

The Association Between Weekend Catch-Up Sleep and Depression by Age Group in Korean Adults

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ABSTRACT

Objectives : We aimed to explore weekend catch-up sleep (CUS) by age and to find out the association between CUS and depression by the age group and weekday sleep duration (SD).

Methods : Using data from the 2016–2018 Korean National Health and Nutrition Examination Survey, the CUS by age of 16,174 subjects was investigated, and the depression data of 11,088 subjects were analyzed. CUS was calculated as the weekend sleep duration minus weekday sleep duration (SD). The mean of CUS and weekday SD in depression group and non-depression group was compared by early, middle, and late adulthood groups, and logistic regression analysis was performed to investigate the effect of CUS on the depression by age group when weekday SD was insufficient.

Results : The CUS tended to decrease continuously with age, the mean of CUS in the late adult group was the shortest. However, the average SD, adjusted for weekend CUS, was the shortest in the middle adulthood group. Overall, the sleep durations were shorter in the depression group than in the non-depression group, but the CUS difference between the two groups was significantly only in the middle adulthood. The risk of depression was significantly higher when weekend CUS was less than 1 hour with a short weekday SD of less than 6 hours (OR 2.44, 95% CI: 1.78–3.35), and this finding was significant in all adult groups.

Conclusions : The findings of this study suggest that short weekday SD and inadequate weekend CUS are associated with depression and that CUS is an option to compensate for sleep deprivation and prevent depression.

KEYWORDS : Sleep deprivation; Depression; Age group; Public health.

INTRODUCTION

Age-related changes of sleep are well described in the literatures. Changes in sleep structure occur with aging, such as a decrease in deep sleep and sleep efficiency, an increase in nighttime arousal, and shortening of REM latency.¹⁻⁴⁾ Research has recommended appropriate sleep duration (SD) as 8–10 hours for adolescents (aged 14–17 years), 7–9 hours for adults (18–64 years), and 7–8 hours for older adults (≥65 years).⁵⁾ It is not yet clear whether the difference in SD according to age is due to a decrease in sleep need or a decrease in sleep ability without change in sleep need.⁶⁾

Sleep has an important role in mental and physical health and

maintaining overall proper body functioning; adequate sleep enhances development, immune response, and cognition.⁷⁾ Sleep deficiency has been significantly associated with increased prevalence of some public health problems and diseases such as obesity,⁸⁾ diabetes mellitus, hypertension,⁹⁾ and depression,¹⁰⁾ and even mortality.¹¹⁾ In addition, a number of previous studies have found an association between short SD and depression.^{12,13)} Furthermore, several studies have suggested that short SD may be applied as a predictor of depression.¹⁴⁻¹⁶⁾

Unfortunately, sleep deficiency is prevalent in modern society due to tight working schedules, which results in reduced SD.¹⁷⁾ Weekend catch-up sleep (CUS) may be useful in compensating for insufficient sleep over the week. Several studies

Received: September 3, 2022 / **Revised:** October 20, 2022 / **Accepted:** November 1, 2022

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have reported that individuals who take a weekend CUS regularly have a reduced risk of obesity,¹⁸⁾ and hypertension,¹⁹⁾ and have a better health-related quality of life.²⁰⁾ In addition, weekend CUS may enhance physical and psychological wellbeing. One study reported that a weekend CUS more than 2 hours reduces the risk of depression in high school students,²¹⁾ and another study found that a lack of weekend CUS was reported to be independently associated with suicide attempts and self-injury.²²⁾ In a recent study, the risk of depression in individuals with CUS duration between 1 to 2 hours was lower than for those without CUS.²³⁾ However, research on weekend CUS in terms of public health management is still insufficient. In other words, there are few studies on the change in weekend CUS by age in adults, and there is no study on the relationship between weekend CUS and depression, especially when weekday sleep duration is insufficient.

Therefore, we aimed to investigate whether there was the change in weekend CUS with age using the Korean nationally representative sample of adults and to investigate not only the risk of depression of SD but also the risk of depression of CUS when weekday SD is insufficient by age group.

