weekdays were defined as “subjects with sufficient sleep.” A summary of results is presented in Table 4. Subjects with BISS were significantly older than subjects without BISS or subjects with sufficient sleep ( $P < 0.001$ ). BISS was also more common in females than in males ( $P < 0.001$ ).

After controlling for age and sex, subjects with BISS were found to have higher BDI and SSI scores than subjects without BISS or subjects with sufficient sleep (all  $P < 0.001$ ). Even after controlling for BDI scores, subjects with BISS had significantly higher SSI scores than subjects without BISS ( $F = 7.84$ ,  $P < 0.01$ ) or subjects with sufficient sleep ( $F = 11.71$ ,  $P < 0.001$ ). As expected, subjects with BISS slept less on weekdays and more on weekends, overslept longer on weekends, and had a larger weekend rise time delay and a higher ESS score than subjects without BISS or subjects with sufficient sleep (all  $P < 0.001$ ). In addition, subjects with BISS had lower KtCs scores than subjects without BISS or subjects with sufficient sleep (all  $P < 0.001$ ). Subjects with BISS went to bed earlier on weekends than subjects with sufficient sleep ( $P < 0.001$ ), but not than subjects without BISS. Snoring was also more common in subjects with BISS than subjects without BISS ( $P < 0.001$ ) or subjects with sufficient sleep ( $P = 0.04$ ).

For subjects with BISS, longer weekend oversleep predicted higher BDI ( $\beta = 0.28$ ,  $P = 0.01$ ) and SSI scores ( $\beta = 0.35$ ,  $P < 0.001$ ) after controlling for age and sex. Furthermore, longer weekend oversleep predicted a higher SSI score even after BDI score was included as an additional independent variable ( $\beta = 0.20$ ,  $P < 0.01$ ). For subjects without BISS or subjects with sufficient sleep, neither BDI nor SSI scores were significantly associated with weekend oversleep.

### DISCUSSION

To the best of our knowledge, the current study is the first to investigate an association between behaviorally induced sleep insufficiency and suicidality among adolescents. Our results show that BISS increases suicidality independently of the self-reported symptoms of depression. In addition, we found that longer weekend oversleep independently predicted higher suicidality.

Shorter weekday sleep durations and longer weekend oversleep suggest that Korean adolescents are likely to suffer from chronic sleep deprivation. Suicide rates in South Korea have been reported to be highest among OECD countries,<sup>18</sup> and the Korean government reported that the suicide rate among teenagers was 10.7 per 100,000 annually.<sup>19</sup> Although speculative, these results suggest common sleep deprivation among adolescents may contributed to the high suicide rates in Korea.

The current study is also the first to report heightened suicidality among adolescents with BISS. A large difference in sleep duration between weekdays and weekends (i.e., weekend oversleep) was also found to predict a high suicidality, which concurs with previous research findings regarding an association between short sleep duration and suicidality among

**Table 4**—Comparison between subjects with BISS and subjects without BISS (or subjects with BISS and subjects with sufficient sleep)

