

## Weekend catch-up sleep is independently associated with suicide attempts and self-injury in Korean adolescents

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### Abstract

The current study aims to determine the associations of insufficient sleep with suicide attempts and self-injury in a large, school-based Korean adolescent sample.

A sample of 4553 middle- and high-school students (grades 7–10) was recruited in this study. Finally, 4145 students completed self-report questionnaires including items on sleep duration (weekday/weekend), self-injury, suicide attempts during the past year, the Suicidal Ideation Questionnaire (SIQ), and the Beck Depression Inventory (BDI).

A multiple linear regression model showed that higher SIQ scores were associated with longer weekend catch-up sleep duration ( $p = 0.009$ ), higher BDI score ( $p < 0.001$ ), and longer time spent in a private educational institute ( $p = 0.025$ ). The multiple logistic regression analysis revealed that longer weekend catch-up sleep duration ( $p = 0.011$ ), higher BDI score ( $p < 0.001$ ), longer time spent in a private educational institute ( $p = 0.046$ ), and poorer academic record ( $p = 0.029$ ) were associated with suicide attempt and self-injury during the past year.

The present results suggest that weekend catch-up sleep duration – which is an indicator of insufficient weekday sleep – might be associated with suicide attempts and self-injury in Korean adolescents.

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### 1. Introduction

Sufficient sleep is critical for the mental and physical health of adolescents, with sleep being particularly important for their emotion regulation, cognition, attention, psychosocial development, and physical growth. Research has found that the optimal sleep period for adolescents is 9 h/night under controlled conditions (i.e., without clocks or lighting cues), and at least 8.5–9.25 h/night is recommended [1,2]. However, adolescents in modern society tend not to take

enough sleep because of various factors, such as their academic workload, depression, insomnia, and delayed sleep phase.

The most commonly suggested reason for insufficient sleep among adolescents is self-induced sleep restriction and wake extension, a condition that is known as behaviorally induced insufficient sleep syndrome (BISS). Since Korean adolescents are subjected to strong psychological pressure to perform well in their university entrance examinations, they often try to spend more time studying at the cost of insufficient sleep. The prevalence of BISS among Korean adolescents was reported to be 18.78% in our previous study [3]. Korean adolescents have a shorter sleep duration and longer weekend oversleeps than their peers in North America and Europe [4]. One study found that Korean 10th-, 11th-, and 12th-grade adolescents were severely sleep deprived,

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with mean total weekday sleep durations of 6.0, 5.6, and 4.9 h, respectively [5]. Classes in Korean schools usually start at 07:00 ~ 08:30 and end at 16:00 ~ 18:30; moreover, almost all Korean adolescents attend night school, go to a private educational institute (or hagwon (i.e., a for-profit private institute, academy, or cram school) in Korean) for extra after-school tuition, often until 21:00–24:00 [3]. Although in 2009 several local governments began to restrict the closing time of private educational institutes to 22:00, many institutes violate that curfew to teach more night-time classes.

Suicide is a tragic event, and is one of the leading causes of death among adolescents; however, it is potentially preventable. According to the statistics of the Organization for Economic Cooperation and Development countries, South Korea ranks highest with respect to suicide rates [6]. The Korean suicide rate among teenagers overall was 10.7 per 100,000 annually [7], while that among Korean adolescents and young adults (aged from 15 to 24 years) was reported to be 15.3 per 100,000 in 2009 and 13.0 per 100,000 in 2010; suicide is reportedly the leading cause of mortality in this age group [7,8]. The previous studies reported that prevalence of suicidal attempt in the Korean adolescents was 5.3% and 3.9% [9,10]. Adolescents are known to be vulnerable to self-harm or suicide attempts, and to be at increased risk of emotional instability and impulsive behaviors [11,12]. Accordingly, the suicide rate, lack of sleep, and the burden of academic pressure among Korean adolescents are becoming serious social issues that require a solution.

While sleep disturbance has not been included in the lists of suicide risk factors reported by World Health Organization, there are many articles and reviews about the adult population that associate sleep disturbances with suicidal thoughts and behaviors [13–16]. Since both suicide and insufficient sleep are important health issues for adolescents, there have been several investigations regarding possible associations between these two problems [3,17–19].