METHODS

1. Participants

Participants were selected through the 2016–2018 Korea National Health and Nutrition Examination Survey (KNHANES VII). KNHANES is a nationwide representative survey on the health status and nutrition of the Koreans that is conducted by the Korea Centers for Disease Control and Prevention (KCDC). The survey annually selects 25 households in 192 regions through a sample design and conducts surveys on health level, health-related consciousness and behavior, and food and nutrition for 10,000 members.^{24,25)} Health and nutrition surveys are conducted through self-report questionnaires. This study was approved by the Wonju Severance Christian Hospital Institutional Review Board (IRB No. CR320382).

Of the 24,269 participants in the KNHANES VII (2016–2018), 16,714 people were included in this study, excluding participants under the age of 18 (n=4,880), shift workers, people with acute state conditions of any physical or mental illness, or pregnant women (n=2,675), and incomplete data (n=1,834). The questionnaire included data on age, sex, education level, income level, marital status, weekday SD, and weekend SD. The association between depression and CUS was analyzed with data of 11,088 subjects. This is because KNHANES VII investigated the questionnaire for depression only in 2016 and 2018,

excluding 2017 (n=5,626).

2. Measurements

1) Sleep duration and Weekend CUS

Participants' weekdays and weekends SD were obtained using the response to the question "What time did you go to bed and when did you wake up during the usual weekday (or workday)?" and "When did you go to bed and when did you wake up on the usual weekend (or the day you don't work, the day before the day you don't work)?" Average SD was calculated as (weekday SD*5+weekend SD*2)/7. Weekend CUS was defined as the difference between weekend SD and weekday SD.

Insufficient SD was defined as a case of less than 6 hours of sleep time according to the National Sleep Foundation in the US.²⁶⁾ In a study of older adults, a positive association with obesity, poor health, insomnia, and insomnia accompanied by daytime sleepiness and cognitive impairment was observed in the nighttime SD group of 4 hours and 30 minutes or less.²⁷⁾ In addition, it was confirmed that all-cause mortality increased in the SD group of 4 hours or less in a cohort study targeting adults aged 40–79 years.²⁸⁾ Therefore, in our study, the risk of short SD for depression was examined by weekday or average SD into three categories (≥ 6 hours, 4–6 hours, <4 hours).

To identify the risk of depression according to CUS of short sleepers who sleep less than 6 hours on weekdays,²⁶⁾ they were divided into 3 groups: CUS for less than 1 hour, CUS for 1–2 hours, and CUS for more than 2 hours.

2) Depression

The questionnaire for depression used in KNHANES VII was the Patient Health Questionnaire-9 (PHQ-9). The PHQ-9 included a total of 9 questions that corresponded to the diagnostic criteria for depressive episodes of Diagnostic and Statistical Manual of Mental Disorders-4 (DSM-4), and scores from 0 (not at all) to 3 (almost every day) for each question are summed. When the PHQ-9 score is 10 or more (cut-off point), it is reported that it has 88% sensitivity and 88% specificity of major depression.²⁹⁾ In this study, the case of PHQ-9 ≥ 10 was classified as a depression group.

3. Statistical analysis

Results were analyzed using SPSS complex sample module.^{30,31)} Sample weights were applied for probabilities of selection, non-responder, post-stratification factor for age, sex, and metropolitan/province area. First, frequency analysis and one-way ANOVA was performed by complex sample method for descriptive analysis. The mean and standard error of SD and CUS between three age groups were compared by the Bonfer-

roni correction to avoid the increased risk of type I error. The level of significance was set at $p < 0.001$ and a 99% confidence interval. Next, the comparison of SD between the depressed group and the non-depressed group was analyzed, and subpopulations analysis of the three age groups was performed using the SUBPOP of complex sample method. Finally, complex sample logistic regression analysis was conducted to estimate the effect of short SD on the depression and to estimate the effect of CUS on the depression when weekday SD is insufficient. Subpopulation analysis by age group was also applied. Odds ratios (OR) for age, sex, educational level, income level, and marital status were conducted, and OR was described with a 95% confidence interval. SPSS 25.0 and open-source software R were used for all statistical analysis and illustrated by ggplot2 package in R of the figure.

