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Original Article

Weekend catch-up sleep and depression: results from a nationally representative sample in Korea

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ABSTRACT

Background: There is limited information on the association between weekend catch-up sleep (CUS), which has beneficial effects on health, and depression. This study aimed to investigate the association between CUS and depression in adults.
Methods: We used the data of the Seventh Korea National Health and Nutrition Examination Survey, 2016. Depression was defined as Patient Health Questionnaire-9 score ≥10. We categorized CUS duration as ≤0, 0 < to 1, 1 < to 2, and >2 h.
Results: Of 5550 eligible participants, 3286 (54.9%), 1033 (19.5%), 723 (14.7%) and 508 (10.9%) had CUS duration ≤0, 0 < to 1, 1 < to 2, and >2 h, respectively; of these, the prevalence of depression was 7.0%, 4.2%, 2.9%, and 6.0%, respectively. Multivariable regression analyses including covariates revealed that individuals with CUS duration 1 < to 2 h had a significantly decreased risk of depression compared to individuals with CUS duration ≤0 h (odds ratio [OR] = 0.517, 95% CI = 0.309–0.865). Individuals with CUS duration 0 < to 1 h (OR = 0.731, 95% CI = 0.505–1.060) and >2 h (OR = 1.164, 95% CI = 0.718–1.886) showed no significantly different risk of depression.
Conclusions: The risk of depression in individuals with CUS duration 1 < to 2 h was lower than for those with CUS duration ≤0 h. This finding provides a better understanding on the association between CUS and depression; and can be a basis for better management of depression.

1. Introduction

Depression, a common disabling disorder, affects approximately 7% of the global population [1]. Individuals with depression experience an increased risk of reduced functional abilities and a high degree of impairment; defined by poor self-perceived health [2]. Owing to its disabling symptoms and high prevalence, depression was the third leading cause of global disability in 2015, of all diseases and injuries [3]. Depression is often associated with chronic illnesses and can lead to suicide [4].

In recent times, sleep restriction often occurs for social requirements or work schedules, with a trend toward reduced sleep duration. Short sleep duration has negative effects on psychiatric and metabolic conditions. Short sleep duration is associated with an increased risk of depression [5,6]. Some individuals recompense short sleep duration with extended weekend sleep duration (weekend catch-up sleep [CUS]). CUS has beneficial effects on metabolism including increased insulin sensitivity, lower body mass index, hypertension, and lower risk of dyslipidemia [7–9]. Nevertheless, information on the association between CUS and depression in a general population-based setting is currently limited. Such information would not only clarify the association between depression and sleep, but also could help in the treatment of depression.

Abbreviations: CI, confidence interval; CUS, catch-up sleep; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition; GPAQ, global physical activity questionnaire score; KNHANES VII, Seventh Korea National Health and Nutrition Examination Survey; MSF, mid-sleep time on free days; MSFsc, mid-sleep time on free days corrected by sleep debt accumulated over the workdays; MSW, mid-sleep time on work days; OR, odds ratio; PHQ-9, Patient Health Questionnaire-9; SD, standard deviation; SPSS 23.0, Statistical Package for Social Sciences version 23.0.

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This study aimed to investigate the association between CUS and depression in adults using a nationally representative sample of Korea. We hypothesized that CUS would be related to a lower risk of depression.

2. Methods

2.1. Study population and survey

We used the Seventh Korea National Health and Nutrition Examination Survey (KNHANES VII), 2016 data. The KNHANES, an annual nationally representative cross-sectional survey, collects information about participants' (aged 1–80 years) demographic, social, health, and nutritional status, in Korea. The study uses a multistage clustered random sampling method based on the national census data. Detailed KNHANES information was previously described [10].

2.2. CUS

CUS duration was calculated as follows: average sleep duration on weekend − average sleep duration on weekdays. CUS duration >0 h was classified as having CUS. We further classified CUS duration into 0 < to 1, 1 < to 2, and >2 h.

2.3. Depression

To assess the severity of depression, we used the Patient Health Questionnaire-9 (PHQ-9), developed based on the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for major depression including: (1) little interest or pleasure in doing things; (2) feeling down, depressed, or hopeless; (3) trouble with sleep; (4) feeling tired or having little energy; (5) poor appetite or overeating; (6) feeling bad about yourself; (7) trouble concentrating on things; (8) moving or speaking too slowly or too fast; and (9) suicidal thoughts. Response options were rated on a four-point scale from 0 to 3, regarding the past two weeks experience. The total PHQ-9 score was the sum of the nine item scores; with higher scores indicating more severe depression [11]. The Korean PHQ-9 version was previously validated with 81.1% sensitivity and 89.9% specificity for diagnosing depression [12], when using the total PHQ-9 score of 10 as the cut-off value.

2.4. Sleep-related covariates

Weekly average sleep duration (hour per night), chronotype (early, intermediate, and late types) and social jetlag were known to be related to depression and were included as sleep-related covariates in the analyses [5,13–15].