We have recently reported that BISS in adolescents is associated with suicidal ideation, independent of confounding factors including depressed mood, daytime sleepiness, snoring, and insomnia [3]. That study was the first to investigate an association between BISS and suicidality among adolescents [3]. The biological sleep requirement varies among individuals; thus, a short sleep duration does not always reflect insufficient sleep [20]. A longer sleep duration during the weekend compared with weekdays may reflect the actual sleep needed. The weekend catch-up sleep may therefore be a better indicator of sleep insufficiency [21].

Self-injury and suicide attempts have been regarded as the most important predictors of completed suicide [22]. Although in our previous study we found that BISS among Korean adolescents is associated with increased suicidal ideation, based on the Beck Scale for Suicidal Ideation score, we did not investigate suicidal behaviors such as self-injury or suicide attempt. Therefore, the aim of the present study was to determine the relationship between insufficient sleep

and heightened suicide risk by determining whether or not insufficient sleep is related to an increase in the incidence of suicidal behaviors among Korean adolescents. In addition, in order to validate our former notion of an association between sleep duration and suicidal ideation, we used a different scale to measure the latter in the independent large-scale sample.

The aim of the current study was to determine the relationship between sleep insufficiency and suicidality – including not only suicidal ideation but also suicidal behaviors – in a school-based Korean adolescent sample.

## 2. Methods

### 2.1. Subjects

We recruited adolescent middle- and high-school students in Incheon as participants. Questionnaires were distributed to a total of 4553 students at 9 middle schools and 7 high schools, all of whom gave their consent to participate in this study. A total of 4145 students completed the entire questionnaire, among which 2297 (55.4%) were male and 1847 (44.6%) were female; all were 7th–10th graders aged  $15.3 \pm 1.5$  (mean  $\pm$  SD) years. Written informed consent was obtained from the students' parents, and consent to participate was provided by all of the students. The study protocol was approved by the Institutional Review Board of Gachon University of Medicine and Science.

### 2.2. Assessments

Sleep durations on weekdays and weekends were assessed using a self-report questionnaire. The questionnaire asked: "On average, how many hours do you sleep on weekdays and weekends?" Individual weekend catch-up sleep durations were calculated as weekend sleep duration minus weekday sleep duration.

The severity of suicidal ideation was measured using the Korean version of the Suicidal Ideation Questionnaire (SIQ), developed by Reynolds [23] and standardized by Shin et al. [24], which the participants were asked to complete. This questionnaire is a 30-item self-report scale that assesses specific thoughts about suicide and death experienced by the participant over the past month. Another self-report questionnaire was used to measure the suicide attempts and self-injuries during the past year, which asked: "Have you made any intentional suicide attempt or performed any self-injury over the past 1-year period?"

The Korean version of the 21-item Beck Depression Inventory (BDI) was administered to evaluate the students' depressive symptoms [25,26]. In addition, the questionnaire included an item about the time spent in a private educational institute and a self-report on the academic record: Likert scale of 1–4, where 1 = within the top ten in class, 2 = 10th–20th in class, 3 = 20th–30th in class, and 4 = below 30th in class.

### 2.3. Statistical analysis

The categorical data were analyzed by means of the  $\chi^2$  test, and continuous variables were analyzed using Student's *t* test or analysis of covariance (with the covariates age and gender). Two multiple regression models for suicidal ideation (SIQ) and two multiple logistic regression models for the suicide attempts and self-injury were used to explore the effects of the following independent variables: weekend catch-up sleep duration (or sleep duration of weekday), depressed mood (BDI score), age, gender, time spent in a private educational institute, and academic record. The independent sleep variable was weekend catch-up sleep duration in model 1 and weekday sleep duration in model 2. Since these two sleep variables exhibit high multicollinearity, only one sleep variable was entered into the separate regression model. All of the analyses were performed using SPSS for Windows. Probability values smaller than 0.05 (two-tailed) were considered indicative of statistical significance.

## 3. Results

### 3.1. Demographic data of the entire cohort, and comparison of their characteristics

The statistics regarding the demographic characteristics of the 4145 participants are presented in Table 1. The SIQ score of the entire cohort was  $13.7 \pm 23.1$ . The prevalence of a suicide attempt or intentional self-injury was 5.1% ( $n = 213$ ).