RESULTS

1. Basic characteristics, sleep duration and CUS

Fig. 1 shows weekday SD, weekend SD, and CUS with age. The CUS tended to decrease continuously with age. Table 1 shows the general and sleep characteristics of the study participants and by the age groups. The differences in all SD between age groups were statistically significant ($p < 0.001$). The CUS

was the longest in early adulthood and the shortest in the late adulthood, but the Average SD, adjusted for weekend CUS, was the shortest in the middle adulthood group.

2. Comparison of sleep duration between the depression and the non-depression groups

Table 2 shows the comparison of SD between the depression and the non-depression groups. PHQ-9 of the 2016 and 2018 of KNHANES VII was evaluated, and 5% of the 11,088 study participants were in the depression group (1,190,576 after weighted). In total population and early adulthood, significant differences were observed in the average SD, weekday SD, and weekend SD between the depression group and the non-depression group, but there was no CUS difference. In middle adulthood, there was no difference in average SD and weekday SD between the two groups, but weekend SD and CUS were significantly shorter in the depression group. In the late adulthood, there was no significant difference in any sleep duration and CUS between two groups.

3. The association between sleep duration and depression

Tables 3 show the association that the shorter weekday SD and average SD, the higher risk of depression. In total popu-

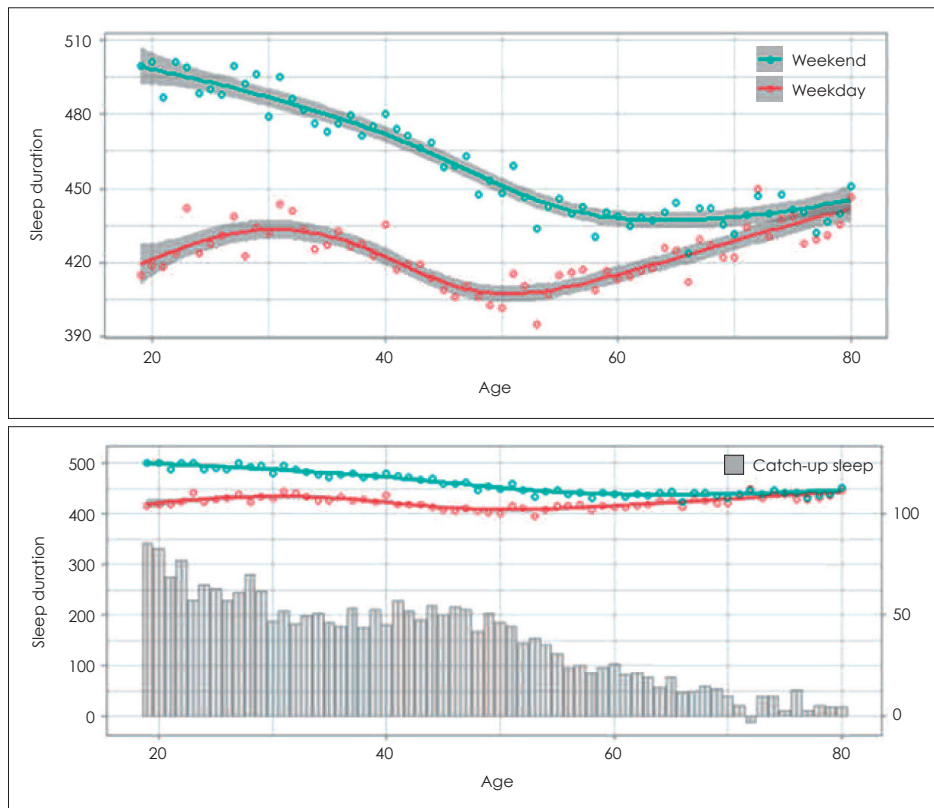


Fig. 1. Changes in sleep duration and weekend catch-up sleep according to age.