Participants' sleep time was evaluated based on the following two questions: "On an average, at what time do you go to sleep and at what time do you wake up on weekdays?" and "On an average, at what time do you go to sleep and at what time do you wake up on weekends?" Weekly average sleep duration was calculated using the following formula: [(weekday sleep duration $\times$ 5) + (weekend sleep duration $\times$ 2)]/7.

Chronotype was determined based on the mid-sleep time on free days corrected by sleep debt accumulated over the workdays (MSFsc) [16]. MSFsc was calculated as follows: MSFsc = the midpoint of sleep on free days −0.5 $\times$ (sleep duration on free days − the weekly average sleep duration). The chronotype was classified based on MSFsc into early, intermediate, and late chronotype as < mean MSFsc −1 standard deviation (SD); between mean MSFsc − 1 SD and +1 SD; and >mean MSFsc + 1 SD, respectively.

Social jetlag status was determined based on the responses to questions on sleep time and wakeup time on workdays and free days. Social jetlag was estimated as the absolute value of the difference (hours) in the midpoint of sleep times between workdays and free days (MSF − MSW) [17].

2.5. Lifestyle covariates

Demographic (age and sex) and social factors (job status, alcohol intake, educational level, physical activity, and smoking) are known factors associated with depression [18–22]. Age, sex, job status, alcohol intake, educational level, physical activity, and smoking information were obtained from each KNHANES VII, 2016 item response via interview and examination. Some factors were divided into groups for comparison: job status (employed vs. non-employed); alcohol intake (<2 times/week vs. $\geq$ 2 times/week); highest achieved education ($\geq$12 years vs. < 12 years); and smoking (current vs. never or former). Physical activity was classified based on global physical activity questionnaire score (GPAQ), which was included in KNHANES VII, 2016 [23]. We classified the participants into whether physical activity met the World Health Organization recommendation or not (metabolic equivalents [MET] minutes per week $\geq$600 vs. MET minutes per week <600).

2.6. Ethical approval

This study was exempted from review by the Institutional Review Board of Severance Hospital, Yonsei University (No. 4-2020-0858). The present study was conducted in adherence with the KNHANES usage guidelines and the Declaration of Helsinki [24,25]. Written informed consent was obtained from all participants [26].

2.7. Statistical analyses

We analyzed the KNHANES VII data, using sampling weights, which accounted for the complex survey design, non-response, and post-stratification, to acquire nationally representative estimates. The data were presented as weighted means or weighted proportions for continuous or categorical variables, respectively. Characteristics of the study population were analyzed using either weighted chi-square test for categorical variables or weighted one-way analysis of variance for continuous variables. Categorical variables are represented as numbers and percentages, and continuous variables are represented as means ± standard errors.

To investigate the association between CUS and depression, multivariable logistic regression analysis including CUS (independent variable) and depression (yes/no; dependent variable) was performed; with demographic (age and sex), lifestyle (job status, alcohol intake, educational level, physical activity, and smoking), and sleep-related variables (chronotype, social jetlag, and weekly average sleep duration) as covariates. In model 1, we adjusted for demographic variables (age [year, continuous] and sex). Model 2 was adjusted for lifestyle variables (job status, alcohol intake, educational level, physical activity, and smoking) in addition to model 1. Model 3 further adjusted for sleep-related variables (chronotype, social jetlag [hour, continuous] and weekly average sleep duration [hour, continuous]) in addition to model 1. Model 4 included demographic, lifestyle, and sleep-related variables (age, sex, job status, job status, alcohol intake, educational level, physical activity, smoking, chronotype, social jetlag and weekly average sleep duration. We also performed multivariable linear regression analysis to investigate whether CUS duration was associated with continuous depression severity (PHQ-9) scores adjusting for covariates.

The IBM Statistical Package for Social Sciences Statistics for Windows, version 23.0 (IBM Corp., Armonk, N.Y., USA) was mostly used for all statistical analyses. Two-tailed statistical significance was set at $p < 0.05$. Post hoc analyses were performed using Bonferroni's correction ($p = 0.050/6$, 0.008 for comparing among the four CUS duration groups and $p = 0.050/3$, 0.016 for comparing among the three sleep duration groups).

3. Results

3.1. Participants

The flow of participants is summarized in Fig. 1. In the 2016 KNHANES VII, of the 10,806 individuals (aged 1–80 years) invited, 8150 completed the survey (response rate 75.4%), and 6382 (aged 19–80 years) were included. Among the 6382 participants, 201 and 631 were excluded owing to shift work and incomplete data, respectively. Finally, data of 5550 participants were used in the present study.

