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# Longitudinal Trends in Sleep and Related Factors Among South Korean Adults From 2009 to 2018

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**Background and Purpose** Excess or insufficient sleep, irregular sleep-wake patterns, and an extreme early or late chronotypes adversely impact physical and mental health. Changes in sleep characteristics should therefore be tracked, and factors that contribute to poor sleep should be identified. We investigated the changes in sleep patterns among South Korean adults during 2009−2018.

**Methods** Using data of a representative sample of South Korean adults from the 2009 ($n$=2,658, 48.5% males; age=44.5±15.0 years old [mean±standard deviation], age range=19−86 years) and 2018 ($n$=2,389, 49.1% males; age=47.9±16.3 years, age range=19−92 years) Korean Headache-Sleep Study, we explored changes in sleep timing, sleep duration, chronotype, and social jetlag (SJL). Logistic regression analysis was used to examine the association between average sleep duration and depression.

**Results** From 2009 to 2018, bedtimes were advanced by 10 and 25 min on workdays and free days, respectively. Meanwhile, wake-up times were advanced by 13 min and delayed by 12 min on workdays and free days, respectively. The average sleep duration significantly decreased from 7.45 h to 7.13 h. The prevalence of short sleep duration (<7 h) increased, whereas that of long sleep duration (≥8 h) decreased. A circadian preference toward eveningness and SJL increased. The prevalence of depression increased from 4.6% to 8.4%, and there were significant reverse J-shaped and U-shaped associations between average sleep duration and depression in 2009 and 2018, respectively.

**Conclusions** Changes in sleep patterns and the association between sleep duration and depressive mood were determined from a representative sample of the South Korean adult population. Interventions to modify sleep behaviors might improve public health.

**Keywords** trends; sleep patterns; sleep duration; chronotype; depression.

## INTRODUCTION

Adequate sleep is vital to human health and well-being. Most studies focus on sleep duration. Sleeping for <7 h might increase the risks of cardiovascular disease, metabolic syndrome, stroke, dementia, and neuropsychiatric symptoms including depression and anxiety.[1] The relationships between sleep timing, sleep-wake cycle regularity, and circadian preference and health-related outcomes have recently been investigated.[1,2] Individuals with an evening chronotype and shift workers who experience chronic misalignment between their intrinsic circadian rhythm and behavioral cycles have higher rates of cardiometabolic diseases and all-cause mortality.[3] Recent studies found that cardiovascular health and mortality were predicted by diverse aspects of sleep other than sleep duration, such as napping, sleep regularity, and satisfaction with sleep.[4,5]

Despite the consensus that good sleep is crucial for maintaining and promoting health,

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poor sleep is pervasive in modern society. Sleep patterns and behaviors are strongly influenced by demographic, socioeconomic, behavioral, and environmental factors. For example, the burden of inadequate sleep and sleep disorders will inevitably increase in rapidly aging populations.[6] South Korea has a rapidly aging population, and the proportion of South Korean individuals aged ≥65 years increased from 9.9% in 2008 to 14.4% in 2018 due to a large decrease in the fertility rate and increased life expectancy.[7] In modern society, there are high social demands and expectations for the constant operation of various essential services, and the individuals fulfilling such duties meet these demands by reducing or interrupting their own sleep.[8] Irregular or nonstandard work schedules such as shift work and long working hours have become increasingly common and are associated with a short sleep duration, long sleep latency, and poor sleep quality, all of which negatively affect health.[9] Furthermore, the availability and use of electronic media devices has increased sharply in the last 10 years. The use of such devices has become a bedtime routine, with 90% of Americans reporting the habitual use of at least one electronic device during the hour before sleeping.[10] Exposure to artificial light before bedtime increases sleep onset latency, delays the circadian rhythm phase toward an evening chronotype, and suppresses the release of the sleep-facilitating hormone melatonin, which could adversely impact daytime performance and health.[11]