Table 1. General characteristics and sleep duration of the study participants by age groups

	Total (n=16,714)	Early adulthood (n=4,584)	Middle adulthood (n=7,818)	Late adulthood (n=4,312)
Age, year	47.24±0.24	29.41±0.15	51.50±0.12	72.98±0.11
Sex, n (weighted %)				
Male	7,258 (49)	2,098 (53)	3,333 (49)	1,827 (41)
Female	9,456 (51)	2,486 (47)	4,485 (51)	2,485 (59)
Education level, n (weighted %)				
< Elementary school	3,465 (15)	22 (0)	912 (10)	2,531 (58)
Middle school	1,681 (9)	80 (2)	976 (12)	625 (14)
High school	5,319 (35)	1,696 (39)	2,920 (38)	713 (17)
≥ College	6,228 (42)	2,796 (58)	3,002 (40)	430 (11)
Household income, n (weighted %)				
Low	3,329 (16)	346 (9)	814 (10)	2,079 (48)
Low-middle	3,392 (23)	1,109 (24)	1,746 (22)	1,137 (26)
High-middle	4,571 (29)	1,581 (34)	2,364 (31)	626 (15)
High	4,868 (31)	1,540 (33)	2,881 (37)	447 (11)
Marital status, n (weighted %)				
Married	11,593 (66)	2,148 (40)	6,597 (85)	2,848 (64)
Separated	110 (1)	10 (0)	71 (1)	29 (1)
Widowed	1,498 (7)	7 (0)	261 (3)	1230 (31)
Divorced	714 (4)	42 (1)	500 (6)	172 (4)
Sleep Duration, (minute)				
Average Sleep Duration	432.62±0.78	444.11±1.32	423.41±0.94	434.57±1.87
Weekday Sleep Duration	420.86±0.83	427.23±1.46	412.26±1.00	432.02±1.90
Weekend Sleep Duration	462.01±0.95	486.32±1.63	451.30±1.16	440.93±1.95
Catch-up Sleep (CUS)	41.15±0.83	59.10±1.62	39.04±1.02	8.91±0.87

Data presented as number (weighted %) or mean ± standard error (SE) values

Table 2. Comparison of sleep duration between the depression and non-depression groups

	Depression group	Non-depression group	p-value
Total	n=578	n=10,510	
Average SD (min)	413.76±4.83	432.86±0.89	<0.001
Weekday SD (min)	402.97±5.04	420.92±0.96	<0.001
Weekend SD (min)	440.72±5.83	462.70±1.09	<0.001
CUS (min)	37.71±4.72	43.60±1.48	0.18
Early adulthood	n=170	n=2,939	
19–39 years			
Average SD (min)	419.14±8.20	444.98±1.57	0.01
Weekday SD (min)	402.60±8.98	428.40±1.75	0.02
Weekend SD (min)	460.50±10.20	486.45±1.95	0.01
CUS (min)	57.90±9.91	58.05±1.99	0.81
Middle adulthood	n=208	n=4,964	
40–64 years			
Average SD (min)	409.74±8.07	423.88±1.14	0.05
Weekday SD (min)	401.07±8.14	412.69±1.21	0.12
Weekend SD (min)	431.43±9.69	451.85±1.43	0.01
CUS (min)	30.36±6.66	39.16±1.27	0.01
Late adulthood	n=200	n=2,607	
> 65 years			
Average SD (min)	418.16±9.22	433.52±2.27	0.20
Weekday SD (min)	416.96±9.40	430.98±2.31	0.25
Weekend SD (min)	421.17±9.20	439.87±2.34	0.12
CUS (min)	4.22±3.31	8.89±1.06	0.22

Depression: The Patient Health Questionnaire-9 (PHQ-9) score ≥ 10. Data presented as number or mean ± standard error (SE) values. SD, sleep duration; CUS, catch-up sleep