	Subjects with BISS (n = 1,504)	Subjects without BISS (n = 5743)	Subjects with sufficient sleep (n = 2,053)	F <sup>a</sup>	F <sup>b</sup>
Age	Mean (n) 16.96 ± 0.89	SD (%) 16.66 ± 1.13	SD (%) 16.05 ± 1.23	t = 9.72***	t = 24.30***
Sex	M/F: 492/1,012	M/F: 2,355/3,388	M/F: 1,034/1,019	χ <sup>2</sup> = 34.02***	χ <sup>2</sup> = 109.71***
Suicidality and depression					
SSI <sup>†</sup>	8.26 ± 5.51 [0~27]	6.28 ± 4.96 [0~27]	5.84 ± 5.06 [0~27]	151.49***	106.11***
BDI <sup>†</sup>	12.15 ± 6.99 [0~37]	9.14 ± 6.17 [0~38]	8.82 ± 6.46 [0~38]	236.87***	130.73***
Sleep time					
Sleep duration on weekday <sup>†</sup>	5 hr 37 min ± 57 min [3 hr ~ 7 hr]	6 hr 13 min ± 1 hr 18 min [3 hr ~ 11 hr]	7 hr 34 min ± 55 min [7 hr ~ 11 hr]	159.73***	2694.93***
Sleep duration on weekend <sup>†</sup>	9 hr 22 min ± 1 hr 37 min [6 hr ~ 14 hr]	8 hr 31 min ± 1 hr 50 min [3 hr ~ 14 hr]	9 hr 7 min ± 1 hr 45 min [3 hr ~ 14 hr]	290.32***	10.96***
Weekend oversleep <sup>†</sup>	3 hr 45 min ± 1 hr 37 min [2 hr ~ 9 hr]	2 hr 19 min ± 1 hr 53 min [-3 hr ~ 8 hr]	1 hr 33 min ± 1 hr 43 min [-3 hr ~ 7 hr]	629.04***	1017.37***
Weekend bedtime delay <sup>†</sup>	35 min ± 1 hr 12 min [-3 hr 30 min ~ 4 hr]	37 min ± 1 hr 8 min [-3 hr 30 min ~ 4 hr]	50 min ± 1 hr 7 min [-2 hr 30 min ~ 4 hr]	0.30	42.55***
Weekend rise time delay <sup>†</sup>	3 hr 52 min ± 1 hr 44 min [0 hr ~ 8 hr 55 min]	2 hr 45 min ± 1 hr 44 min [-1 hr 6 m in ~ 8 hr 40 min]	2 hr 22 min ± 1 hr 40 min [-1 hr ~ 8 hr 30 min]	405.67***	400.46***
Sleep problem					
ESS <sup>†</sup>	10.82 ± 2.08 [9~19]	6.14 ± 2.44 [0~16]	6.29 ± 2.83 [0~16]	4995.74***	2069.66***
KtCS <sup>†</sup>	30.11 ± 5.34 [14~50]	33.55 ± 5.50 [14~53]	34.71 ± 5.44 [16~53]	425.14***	473.92***
Significant snoring	110 (7.31 %)	267 (4.65 %)	115 (5.60 %)	χ <sup>2</sup> = 16.62***	χ <sup>2</sup> = 4.01*

<sup>a</sup>Comparison between subjects with BISS and subjects without BISS. <sup>b</sup>Comparison between subjects with BISS and subjects with sufficient sleep. <sup>†</sup>After controlling for age and sex. \*P < 0.05, \*\*P < 0.01, \*\*\*P < 0.001. BISS, behaviorally induced insufficient sleep syndrome; BDI, Beck Depression Inventory; ESS, Epworth Sleepiness Scale; KtCS, Korean Translation of Composite Scale; M/F, male/female; SD, standard deviation; SSI, Beck Scale for Suicidal Ideation.

adolescents,<sup>3-4</sup> because sleep duration is primarily affected by self-selected sleep restriction.<sup>5</sup> In terms of sleep debt created by self-induced sleep restriction, weekend oversleep could provide more reliable information than habitual sleep duration, which is directly affected by insomnia or natural short sleepers. Accordingly, our findings also suggest that sleep restriction may increase the risk of suicide in adolescents.

In the current study, weekend oversleep was found to be an independent predictor of suicidality after adjusting for depression, insomnia, sleepiness, and snoring, which have been previously reported to be associated with suicidality.<sup>20-23</sup> Although some studies have reported an association between suicidality and sleep duration<sup>3</sup> or sleep disturbance<sup>20</sup> among adolescents after controlling for depression, most previous studies were not adjusted for insomnia, daytime sleepiness, or snoring. However, our results suggest that chronic sleep deprivation during adolescence may increase the suicidal risk independently of insomnia, depression, and daytime sleepiness.

Some other variable could make sleep-deprived adolescents more vulnerable to suicidality. In particular, decreased impulse control and various risky behaviors have been reported to be associated with short sleep duration in adolescents.<sup>4,24,25</sup> Therefore, it is plausible that chronic sleep deprivation in adolescents might increase suicidality through heightened impulsivity or intolerance to other stressors. In addition, the neurobiologic effects of chronic sleep deprivation may be related and increase suicidality. However, our results shed no light on the causal pathway linking chronic sleep deprivation to suicidality.

In the current study, the association between weekday sleep duration and suicidality disappeared after controlling for confounding variables, especially depression. Although the association between sleep duration and suicidality was reported to be independent of depression in 1,362 Chinese adolescents,<sup>3</sup> other studies have reported that the association between sleep duration and suicidality during adolescence was moderated by insomnia or depression.<sup>4,6</sup> Although weekday sleep duration is closely related to weekend oversleep, our findings suggest that although the effect of sleep duration on depression is substantial, its effects on suicidality are not independent and are mediated by depression.