3.2. Chronotype, sleep duration on weekdays and weekend, and weekly average sleep duration

Among 5550 participants, 1327 (18.2%), 3579 (66.4%), and 644 (15.4%) were classified into early, intermediate, and late types, respectively. Mean sleep duration on weekdays and weekends were 7.0 ± 0.2 and 7.7 ± 0.3 h, respectively. Mean weekly average sleep was 7.2 ± 0.0 h. Overall, 705 (12.7%), 4525 (81.9%), and 320 (5.4%) participants had weekly average sleep duration <6, 6–9, and >9 h, respectively.

3.3. Demographic, social, lifestyle, and sleep-related parameters according to CUS duration

Women were more in the group with CUS duration >0–1 h than CUS duration ≤0 h ($p = 0.001$) (Table 1). Mean age was lower in individuals with CUS duration >0 to 1 ($p < 0.001$), >1 to 2 ($p < 0.001$) and >2 h ($p < 0.001$) than for ≤0 h. Having the highest educational level of ≥12 years and a job were more common in individuals with CUS duration >0 to 1 ($p < 0.001$), >1 to 2 ($p < 0.001$) and >2 h ($p < 0.001$) than those in the ≤0 h group. Weekday sleep duration was shorter in individuals with CUS duration >0 to 1 ($p < 0.001$), >1 to 2 ($p < 0.001$), and >2 h ($p < 0.001$) than in the ≤0 h group. Alcohol intake, smoking, and weekly average sleep duration were not significantly different between groups.

3.4. Depression, CUS, and sleep duration

Among 5550 participants, 346 (5.7%) with PHQ-9 score ≥10 were classified as having depression. The prevalence of depression in participants with CUS duration 0 to <1 (4.2%, $p = 0.002$), 1 to <2 h (2.9%, $p < 0.001$) was lower than for those with CUS duration ≤0 h (7.0%), but not for those with CUS duration >2 h (6.0%) ($p = 0.440$) (Table 1).

The prevalence of depression among individuals with weekly average sleep duration <6, 6–9, and >9 h were 8.3%, 5.2%, and 8.1%, respectively (Supplementary table). The prevalence of depression in individuals with weekly average sleep duration <6 h was higher compared to those with 6–9 h ($p = 0.001$), but not for >9 h ($p > 0.999$). The prevalence of CUS was not significantly different among individuals with weekly average sleep duration <6 h, 6–9 h, and >9 h ($p = 0.659$).

3.5. Multivariable logistic regression analyses association between CUS and risk of depression

In model 1 adjusted for age and sex, the multivariable adjusted ORs of having depression were 0.559 (95% confidence interval [CI] 0.391–0.798); 0.389 (95% CI 0.242–0.625); and 0.834 (95% CI 0.533–1.306) for individuals with CUS duration >0 to 1, >1 to 2, and >2 h compared to those with ≤0 h (Table 2). Model 2 (adjusted for lifestyle variables in addition to model 1); model 3, adjusted for sleep-related variables in addition to model 1; and model 4 adjusted for lifestyle and sleep-related variables, all showed similar patterns with CUS duration >1–2 h showing a decreased OR while CUS duration >0 to 1 and > 2 h showed no significant difference with ≤0 h.

3.6. Multivariable linear regression analyses between CUS duration and severity of depression

We conducted multivariable linear regression analyses to evaluate the relationship between CUS duration and the severity of

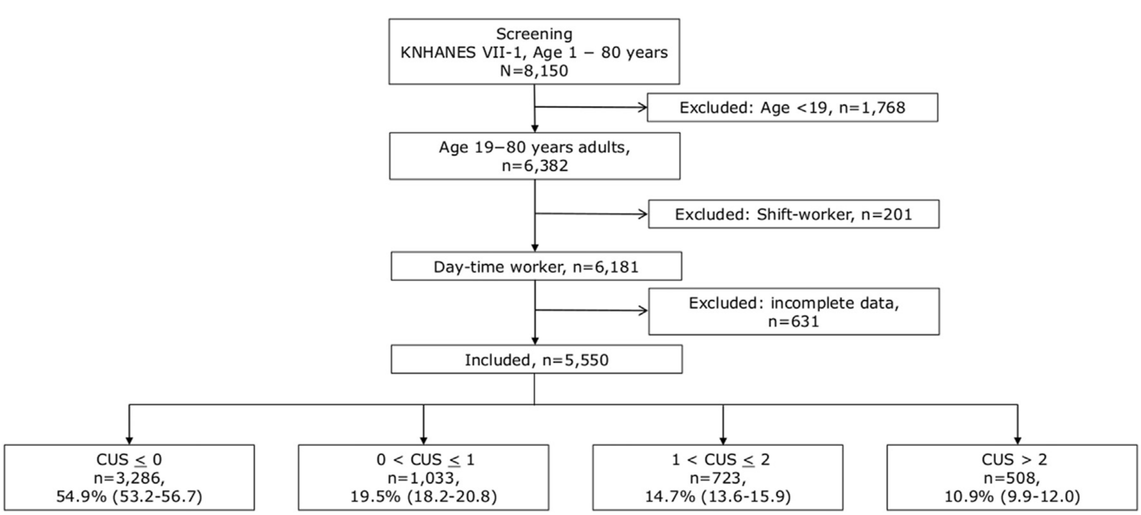

Fig. 1. Flow chart depicting the participation of subjects in the seventh Korea National Health and Nutrition Examination Survey (KNHANES VII-1), 2016. CUS: weekend catch-up sleep

Table 1
Demographic, social, lifestyle and sleep characteristics of individuals with CUS duration ≤0, >0 to 1, >1 to 2 and > 2 h.