Table 3. The risk for depression based on sleep duration

	Weekday sleep duration	OR	95% CI	Average sleep duration	OR	95% CI
Total	≥ 6 hours	1		≥ 6 hours	1	
	4–6 hours	1.57	1.18–2.10	4–6 hours	1.96	1.50–2.57
	< 4 hours	7.82	4.57–13.36	< 4 hours	8.08	4.51–14.47
Early adulthood 19–39 years	≥ 6 hours	1		≥ 6 hours	1	
	4–6 hours	1.73	1.06–2.81	4–6 hours	2.56	1.57–4.17
	< 4 hours	17.11	6.81–43.00	< 4 hours	26.57	8.33–84.73
Middle adulthood 40–64 years	≥ 6 hours	1		≥ 6 hours	1	
	4–6 hours	1.53	0.98–2.38	4–6 hours	1.62	1.06–2.49
	< 4 hours	9.76	4.07–23.43	< 4 hours	13.33	4.83–36.82
Late adulthood > 65 years	≥ 6 hours	1		≥ 6 hours	1	
	4–6 hours	1.75	1.17–2.62	4–6 hours	1.78	1.19–2.65
	< 4 hours	2.34	1.04–5.30	< 4 hours	2.44	1.03–5.77

OR, odds ratio; CI, confidence interval

Table 4. The risk of depression based on weekday sleep duration and the weekend catch-up sleep (CUS)

	OR	95% CI	
Total	≥ 6 hours	1	
	< 6 hours with CUS (> 2 hrs)	1.52	0.90–2.57
	< 6 hours with CUS (1–2 hrs)	0.85	0.41–1.77
	< 6 hours with CUS (0–< 1 hrs)	2.44	1.78–3.35
Early adulthood 19–39 years	≥ 6 hours	1	
	< 6 hours with CUS (> 2 hrs)	1.78	0.97–3.27
	< 6 hours with CUS (1–2 hrs)	1.34	0.48–3.77
	< 6 hours with CUS (0–< 1 hr)	3.22	1.60–6.48
Middle adulthood 40–64 years	≥ 6 hours	1	
	< 6 hours with CUS (> 2 hrs)	1.26	0.42–3.75
	< 6 hours with CUS (1–2 hrs)	0.40	0.09–1.83
	< 6 hours with CUS (0–< 1 hr)	2.57	1.62–4.10
Late adulthood > 65 years	≥ 6 hours	1	
	< 6 hours with CUS (> 2 hrs)	1.60	0.22–11.77
	< 6 hours with CUS (1–2 hrs)	1.07	0.23–5.05
	< 6 hours with CUS (0–< 1 hr)	1.95	1.33–2.86

OR, odds ratio; CI, confidence interval

lation, compared to the group with weekday SD > 6 hours, the Odds ratios (OR) of depression were 1.57 (95% CI; 1.18–2.10) in weekday SD 4–6 hours, and 7.82 (95% CI; 4.57–13.36) in weekday SD < 4 hours. When compared to the Average SD reflecting the weekend SD or CUS, Odds ratios (OR) were 1.96

(95% CI; 1.50–2.57) and 8.08 (95% CI; 4.51–14.47), respectively. Except for the middle adulthood group with 4–6 hours of weekday SD, it was significant at all age groups that the shorter weekday SD or average SD, the higher the risk of depression.

4. The association between weekend CUS and depression

Table 4 shows the association of depression by weekday SD and CUS. Compared to a group with weekday SD ≥ 6 hours, the risk of depression was significantly higher when the weekday SD < 6 hours and weekend CUS was less than 1 hour in total population and all age groups.

DISCUSSION

Our study used a complex multi-stage representative sample to identify decreases in CUS with age in adults and to investigate the association between weekend CUS and depression. The present study found that the CUS time decreased with age as the difference between weekday SD and weekend SD decreased, and there was a risk of depression when the weekday SD was less than 6 hours and the weekend CUS was less than 1 hour. This finding of the risk of depression was also significant in all groups of early, middle, and late adulthood.

1. Changes in sleep duration of weekdays and weekends, and CUS with age

In this study, weekend SD continued to decline with age but remained no longer decreasing in late adulthood. On the other

hand, weekday SD decreased until middle adulthood and then increase again in late adulthood. As a results, it was identified that the CUS, the difference between weekend SD and weekday SD, continued to decrease with age. A recent large representative sample study in France found similar findings to our study that the weekday total sleep time (TST) decreased from the youngest group (18–24 years old) to 45–54-year-old group, which displayed the lowest TST reported, and then increased to reach the ideal TST in the oldest group (65–75 years old).³²⁾ In another large Scandinavian cohort (n=21,000), subjective weekday SD but not weekend SD increased from the age of 60–64 years to reach a plateau from the age of 70–74 years.³³⁾ Their finding that there was no difference between weekday SD and weekend SD after the age of 65 are similar to ours.