Although short sleep duration was found to be directly related to depressive symptoms, weekend oversleep was less directly related. Although longer weekend oversleep was a predictor of depression, this association did not remain significant after controlling for daytime sleepiness. This finding is consistent with that of a prior study that reported an association between daytime sleepiness and depression among adolescents.<sup>26</sup> Our findings suggest that adolescent depression induced by insufficient sleep may be mediated by excessive daytime sleepiness.

In the current study, weekend rise time but not weekend bedtime was found to be delayed. Furthermore, eveningness was found to be related with daytime sleepiness, longer weekend oversleep, and BISS. These findings suggest that adolescent sleep insufficiency might be caused by a mismatch between intrinsic factors such as circadian rhythm and extrinsic factors such as school schedule.<sup>27-29</sup> Furthermore, the current study sug-

gests that sleep insufficiency induced by this mismatch might mediate the relationship between eveningness and suicidality/depression, and modifying school start times may reduce sleep insufficiency and associated suicide risk.

As has been discussed in other studies,<sup>30,31</sup> we found that females overslept longer on weekends and had a shorter weekday sleep duration than males. A greater degree of insufficient sleep in females may be due to social requirements, such as morning grooming<sup>30</sup> or the earlier onset of pubertal signs, including circadian rhythm delay.<sup>32</sup> In addition, an older age was associated with longer weekend oversleep. This finding was expected because moving to a higher grade entails earlier school starts, a more delayed biologic sleep-wake cycle, and heavier and more demanding academic pressures.<sup>31</sup>

Despite its strengths, such as the large sample size and adjustment for many potential confounding variables, the current study has several limitations. One limitation is that it relies solely on self-report measures. However, although objective tools such as polysomnography and actigraphy enable more direct measure of sleep, these tools are impractical for large-scale population-based studies. Another limitation may be the cross-sectional nature of the study. A longitudinal study may be needed to confirm the causal relationship between insufficient sleep and suicidality. Another area of concern involves the sample representativeness, because most of the participants were female and high school students. To investigate the true prevalence of BISS in Korea, a future study with a more representative sample is needed. In addition, considering the unique university-bound culture in Korea, our findings may not be applicable in other sociocultural contexts. In addition, although the correlation between sleep and suicidality was statistically significant, it was small, especially after controlling for potential covariates, which suggests the relationship between insufficient sleep and suicidality is strongly influenced by covariates such as depression, insomnia, and daytime sleepiness.

In conclusion, we found that BISS among Korean adolescents is associated with increased suicidality. In addition, chronic sleep deprivation, as represented by weekend oversleep, was found to be associated with suicidality independently of depression, insomnia, snoring, and daytime sleepiness. Accordingly, our findings suggest that chronic sleep restriction among adolescents may independently increase suicide risk.

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## DISCLOSURE STATEMENT

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## REFERENCES

1. Carskadon MA, Acebo C, Seifer R. Extended nights, sleep loss, and recovery sleep in adolescents. *Arch Ital Biol* 2001;139:301-12.
2. Pallesen S, Saxvig IW, Molde H, Sorensen E, Wilhelmsen-Langeland A, Bjorvatn B. Brief report: Behaviorally induced insufficient sleep syndrome in older adolescents: Prevalence and correlates. *J Adolesc* [E-pub ahead of print].