	CUS ≤0 h (n = 3286)	>0 CUS ≤1 h (n = 1033)	>1 CUS ≤2 h, (n = 723)	CUS >2 h, (n = 508)	*p*-value
Sex, women, n (%)	1832 (49.1)	654 (56.5)	440 (53.9)	296 (51.9)	0.003
Age, mean ± SE	51.0 ± 0.4	43.4 ± 0.6	41.3 ± 0.6	38.8 ± 0.7	<0.001
Chronotype					
Early chronotype, n (%)	1101 (26.7)	100 (7.2)	61 (7.0)	64 (10.6)	<0.001
Intermediate chronotype, n (%)	1898 (60.8)	794 (75.3)	550 (76.1)	366 (65.4)	
Late chronotype, n (%)	287 (12.5)	139 (17.6)	112 (17.0)	106 (24.0)	
Educational level, ≥ 12 yrs, n (%)	1916 (66.9)	820 (84.3)	608 (86.9)	442 (89.7)	<0.001
Alcohol intake (≥2 times/week), n (%)	771 (24.5)	207 (21.3)	157 (23.0)	122 (25.2)	0.319
Smoking (current smoking), n (%)	584 (22.3)	166 (19.3)	130 (20.9)	116 (25.6)	0.152
Job status (having current job), n (%)	1689 (56.0)	673 (66.1)	495 (68.6)	373 (74.0)	<0.001
Physical activity (≥600 MET), n (%)	1345 (44.2)	516 (54.0)	372 (52.6)	249 (49.3)	<0.001
Weekday sleep duration per day, mean ± SE	7.3 ± 0.0	7.0 ± 0.0	6.7 ± 0.1	6.2 ± 0.1	<0.001
Weekend sleep duration per day (hour), mean ± SE	7.1 ± 0.3	7.8 ± 0.0	8.4 ± 0.1	9.4 ± 0.1	<0.001
Weekly average sleep duration (hour), mean ± SE	7.2 ± 0.3	7.3 ± 0.0	7.2 ± 0.1	7.1 ± 0.1	0.150
Social jetlag (hour), mean ± SE	0.1 ± 0.0	0.8 ± 0.0	1.1 ± 0.1	1.7 ± 0.7	<0.001
PHQ-9 score, mean ± SE	2.8 ± 1.0	2.4 ± 1.3	2.4 ± 0.1	2.8 ± 0.2	0.001
PHQ-9 ≥ 10, n (%)	244 (7.0)	47 (4.2)	25 (2.9)	30 (6.0)	<0.001

CUS, weekend catch-up sleep; MET: metabolic equivalents, SE, standard error; PHQ-9, Patient Health Questionnaire-9.

Table 2
Multivariable adjusted OR (95% CI) for the association between CUS with depression.

	CUS ≤0 h (n = 3286)	>0 CUS ≤1 h (n = 1033)	>1 CUS ≤2 h, (n = 723)	CUS >2 h (n = 508)
Model 1	REF	0.559 (0.391–0.798)	0.389 (0.242–0.625)	0.834 (0.533–1.309)
Model 2	REF	0.688 (0.474–0.999)	0.463 (0.284–0.754)	1.040 (0.654–1.652)
Model 3	REF	0.614 (0.431–0.873)	0.441 (0.267–0.729)	0.924 (0.575–1.484)
Model 4	REF	0.731 (0.505–1.060)	0.517 (0.309–0.865)	1.164 (0.718–1.886)

OR, odds ratio; 95% CI, 95% confidence interval; CUS, weekend catch-up sleep.
Model 1: adjusted for age and sex.
Model 2: adjusted for age, sex, job status, alcohol intake, educational level, physical activity and smoking.
Model 3: adjusted for age, sex, average sleep duration, chronotype, social jetlag and chronotype.
Model 4: adjusted for age, sex, job, alcohol, education, smoking, average sleep duration, social jetlag and chronotype.

depression (PHQ-9 score) using the four models (Table 3). In model 1, adjusted for age and sex, individuals with CUS duration >2 h showed a significantly positive linear relationship between CUS duration and PHQ-9 score. Among individuals with CUS duration ≤0, >0 to 1, and >1–2 h, showed no significantly linear relationship. In models 2, 3, and 4, similar relationships were found, with CUS duration >2 h showing a significantly positive linear relationship with PHQ-9 score while those with CUS duration ≤0, >0 to 1, and >1–2 h showed no significant linear relationship.