However, it is difficult to understand and interpret this our finding because there is not enough evidence to explain the decrease in CUS duration with age and the decrease in the difference between weekday SD and weekend SD in older age.³⁴⁾ According to two hypotheses on the still controversial need for sleep as we age,³⁵⁾ one thing may be that the need for CUS may have decreased compared to previous age groups even after less sleep because they simply need less sleep as they get older. Another hypothesis is that although the need for sleep in the elderly is still as high as in other age groups, there may be difficulties in CUS generation and compensation due to impaired ability to generate sleep.⁶⁾ Although age-dependent sleep structural changes occur before the age of 60,⁴⁾ there are many sleep complaints such as early waking and frequent sleep fragmentation in the older adults.³⁶⁾ This is because, apart from sleep modification of normal aging, sleep disturbance and sleep deficiency can be caused by sleep pathologies (e.g., sleep breathing disorder or abnormal movement during sleep) or medical comorbidity (e.g., cardiovascular, metabolic, psychiatric, or neurological disease and pain) and medication that affects sleep structures.^{28,32)} Our study cannot determine whether the CUS reduction in older group is related to normal sleep of aging, or related to other factors above, or due to environmental changes such as social role, and further research is needed to know it.

2. Sleep duration between the depression and non-depression group

In present study, the depression group had significantly shorter weekday, weekend, and average sleep time than the depression group compared to non-depression group. These findings were consistent with those of previous reports including meta-analyses,¹⁰⁾ and systematic reviews,³⁷⁾ which confirmed the association between short sleep time and depression.

In early adulthood of our study, the depression group had sig-

nificantly shorter weekdays, weekend, and average SD. However, there was no difference in CUS itself because both groups slept about an hour more on weekends than on weekdays. Young adults without depression slept about 7 hours on weekdays and about 8 hours on weekends, corresponding to the recommended hours of the National Sleep Foundation.⁵⁾ On the other hand, in the middle adulthood, both groups showed short weekday SD of less than 6 hours, and there was no difference in weekday SD between two groups, but the weekend SD of the depression was about 20 minutes less than that of the non-depression group, and the CUS was significantly shorter. Regardless of depression, less sleep during the week in middle age may have been due to socioenvironmental influences and poor sleep habits compared to young and older adulthoods,²⁸⁾ but even so, this study indicates that depressed middle age may not be as well compensated for weekday sleep debt as normal middle-aged adults. In late adulthood, there was no difference in CUS as well as weekday, weekend, and average between the depression group and non-depression group. This finding can contribute to lack of evidence in CUS or sleep compensation in the elderly. However, further research is needed because older adults have more sleep disorder or daytime sleepiness than younger people³⁶⁾ and may have compensated for sleep deprivation through naps.¹⁾

3. The risk for depression based on sleep duration and CUS

This study showed the same findings as previous studies that short average SD was significantly related to depression.^{10,38)} Compared to the group with average SD ≥ 6 hours, Odds ratios (OR) of depression were 1.96 (95% CI; 1.50–2.57) in average SD 4–6 hours, and 8.08 (95% CI; 4.51–14.47) in average SD < 4 hours. It was not different in the subgroup analysis by age group. The risk of depression (OR) in late adult group when the average SD was less than 4 hours was smaller in the early or middle adult groups. It may be related to decreased sleep need or sleep demand with aging. However, as mentioned above, the decline in sleep need in the elderly is controversial³⁵⁾ and lacks research evidence.³⁴⁾ The subgroup analysis of a meta-analysis reported that there was no significant effect of short SD among those over 60 years old.¹⁰⁾ On the other hand, there is a report of longitudinal study that found that elderly over 60-years old with short SD had a higher risk of depression than those under 60-years old middle aged group.³⁸⁾ In terms of age-specific individualized sleep improvement interventions, more data are needed.