3. Liu X. Sleep and adolescent suicidal behavior. *Sleep* 2004;27:1351-8.
4. Yen CF, King BH, Tang TC. The association between short and long nocturnal sleep durations and risky behaviours and the moderating factors in Taiwanese adolescents. *Psychiatry Res* 2010;179:69-74.
5. Klerman EB, Dijk DJ. Interindividual variation in sleep duration and its association with sleep debt in young adults. *Sleep* 2005;28:1253-9.
6. Liu X, Zhou H. Sleep duration, insomnia and behavioral problems among Chinese adolescents. *Psychiatry Res* 2002;111:75-85.
7. Park S, Cho MJ, Chang SM, et al. Relationships of sleep duration with sociodemographic and health-related factors, psychiatric disorders and sleep disturbances in a community sample of Korean adults. *J Sleep Res* 2010;19:567-77.
8. Yang CK, Kim JK, Patel SR, Lee JH. Age-related changes in sleep/wake patterns among Korean teenagers. *Pediatrics* 2005;115:250-6.
9. Beck AT, Kovacs M, Weissman A. Assessment of suicidal intention: the scale for suicide ideation. *J Consult Clin Psychol* 1979;47:343-52.
10. Lee HS, Kwon JH. Validation for the Beck scale for suicide ideation with Korean university students. *Kor J Psychology* 2009;28:1155-72.
11. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry* 1961;4:561-71.
12. Hahn HM, Yum TH, Shin YW, Kim KH, Yoon DJ, Chung KJ. A standardization study of Beck depression inventory in Korea. *J Korean Neuropsychiatr Assoc* 2002;41:487-502.
13. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep* 1991;149:540-5.
14. Lee JS, Kim SJ, Choi JB, Jeong DU. Comparison of daytime sleepiness between normal subjects and patients with sleep disorders and analysis of its clinical implications. *Sleep Med Psychophysiol* 2002;9:106-14.
15. Smith CS, Tisak J, Bauman T, Green E. Psychometric equivalence of a translated circadian rhythm questionnaire: implications for between- and within-population assessments. *J Appl Psychol* 1991;76:628-36.
16. Yoon JS, Shin SM, Kook SH, Lee HY. A preliminary study on the Korean Translation of Composite Scale (KiCS) to measure morningness-eveningness. *J Korean Neuropsychiatr Assoc* 1997;36:122-30.
17. Komada Y, Inoue Y, Hayashida K, Nakajima T, Honda M, Takahashi K. Clinical significance and correlates of behaviorally induced insufficient sleep syndrome. *Sleep Med* 2008;9:851-6.
18. OECD. OECD Health Data 2010: Statistics and Indicators for 34 Countries. 2010
19. Statistics Korea. Causality of mortality in 2009. 2010.
20. Goldstein TR, Bridge JA, Brent DA. Sleep disturbance preceding completed suicide in adolescents. *J Consult Clin Psychol* 2008;76:84-91.
21. Wojnar M, Ilgen MA, Wojnar J, McCammon RJ, Valenstein M, Brower KJ. Sleep problems and suicidality in the National Comorbidity Survey Replication. *J Psychiatr Res* 2009;43:526-31.
22. Krakow B, Artar A, Warner TD, et al. Sleep disorder, depression, and suicidality in female sexual assault survivors. *Crisis* 2000;21:163-70.
23. Choquet M, Menke H. Suicidal thoughts during early adolescence: prevalence, associated troubles and help-seeking behavior. *Acta Psychiatr Scand* 1990;81:170-7.
24. Dahl RE, Lewin DS. Pathways to adolescent health sleep regulation and behavior. *J Adolesc Health* 2002;31:175-84.
25. Pasch KE, Laska MN, Lytle LA, Moe SG. Adolescent sleep, risk behaviors, and depressive symptoms: are they linked? *Am J Health Behav* 2010;34:237-48.
26. Saarenpaa-Heikkila O, Laippala P, Koivikko M. Subjective daytime sleepiness and its predictors in Finnish adolescents in an interview study. *Acta Paediatr* 2001;90:552-7.
27. Giannotti F, Cortesi F, Sebastiani T, Ottaviano S. Circadian preference, sleep and daytime behaviour in adolescence. *J Sleep Res* 2002;11:191-9.
28. Hansen M, Janssen I, Schiff A, Zee PC, Dubocovich ML. The impact of school daily schedule on adolescent sleep. *Pediatrics* 2005;115:1555-61.
29. Lazaratou H, Dikeos DG, Anagnostopoulos DC, Sbokou O, Soldatos CR. Sleep problems in adolescence. A study of senior high school students in Greece. *Eur Child Adolesc Psychiatry* 2005;14:237-43.
30. Lee KA, McEnany G, Weekes D. Gender differences in sleep patterns for early adolescents. *J Adolesc Health* 1999;24:16-20.
31. Gau SF, Soong WT. Sleep problems of junior high school students in Taipei. *Sleep* 1995;18:667-73.
32. Tonetti L, Fabbri M, Natale V. Sex difference in sleep-time preference and sleep need: a cross-sectional survey among Italian pre-adolescents, adolescents, and adults. *Chronobiol Int* 2008;25:745-59.