4. Discussion

In this cross-sectional study, individuals with CUS duration >1–2 h had a decreased risk of depression compared to those with CUS duration ≤0 h after adjusting for potential covariates. Additionally, we observed a significantly positive linear relationship between CUS duration and severity of depression in individuals with CUS duration >2 h. To the best of our knowledge, this is the first report to evaluate the association between CUS duration and depression among adults in a population-based setting.

A close association of sleep or sleep disturbances with depression has been reported. Individuals with insomnia, restless leg syndrome, and obstructive sleep apnea have an increased risk of depression [27]. Sleep disturbance shows a bidirectional comorbidity with migraine, which suggests shared mechanisms in the pathogenesis of both conditions [27]. For sleep duration, short (relative risk 1.31, 95% CI 1.04–1.64) and long sleep duration (relative risk 1.42, 95% CI 1.04–1.92) are significantly associated with an increased risk of depression [5], as reported in a recent metanalyses including 7 prospective studies. In the present study, individuals with <6 h of weekly average sleep duration had a higher prevalence of depression compared to those with 6–9 h of weekly average sleep duration (Supplementary table). The validity of the present study is in its similarity with

Table 3
Association between CUS duration and severity of depression (PHQ-9 score) among individuals with CUS duration ≤0, 0 < to 1, 1 < to 2 and >2 h.

	CUS ≤0 h			>0 CUS ≤1 h			>1 CUS ≤2 h			CUS >2 h		
	β	95% CI	P-value	β	95% CI	P-value	β	95% CI	P-value	β	95% CI	P-value
With CUS[a]	0.022	−0.287, 0.332	0.887	−0.065	−0.899, 0.769	0.878	0.190	−0.649, 1.029	0.655	0.430	0.093, 0.767	0.013
With CUS[b]	0.042	−0.241, 0.324	0.771	0.030	−0.813, 0.872	0.945	0.084	−0.757, 0.925	0.845	0.425	0.086, 0.763	0.014
With CUS[c]	0.046	−0.266, 0.359	0.770	−0.077	−0.911, 0.757	0.855	−0.027	−0.840, 0.786	0.948	0.436	0.075, 0.798	0.019
With CUS[d]	0.052	−0.233, 0.336	0.721	0.009	−0.420, 0.821	0.983	−0.810	−0.898, 0.737	0.846	0.424	0.055, 0.795	0.005

CUS, weekend catch-up sleep; PHQ-9, Patient Health Questionnaire-9.
[a] Adjusted for age and sex.
[b] Adjusted for age, sex, job status, alcohol intake, educational level, physical activity and smoking.
[c] Adjusted for age, sex, chronotype, social jetlag and weekly average sleep duration.
[d] Adjusted for age, sex, job status, alcohol intake, educational level, physical activity, smoking, chronotype, social jetlag and weekly average sleep duration.

previous studies in the association between sleep duration and depression.

Short sleep duration is associated with various negative outcomes on health problems, and CUS was investigated as a way to reduce the consequences of short sleep duration [28,29]. For behavioral problems, the effect of CUS has been reported in some studies. A Korean adolescent study in Incheon region used to examine the association of depression and suicidal attempts with CUS, found a significant association with the risk of suicide attempts and self-injury regardless of depression. Nevertheless, the study did not include sleep duration in the analyses, and CUS may be an indicator for short sleep duration [30]. Another Korean study investigated the association among chronotype, CUS, sleep duration, perceived insufficient sleep, sleep environment, and school-related factors among high school students from 15 districts. The study categorized CUS duration as <0, between 0 and 2, and ≥2 h, and found that CUS duration ≥2 h was a significant factor for decreased risk of depression when compared to CUS duration <0 h. Furthermore, the study found that evening preference and perceived insufficient sleep are associated with an increased risk for depression in multiple regression analyses [31]. Nevertheless, both studies were conducted for teenagers in middle and high school and the information on the association between CUS and depression in adults has not been reported yet. Sleep and sleep disturbances in teenagers differ from those in adults. Total sleep duration decreases during adolescence [32]. Circadian phase delay occurs during adolescence. With maturity, the circadian phase delay progresses [33]. Delayed sleep phase disorder is more prevalent in adolescence than in adult populations [34]. The present study firstly reported the association between CUS and depression in adults aged 19–80 years using a nationally representative sample.