The sleep duration was (h:min)  $7:01 \pm 1:18$  on weekdays and  $8:51 \pm 1:40$  on weekends. The mean weekend catch-up sleep duration was  $1:50 \pm 1:35$ . The weekday and weekend catch-up sleep durations were  $7:10 \pm 1:14$  and  $1:36 \pm 1:35$

respectively, for the male participants, and  $6:50 \pm 1:22$  and  $2:07 \pm 1:31$  for the female participants. There were significant differences in the duration of weekday sleep duration ( $t = 8.34, p = 0.001$ ) and weekend catch-up sleep duration ( $t = -10.57, p < 0.001$ ) between the genders. The BDI score was  $9.0 \pm 6.7$  for the males and  $12.2 \pm 8.1$  for the females; the difference between these figures was statistically significant ( $t = -13.50, p < 0.001$ ).

Since a short sleep duration on weekdays ( $\leq 7$  h) was one of the BISS criteria and the average sleep hours of all participants was approximately 7 h, the participants were divided into two groups, and their clinical characteristics compared: those taking 7 h or more of sleep on weekdays and those taking less than 7 h. Those who slept less than 7 h on weekdays were older ( $t = 38.07, p < 0.001$ ), comprised more females ( $\chi^2 = 77.80, p < 0.001$ ), and had higher BDI scores ( $F = 69.01, p < 0.001$ ) and SIQ scores ( $F = 22.80, p < 0.001$ ) compared with those who slept for more than 7 h. However, there was no statistically significant difference in the frequency of participants with suicide attempts or self-injury between these two groups ( $\chi^2 = 0.05, p = 0.823$ ).

### 3.2. Multiple linear regression models for SIQ score

The results of multiple regression models 1 and 2 using SIQ score as the dependent variable are given in Table 2. In multiple regression model 1, higher SIQ scores were found to be predicted by longer weekend catch-up sleep duration ( $B = 0.48, p = 0.009$ ), higher BDI score ( $B = 2.06, p < 0.001$ ), younger age ( $B = -1.18, p < 0.001$ ), female gender ( $B = 2.00, p = 0.001$ ), and a longer time spent in a private educational institute ( $B = 0.19, p = 0.025$ ). Instead of the weekend catch-up sleep duration, the weekday sleep

Table 1

Demographic data of the entire cohort and the comparison of clinical characteristics between subjects who sleep  $\geq 7$  h and subjects who sleep less than 7 h on weekdays.

| Variables                             | Total subjects<br>( $n = 4145$ ) | Subjects sleep $\geq$<br>7 h ( $n = 2480$ ) | Subjects sleep less than<br>7 h ( $n = 1665$ ) | $F^a$ ( $p$ value)                            |
|---------------------------------------|----------------------------------|---|--|---|
| Age                                   | $15.3 \pm 1.5$                   | $14.6 \pm 1.2$                              | $16.2 \pm 1.3$                                 | $t = 38.07$ ( $p < 0.001$ ) <sup>b</sup>      |
| Gender                                |                                  |   |  | $\chi^2 = 77.80$ ( $p < 0.001$ ) <sup>c</sup> |
| Male                                  | 2297 (55.4%)                     | 1513 (61.0%)                                | 784 (47.1%)                                    |   |
| Female                                | 1847 (44.6%)                     | 967 (39.0%)                                 | 880 (52.9%)                                    |   |
| Sleep duration (h:min)                |                                  |   |  |   |
| Weekday                               | $7:01 (\pm 1:18)$                | $7:53 (\pm 0:52)$                           | $5:45 (\pm 0:39)$                              | $4247.59$ ( $p < 0.001$ )                     |
| Weekend                               | $8:51 (\pm 1:40)$                | $9:22 (\pm 1:34)$                           | $8:05 (\pm 1:30)$                              | $471.14$ ( $p < 0.001$ )                      |
| Weekend catch-up sleep                | $1:50 (\pm 1:35)$                | $1:29 (\pm 1:34)$                           | $2:21 (\pm 1:28)$                              | $116.28$ ( $p < 0.001$ )                      |
| Time in private educational institute | $2:56 (\pm 3:16)$                | $2:57 (\pm 3:16)$                           | $2:56 (\pm 3:18)$                              | $21.27$ ( $p < 0.001$ )                       |
| Academic record                       | $2.2 \pm 1.0$                    | $2.3 \pm 1.0$                               | $2.1 \pm 0.9$                                  | $27.76$ ( $p < 0.001$ )                       |
| BDI                                   | $10.4 \pm 7.5$                   | $9.2 \pm 7.1$                               | $12.2 \pm 7.7$                                 | $69.01$ ( $p < 0.001$ )                       |
| SIQ                                   | $13.7 \pm 23.1$                  | $12.0 \pm 22.5$                             | $16.3 \pm 23.7$                                | $22.80$ ( $p < 0.001$ )                       |
| Suicide attempts or self-injury       | 213 (5.1%)                       | 129 (5.2%)                                  | 84 (5.0%)                                      | $\chi^2 = 0.05$ ( $p = 0.823$ ) <sup>c</sup>  |
| Number of attempts ( $n = 122$ )      | $2.6 \pm 4.7$                    | $2.8 \pm 6.0$                               | $2.4 \pm 2.1$                                  | $0.03$ ( $p = 0.854$ )                        |