In this study, the risk of depression in weekday short sleepers less than 6 hours with less than 1 hour of weekend CUS was

significantly higher (OR 2.44, 95% CI: 1.78–3.35). These findings were found at all age adult groups. One study found the risk of depression was lower when a depressed person took a nap for more than 60 minutes.³⁹⁾ This finding suggests that compensatory sleep can prevent depression. Our study findings also suggests that sleep deprivation can be compensated for through weekend CUS and that the risk of depression increases if the compensation for sleep deprivation during the weekdays through weekend CUS is insufficient. This is consistent with the findings of a previous KNHANES VII-1 study on the relationship between CUS and quality of life, which reported that the risk of anxiety and depression in the non-CUS group was significantly higher than that of the CUS group.²⁰⁾ However, unlike our study, which conducted statistical analysis on the entire 2016–2018 KNHANES VII, the study was conducted for only one year (2016), and it was also limited by lack of age-based analysis. In a previous study on Korean adolescents, the depression group had significantly shorter CUS than the control group.²¹⁾ In a study confirming the association between CUS and inflammation in Korean adults, it was confirmed that the group with CUS was beneficial for low-grade systemic inflammation in those with shorter weekday SD.³⁹⁾ In addition, several studies have confirmed the association between inflammation and depression.^{40,41)} The results of our study suggesting that the presence of CUS may have a protective effect on depression may be similar to the results of the above study that the presence of CUS may have a protective effect on inflammation, and further research will be needed.

4. Limitation

We only used self-reported weekday and weekend sleep time to determine sleep time; this is subjective information, and the objective information could not be confirmed. Self-report about sleep has a discrepancy with objective evaluation.⁴²⁾ However, it is difficult to objectively measure SD in a large population study. Therefore, many epidemiological studies use self-reported sleep time, and there are also research suggesting adequate agreement between self-reported SD and values obtained through actigraphy monitoring.⁴³⁾ Also, self-reported sleep measurement has a problems that is affected by depression, and the severity of depression influence self-estimation of total sleep time.⁴⁴⁾ Despite these concerns, one study confirmed that subjective sleep results through questionnaire were similar to objective results obtained by polysomnography in both the depressed group and the healthy control group.⁴⁵⁾ Our study was unable to identify information on naps, which is another option to compensate for sleep deprivation. However, a previous study on whether French adults' naps and weekend CUS compensated for sleep

debt and short sleep reported that only a limited proportion (approximately 7%) of adults with sleep debt compensated sleep deprivation through naps.³²⁾ This suggested that there is a small percentage of people who intentionally compensated for sleep deprivation through naps. We lacked information on subjects' sleep satisfaction, sleep quality, abnormal sleep time, sleep disorders or other medical conditions that could affect sleep, so it was not considered in the present study.

Finally, we were able to confirm the statistical association between CUS and depression, but it is difficult to explain the causal relationship. Although the results of the present study are consistent with several previous related studies, longitudinal studies are needed in the future to determine the causality between CUS and depression. In addition, since the characteristic are different for each age group, exploration through various studies is necessary. Nevertheless, the findings of this study suggest that the following practical implications: first, although the amount of CUS varies by age group, short average SD, including CUS, is associated with depression in all age groups. Second, lack of weekend CUS in the presence of sleep deprivation during the weekday is associated with depression in all age groups. Finally, CUS may be an effective option to compensate for lack of weekday SD and prevent depression.

5. Conclusions

This study demonstrated that short SD <6 hours of the weekday and CUS duration <1 hours of the weekend were associated with depression in all ages of adults. For the prevention and management of depression, further studies are needed on the causes of sleep deprivation and appropriate CUS by age group.

Acknowledgments

This work was supported by Fostering regional innovation clusters (R&D) funded by the Ministry of Trade, Industry and Energy (MOTIE, Korea). [Project number: P0016244.] The results of this study were presented as a poster at PRCP 2021(2021.04.08-04.10).

Conflicts of Interest

The authors have no financial conflicts of interest.

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