The present study found that individuals with CUS duration >1–2 h had a decreased risk of depression compared to those with CUS duration ≤0 h. In contrast, individuals with CUS duration >0 to 1 and > 2 h did not show significant change in the risk of depression. On the other hand, the severity of depression (PHQ-9) score showed a linear association with CUS duration in individuals with CUS duration >2 h, but not in individuals with CUS duration ≤0, >0 to 1, and >1–2 h. These findings suggest that the association between CUS duration and depression is not linear. Considering recovery, CUS in the weekend is a modifiable lifestyle factor, and our study suggested a potential strategy of reducing the risk of depression by having CUS duration of >1–2 h. Further longitudinal studies are needed to verify the effect of CUS on depression.

There are several possible explanations for the non-linear association between CUS and depression. One possible reason is a change in the balance of good and bad effects of CUS over CUS duration. CUS is an extension of sleep on weekend and may compensate for insufficient sleep during weekdays. In addition to compensatory effects, sleep extension on weekend may cause circadian misalignment and social jetlag. Social jetlag is reported to have bad effects on metabolism, body mass index, atherosclerosis and depression [35–37]. An increase in social jetlag with the increase in CUS duration has also been observed in our study (Table 1). In CUS duration 1 to ≤2 h, the positive effects outweighed the negative ones and the risk of depression decreased compared to CUS duration ≤0 h. In contrast, bad effects offset good effects in CUS duration >2 h and resulted in the no difference in depression risk. Another possible reason is the incomplete compensatory effects of CUS for insufficient sleep. Although CUS has some compensatory roles, it only mitigates the effects of insufficient sleep and cannot completely compensate for them [38]. CUS duration >2 h suggests a high level of insufficient sleep. Such insufficiency could not be fully recovered by CUS and resulted in no significant difference in the risk of depression. In contrast, the amount of insufficient sleep in CUS duration 1 to ≤2 h was less than CUS duration >2 h and insufficient sleep was partially compensated by CUS and resulted in a decreased risk of depression. In CUS duration >0–1 h, both the amount of insufficient sleep and sleep compensation were low and the risk of depression was not significantly different from that in CUS ≤0 h.

Chronotype is the behavioral manifestation of the underlying circadian rhythms and can be determined by daytime activity and sleep-wake timing [39]. The association between late chronotype and depression has been consistently reported. A meta-analysis including 36 cross-sectional studies concluded that late chronotype (an eveningness) was associated with more severe depressive symptoms [40]. Longitudinal studies also revealed a significant association between the two conditions [15,41]. Chronotype is also associated with CUS. Late chronotype is more prone to leading to insufficient sleep and has more likelihood to have CUS. A nationwide population study in Korea showed that individuals with CUS had a higher propensity for late chronotype compared to those without CUS [7]. The present study observed a similar finding in that the prevalence of late chronotype increased as CUS duration increased (Table 1). Therefore, there was a close association among chronotype, CUS, and depression. The present study investigated the association of CUS and depression after adjusting for chronotype and other sleep-related variables. Our approaches might allow us to accurately investigate the association between CUS and depression.

The present study has several limitations. First, we assessed the sleep duration on weekdays and the weekend by two questions rather than using objective methods such as polysomnography or actigraphy. Nevertheless, objective assessments using devices in a population-based study are very difficult, and most epidemiological studies have investigated sleep time based on participants' reports. Indeed, self-reported sleep time is well correlated with the values obtained through actigraphy monitoring [42]. Second, the present study was cross-sectional in design and examined the effect of CUS on depression in a population-based setting. Therefore, it is not possible to deduce a cause–effect association between CUS and depression. Third, we diagnosed depression using the PHQ-9 questionnaire, rather than by face-to-face interview based on DSM-5 criteria. The PHQ-9 was developed to screen for depression in the community and has a high sensitivity and modest specificity [11]. The PHQ-9 was used to evaluate for depressive symptoms during the previous two weeks, and the prevalence currently determined was the point prevalence of depression. For epidemiological studies on depression, the Composite International Diagnostic Interview (CIDI) was developed [43]. Nevertheless, the PHQ-9 scores showed high agreement with that of CIDI in a population-based setting [44]. The Korean version PHQ-9 has shown good sensitivity and specificity when doctors' diagnoses were compared with those based on DSM-IV [12]. Lastly, we did not include other sleep-related factors, such as excessive daytime sleepiness (EDS) and insomnia, in the analyses. Insomnia is closely related with depression and is a typical symptom of depression [45]. EDS is another common sleep-related complaint and can be a result of sleep deprivation or poor sleep quality [46,47]. EDS is also associated with depression and is considered to be one of the symptoms of depression [46]. Nevertheless, the KNHANES VII has no data for EDS and insomnia. Further studies including data of EDS and insomnia in analyses will provide a better understanding on the association between CUS and depression.

The present study has several strengths. First, our study used a nationally representative sample with large sample size. With such data, we could successfully investigate the relationship between CUS and depression. Second, we evaluated the association between CUS and depression including sleep-related factors (chronotype, weekly average sleep duration, and social jetlag), and socioeconomic and lifestyle factors (educational level, alcohol drinking, smoking, job status, and physical activity) as covariates in the analyses. Chronotype, sleep duration, educational level, alcohol drinking, smoking, job status, and physical activity are associated with depression [5,18,20–22,48]. Therefore, we are sure that we accurately evaluated the relationship between CUS and depression in the present study.