The values are means  $\pm$  SD.

BDI, Beck Depression Inventory; SIQ, Suicidal Ideation Questionnaire.

<sup>a</sup> Analysis of Covariance test (with the covariates age and gender).

<sup>b</sup> Independent Student's *t*-test.

<sup>c</sup> Chi-square test.

Table 2

Multiple linear regression models for SIQ score.

| Independent variables                 | Regression model 1 <sup>a</sup> |                |         |                | Regression model 2 <sup>b</sup> |                |         |                |
|---------------------------------------|---------------------------------|----------------|---------|----------------|---------------------------------|----------------|---------|----------------|
|                                       | B                               | Standard error | $\beta$ | <i>p</i> value | B                               | Standard error | $\beta$ | <i>p</i> value |
| Age                                   | −1.18                           | 0.20           | −0.07   | <0.001         | −0.89                           | 0.23           | −0.06   | <0.001         |
| Gender                                | 2.00                            | 0.58           | 0.04    | 0.001          | 2.42                            | 0.58           | 0.05    | <0.001         |
| Weekend catch-up sleep duration       | 0.48                            | 0.18           | 0.03    | 0.009          |                                 |                |         |                |
| Sleep duration of weekday             |                                 |                |         |                | 0.40                            | 0.26           | 0.02    | 0.130          |
| Time in private educational institute | 0.19                            | 0.09           | 0.03    | 0.025          | 0.22                            | 0.09           | 0.03    | 0.009          |
| Academic record                       | 0.33                            | 0.29           | 0.01    | 0.251          | 0.25                            | 0.29           | 0.01    | 0.398          |
| BDI                                   | 2.06                            | 0.04           | 0.67    | <0.001         | 2.08                            | 0.04           | 0.67    | <0.001         |

Dependent variable: SIQ.

SIQ, Suicidal Ideation Questionnaire; BDI, Beck Depression Inventory.

<sup>a</sup> Multiple regression model 1: independent variables; age, gender, weekend catch-up sleep, time in private educational institute, academic record, BDI.<sup>b</sup> Multiple regression model 2: independent variables; age, gender, sleep duration of weekday, time in private educational institute, academic record, BDI.

duration was entered into multiple regression model 2 as the independent sleep variable, since these two sleep variables exhibited high multicollinearity. In multiple regression model 2, SIQ score was not significantly associated with weekday sleep duration ( $B = 0.40$ ,  $p = 0.130$ ).

### 3. Multiple logistic regression models for suicide attempts and self-injury

The results of multiple logistic regression models 1 and 2 using suicide attempts and self-injury during the past year are summarized in Table 3. In multiple logistic regression model 1, suicide attempts and self-injury were found to be predicted by a longer weekend catch-up sleep duration (odds ratio [OR] = 1.13,  $p = 0.011$ ), higher BDI scores (OR = 1.12,  $p < 0.001$ ), younger age (OR = 0.71,  $p < 0.001$ ), longer time in a private educational institute (OR = 1.05,  $p = 0.046$ ), and poorer academic record (OR = 1.19,  $p = 0.029$ ). In multiple logistic regression model 2, there was no

significant association between suicide attempts and self-injury, and weekday sleep duration (OR = 0.98,  $p = 0.797$ ).

### 4. Discussion

The findings of this study suggest that weekend catch-up sleep duration, as an indicator of insufficient weekday sleep, is associated not only with suicidal ideation but also suicide attempts and self-injury in Korean adolescents. To the best of our knowledge, this is the first report of a significant association between weekend catch-up sleep duration and suicidal behaviors. In addition, we have confirmed our previous finding of a significant association between BISS and suicidality among adolescents, this time in a separate, large sample and using a different scale, and verified the importance of weekend catch-up sleep duration in predicting not only suicidal ideation but also suicide attempts and self-injury.