5. Conclusions

Individuals with CUS duration >1–2 h had a decreased risk of depression compared to individuals with CUS duration ≤0 h. The risk of depression in individuals with CUS duration >0 to 1, >1 to 2, and >2 h did not differ significantly from those with ≤0 h. These findings may help in the proper management of depression and provide better understanding of the relationship between CUS and depression.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2021.02.058.

Conflict of interest

MK Chu was a site investigator for a multicenter trial sponsored by Otsuka Korea, Novartis International AG, and Eli Lilly and Company. MK Chu worked as an advisory member for Teva and received lecture honoraria from Allergan Korea and Yuyu Pharmaceutical Company in the past 24 months. The other authors declared no conflict of interest.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2021.02.058.

References

[1] Andrade L, Caraveo-Anduaga JJ, Berglund P, et al. The epidemiology of major depressive episodes: results from the International Consortium of Psychiatric Epidemiology (ICPE) Surveys. Int J Methods Psychiatr Res 2003;12(1):3–21.
[2] American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 5th ed. 2013.
[3] GBD 2015 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet 2016;388(10053):1545–602.
[4] Ferrari AJ, Charlson FJ, Norman RE, et al. Burden of depressive disorders by country, sex, age, and year: findings from the global burden of disease study 2010. PLoS Med 2013;10(11):e1001547.
[5] Zhai L, Zhang H, Zhang D. Sleep duration and depression among adults: a meta-analysis of prospective studies. Depress Anxiety 2015;32(9):664–70.
[6] Hublin C, Kaprio J, Partinen M, et al. Insufficient sleep–a population-based study in adults. Sleep 2001;24(4):392–400.
[7] Im HJ, Baek SH, Chu MK, et al. Association between weekend catch-up sleep and lower body mass: population-based study. Sleep 2017;40(7).
[8] Killick R, Hoyos CM, Melehan KL, et al. Metabolic and hormonal effects of 'catch-up' sleep in men with chronic, repetitive, lifestyle-driven sleep restriction. Clin Endocrinol 2015;83(4):498–507.
[9] Hwangbo Y, Kim WJ, Chu MK, et al. Association between weekend catch-up sleep duration and hypertension in Korean adults. Sleep Med 2013;14(6):549–54.
[10] Kweon S, Kim Y, Jang MJ, et al. Data resource profile: the Korea national health and nutrition examination survey (KNHANES). Int J Epidemiol 2014;43(1):69–77.
[11] Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. J Gen Intern Med 2001;16(9):606–13.
[12] Choi HS, Choi JH, Park KH, et al. Standardization of the Korean version of patient health questionnaire-9 as a screening instrument for major depressive disorder. J Korean Acad Fam Med 2007;28(2):114–9.
[13] Basnet S, Merikanto I, Lahti T, et al. Associations of common noncommunicable medical conditions and chronic diseases with chronotype in a population-based health examination study. Chronobiol Int 2017;34(4):462–70.
[14] Henderson SEM, Brady EM, Robertson N. Associations between social jetlag and mental health in young people: a systematic review. Chronobiol Int 2019;36(10):1316–33.
[15] Merikanto I, Kronholm E, Peltonen M, et al. Circadian preference links to depression in general adult population. J Affect Disord 2015;188:143–8.
[16] Roenneberg T, Kuehnle T, Juda M, et al. Epidemiology of the human circadian clock. Sleep Med Rev 2007;11(6):429–38.
[17] Wittmann M, Dinich J, Merrow M, et al. Social jetlag: misalignment of biological and social time. Chronobiol Int 2006;23(1–2):497–509.
[18] Bjelland I, Krokstad S, Mykletun A, et al. Does a higher educational level protect against anxiety and depression? The HUNT study. Soc Sci Med 2008;66(6):1334–45.
[19] Camacho TC, Roberts RE, Lazarus NB, et al. Physical activity and depression: evidence from the Alameda county study. Am J Epidemiol 1991;134(2):220–31.
[20] Fluharty M, Taylor AE, Grabski M, et al. The association of Cigarette smoking with depression and anxiety: a systematic review. Nicotine Tob Res 2017;19(1):3–13.
[21] Sullivan LE, Fiellin DA, O'Connor PG. The prevalence and impact of alcohol problems in major depression: a systematic review. Am J Med 2005;118(4):330–41.
[22] Wilson SH, Walker GM. Unemployment and health: a review. Publ Health 1993;107(3):153–62.
[23] Organization WH. Global physical activity questionnaire (GPAQ) analysis guide. Available at: https://www.who.int/ncds/surveillance/steps/resources/GPAQ_Analysis_Guide.pdf. [Accessed 30 September 2020]. Accessed.
[24] Korea Centers for Disease Control and Prevention. Korea national health and nutrition examination survey. Available at: https://knhanes.cdc.go.kr/knhanes/eng/index.do. [Accessed 9 March 2020]. Accessed.
[25] World Medical Association. WMA declaration of helsinki—ethical principles for medical research involving human subjects. JAMA 2013;310(20):2191–4.
[26] Lee J, Kim HR. The association between long working hours and high-sensitivity C-reactive protein in older aged individuals: the Korea national health and nutrition examination survey (KNHANES) 2015. J Occup Environ Med 2018;60(9):775–80.
[27] Fang H, Tu S, Sheng J, et al. Depression in sleep disturbance: a review on a bidirectional relationship, mechanisms and treatment. J Cell Mol Med 2019;23(4):2324–32.
[28] Son SM, Park EJ, Cho YH, et al. Association between weekend catch-up sleep and metabolic syndrome with sleep restriction in Korean adults: a cross-sectional study using KNHANES. Diabetes Metab Syndr Obes 2020;13:1465–71.
[29] Schaetz L, Rimner T, Pathak P, et al. Impact of an employer-provided migraine coaching program on burden and patient engagement: results from interim analysis (1126). AAN Enterprises; 2020.
[30] Kang SG, Lee YJ, Kim SJ, et al. Weekend catch-up sleep is independently associated with suicide attempts and self-injury in Korean adolescents. Compr Psychiatr 2014;55(2):319–25.
[31] Koo DL, Yang KI, Kim JH, et al. Association between morningness-eveningness, sleep duration, weekend catch-up sleep and depression among Korean high-school students. J Sleep Res 2020. https://doi.org/10.1111/jsr.13063.e13063.
[32] Leger D, Beck F, Richard JB, et al. Total sleep time severely drops during adolescence. PLoS One 2012;7(10):e45204.
[33] Carskadon MA, Vieira C, Acebo C. Association between puberty and delayed phase preference. Sleep 1993;16(3):258–62.
[34] Schrader H, Bovim G, Sand T. The prevalence of delayed and advanced sleep phase syndromes. J Sleep Res 1993;2(1):51–5.
[35] Islam Z, Akter S, Kochi T, et al. Association of social jetlag with metabolic syndrome among Japanese working population: the Furukawa Nutrition and Health Study. Sleep Med 2018;51:53–8.
[36] Kantermann T, Duboutay F, Haubruge D, et al. Atherosclerotic risk and social jetlag in rotating shift-workers: first evidence from a pilot study. Work 2013;46(3):273–82.
[37] Parsons MJ, Moffitt TE, Gregory AM, et al. Social jetlag, obesity and metabolic disorder: investigation in a cohort study. Int J Obes 2015;39(5):842–8.
[38] Depner CM, Melanson EL, Eckel RH, et al. Ad libitum weekend recovery sleep fails to prevent metabolic dysregulation during a repeating pattern of insufficient sleep and weekend recovery sleep. Curr Biol 2019;29(6):957–67. e4.

[39] Adan A, Archer SN, Hidalgo MP, et al. Circadian typology: a comprehensive review. Chronobiol Int 2012;29(9):1153–75.
[40] Au J, Reece J. The relationship between chronotype and depressive symptoms: a meta-analysis. J Affect Disord 2017;218:93–104.
[41] Lane JM, Vlasac I, Anderson SG, et al. Genome-wide association analysis identifies novel loci for chronotype in 100,420 individuals from the UK Biobank. Nat Commun 2016;7:10889.
[42] Lockley SW, Skene DJ, Arendt J. Comparison between subjective and actigraphic measurement of sleep and sleep rhythms. J Sleep Res 1999;8(3):175–83.
[43] Wing JK, Babor T, Brugha T, et al. SCAN. Schedules for clinical assessment in neuropsychiatry. Arch Gen Psychiatr 1990;47(6):589–93.
[44] Maske UE, Busch MA, Jacobi F, et al. Current major depressive syndrome measured with the Patient Health Questionnaire-9 (PHQ-9) and the Composite International Diagnostic Interview (CIDI): results from a cross-sectional population-based study of adults in Germany. BMC Psychiatr 2015;15:77.
[45] Hertenstein E, Feige B, Gmeiner T, et al. Insomnia as a predictor of mental disorders: a systematic review and meta-analysis. Sleep Med Rev 2019;43:96–105.
[46] Fava M. Daytime sleepiness and insomnia as correlates of depression. J Clin Psychiatr 2004;65(Suppl 16):27–32.
[47] Gupta RM. Approach to the sleepy patient. Med Health R I 2002;85(3):86–9.
[48] Van den Berg JF, Kivelä L, Antypa N. Chronotype and depressive symptoms in students: an investigation of possible mechanisms. Chronobiol Int 2018;35(9):1248–61.