Table 3

Multiple logistic regression models for suicide attempts or self-injury during this last year.

| Independent variables                 | Suicidal attempts or self-injury ( <i>n</i> = 213) | No attempt ( <i>n</i> = 3932) | Logistic regression model 1 <sup>a</sup> |           |                | Logistic regression model 2 <sup>b</sup> |           |                |
|---------------------------------------|--|-------------------------------|--|-----------|----------------|--|-----------|----------------|
|                                       |  |                               | OR                                       | 95% CI    | <i>p</i> value | OR                                       | 95% CI    | <i>p</i> value |
| Age                                   | 14.7 ± 1.4   | 15.3 ± 1.5                    | 0.71                                     | 0.64–0.80 | <0.001         | 0.73                                     | 0.64–0.83 | <0.001         |
| Gender                                |  |                               |  |           |                |  |           |                |
| Male                                  | 83 (39.0%)   | 2214 (56.3%)                  | 0.85                                     | 0.62–1.17 | 0.315          | 0.81                                     | 0.59–1.11 | 0.184          |
| Female (Ref)                          | 130 (61.0%)  | 1717 (43.7%)                  |  |           |                |  |           |                |
| Sleep duration (h:min)                |  |                               |  |           |                |  |           |                |
| Weekend catch-up sleep duration       | 2:09 ( ± 1:59)                                     | 1:49 ( ± 1:33)                | 1.13                                     | 1.03–1.25 | 0.011          |  |           |                |
| Sleep duration of weekday             | 7:04 ( ± 1:23)                                     | 7:01 ( ± 1:18)                |  |           |                | 0.98                                     | 0.86–1.13 | 0.797          |
| Time in private educational institute | 3:24 ( ± 3:42)                                     | 2:55 ( ± 3:15)                | 1.05                                     | 1.00–1.09 | 0.046          | 1.05                                     | 1.01–1.10 | 0.030          |
| Academic record                       | 2.5 ± 1.0  | 2.2 ± 1.0                     | 1.19                                     | 1.02–1.39 | 0.029          | 1.19                                     | 1.02–1.39 | 0.028          |
| BDI                                   | 19.0 ± 11.5  | 10.0 ± 7.0                    | 1.12                                     | 1.10–1.13 | <0.001         | 1.12                                     | 1.10–1.13 | <0.001         |

Dependent variable: suicide attempts or self-injury during this last year.

OR, odds ratio.

CI, confidence interval.

BDI, Beck Depression Inventory.

<sup>a</sup> Logistic regression model 1: independent variables; age, gender, weekend catch-up sleep, time in private educational institute, academic record, BDI.<sup>b</sup> Logistic regression model 2: independent variables; age, gender, sleep duration of weekday, time in private educational institute, academic record, BDI.



One interesting result in this study was that weekend catch-up sleep duration rather than weekday sleep duration was significantly associated with suicide attempts and suicidal ideation. It has been suggested previously that the weekend catch-up sleep duration and time in bed (TIB) difference ( $=$  weekend TIB minus weeknight TIB) reflects accumulating sleep debt, because the TIB difference was associated with shorter weeknight TIB duration, greater reliance on an alarm for weekday waking, and lower weekday alertness on awakening [21,27]. The weekday sleep duration might not be the most appropriate measurement for determining individual sleep insufficiency because the sleep requirement varies significantly between individual adolescents and different age groups [28].

Sleep loss in adolescents interferes with daytime functioning, causes daytime sleepiness, amotivation, emotional dysregulation, inattention, learning problems, low tolerance for frustration, and many more problems [29]. Students with a short sleep duration on weeknights and/or a long weekend bedtime delay reported increased daytime sleepiness, depressive mood, inattention, and a poorer academic performance [30,31].

The association between sleep duration and suicidality in the adolescent population has been investigated in several studies. Liu reported a significant association between sleep duration and increased risk of suicide attempts among Chinese adolescents after adjustment for age, gender, and depressive symptoms [17]. Yen et al. showed that adolescents with a short nocturnal sleep duration in Taiwanese adolescent students had a greater chance of experiencing all eight risky behaviors, including suicidality, than those with average nocturnal sleep durations after controlling for the effects of depression and sociodemographic characteristics [18]. Fitzgerald et al. indicated that both short and long total sleep times were risk factors for suicidality among the American adolescent population after adjustment for age, gender, race, and feeling of sadness [19]. In our study, while weekend catch-up sleep duration was significantly associated with suicidality, including suicidal ideation and behaviors, we did not find any significant association with weekday sleep duration after adjusting for confounding factors. One feasible explanation for this inconsistency is that sleep duration in Korean adolescents is reportedly very short and markedly restricted by social cues and high academic pressures [5,31]. Therefore, weekend catch-up sleep duration in Korean adolescents might better reflect sleep insufficiency, compared to results from other countries. Other possible explanations include the methods used to measure suicidality and for analysis, and the subject characteristics and ethnicity. In terms of the sleep debt created by behaviorally induced sleep restrictions, weekend catch-up sleep duration might provide a more reliable measure than weekday sleep duration, since the latter is influenced by the existence of naturally short sleepers. Therefore, the present results partially support prior hypotheses that insufficient sleep increases suicidality in adolescents.

In the current study, factors other than insufficient sleep that were associated with suicidality were the severity of depressed mood, age, gender, and time in a private educational institute. Female gender was found to be one of the independent predictors for SIQ score. In line with this result, another survey-based study found a higher prevalence of suicidality in girls [32]. This finding might be due to the higher degree of depressive symptoms and the relatively short weekday sleep duration in the female group. Both our previous study and other studies found that females had a longer weekend catch-up sleep duration and a shorter weekday sleep duration than males [3,33,34]. The severe restriction of sleep in females might be due to morning grooming or earlier onset of circadian rhythm delay, which is a pubertal sign [33,35]. However, the association of gender with suicide attempts and self-injury in the logistic regression model was not significant, possibly because males tend to exhibit more aggressive, injury-producing, and risk-taking behaviors [36].

In line with the notion that self-injury is more common in the early teen years, especially the 13- to 15-year age group (related to the pubertal phase) [12], younger age was an independent predictor in the present study of both SIQ score and suicide attempts and self-injury.

The time spent in a private educational institute was also an independent predictor of SIQ score and suicide attempts and self-injury. The excessive use of private education resulting from parental/societal overenthusiasm for education and the strong competition associated with university entrance examinations is becoming a serious social issue in Korean society. Spending an extended period of time in a private educational institute induces emotional and physical stress in students, as well as placing a financial burden on the household economy [37]. It has been reported that spending excessive amounts of time spent in a private educational institute is associated with depression in school-aged children [38]. The relationship between a poor academic record and increased suicidal ideation found in the present study supports the prior notion that restricted educational achievement in adolescents is one of the risk factors of suicide [12].

The way in which sleep insufficiency affects suicidality remains to be elucidated. However, past studies have found that decreased impulse control and increased risky behaviors are associated with short sleep duration in adolescents [18,39,40]. The cognitive and behavioral effects of sleep disturbance are known to contribute to reduced physical activity, increased depressogenic cognition, and vulnerability to stressors [16]. There is a possibility that the sleep insufficiency can negatively affect the restoration of brain function of the prefrontal cortex which is important in emotional regulation. The connectivity between the limbic system and the frontal networks is substantially reduced during sleep loss and the top-down control of the prefrontal cortex in the processing of emotional stimuli might be impaired [41,42]. In addition, some neurobiological factors –

including serotonergic dysregulation and circadian rhythm – that are shared between suicidal behaviors and sleep disturbances have been suggested, although the findings are contradictory [43].

The results of the present study suggest that getting sufficient sleep might be an important factor in suicide prevention among adolescents, and that the development of a sleep-promotion program is necessary to improve the mental health of adolescents. On the other hand, the results also suggest that when monitoring adolescents for suicide risk, both insufficient sleep and depression should be considered as critical factors.

This study was subject to several limitations. First, although the sample was large, the participants were evaluated using cross-sectional self-report questionnaires. For this reason, reliability on self-report of the suicidal attempt and self-injury might be limited. Second, the questionnaire did not include a global assessment of the symptoms related with the sleep disorders, including insomnia, excessive daytime sleepiness, and nightmares, which might have effect on sleep duration.

In conclusion, a significant association was found between weekend catch-up sleep duration – which is an indicator of insufficient weekday sleep – and suicidality among Korean adolescents. Insufficient sleep in adolescents might be related not only to increased suicidal ideation but also to suicidal behaviors.

## 5. Disclosure statement

This was not an industry supported study. The authors have indicated no financial conflicts of interest.

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