An upward trend of sleep problems, particularly short sleep duration, chronotype change, insomnia, and poor sleep quality, has recently been observed in various populations. Over the past century, the sleep duration of children and adolescents has declined by 1 h[12] and the prevalence rates of very short (<5 h) and short (≤6 h) sleep have increased.[13,14] However, a progressive decrease in morningness among Finnish adults from 2007 to 2012 significantly increased the prevalence of eveningness, especially among those aged 35–44 years.[15] From 2002 to 2012, the age-adjusted prevalence of insomnia symptoms in US adults increased from 17.4% to 18.8%.[16] Very few previous studies have evaluated sleep-related trends in Asian countries. The Chinese Longitudinal Health Longevity Study demonstrated that the prevalence rates of older adults who sleep less than 7 h and report poor sleep quality increased between 2008 and 2018.[17] A recent epidemiological study in Japan indicated that sleep duration decreased and late bedtimes increased between 2004 and 2017.[18]

The current study aimed to determine changes in various aspects of sleep and related features at the population level over almost 10 years in South Korea. For this, we documented self-reported sleep patterns including sleep timing, duration, and quality, as well as sleep-related features such as subjective satisfaction, daytime sleepiness, insomnia symptoms, and depressive mood in representative samples of the South Korean adult population in 2009 ($n$=2,658) and 2018 ($n$=2,389). We also analyzed the association between depression and sleep profile to define which sleep features contribute to depressive mood. Since depression is the most important aspect of mental health, its association with sleep patterns has been studied extensively,[19] and depression and suicide are exceedingly high in South Korea.[20]

## METHODS

### Study design

We conducted large nationwide cross-sectional surveys of a representative sample of the adult (age ≥19 years) South Korean population, with one (phase I)[21] in 2009 and another (phase II) in 2018 termed as the Korean Headache-Sleep Study. The surveys aimed to assess the epidemiology of sleep and headache in the general population and to determine the association between headache and sleep problems. The two surveys had similar designs regarding sampling, recruitment, and interview methods, although the estimated total population ($n$=48,580,293 in phase I; $n$=51,817,851 in phase II) and sample size ($n$=2,836 in phase I; $n$=2,501 in phase II) differed between the phases. The study was conducted by Gallup Korea using two-stage cluster random sampling that was proportional to the population distribution in all 15 South Korean administrative divisions, with the exception of Jeju-do. The administrative districts were subdivided into cities (si), counties (gun), and districts (gu). In the first stage, 15 administrative divisions were selected as the primary sampling units. Each division was assigned a sample number based on its population distribution. In the second stage, representative basic administrative units (si, gun, and gu) were selected, with probabilities proportional to the respective cluster size. There were 75 si, 82 gun, and 69 gu among the 15 administrative divisions. Stratified sampling was then performed based on the ages, sexes, and employment status of the participants. Trained field personnel performed door-to-door visits and face-to-face interviews using a structured questionnaire that was developed to collect information on sociodemographic and anthropometric profiles, headache characteristics, sleep timing and duration, sleep quality, snoring, insomnia, daytime sleepiness, anxiety, and depression.

Ethics approval for this study was obtained from the Institutional Review Boards of Seoul National University Bundang Hospital (IRB No. B-1808-484-303), Chungnam National University Hospital (IRB No. CNUH 2018-04-005-002), and Severance Hospital in the Yonsei University Hospital (IRB No. 2018-1269-001).

### Subjects

In phase I (2009), 2,836 participants (41.8% males; age=43.0±14.5 years [mean±standard deviation], age range=19−86 years) completed the survey. We excluded 151 shift workers, 23 extreme outliers in the mid-sleep time on free days corrected for sleep debts on workdays (MSFsc) (more than three standard deviations), and 4 individuals with missing Patient Health Questionnaire-9 (PHQ-9) data. Consequently, 2,658 participants (48.5% males; age=44.5±15.0 years, age range=19−86 years) were enrolled. In phase II (2018), 2,501 participants (49.5% males; age=47.9±16.4 years, age range=19−92 years) completed the survey. We excluded 92 shift workers, 1 extreme outlier in MSFsc, and those missing any relevant information (*n*=3 for perceived insufficient sleep, *n*=4 for PHQ-9, *n*=4 for Epworth Sleepiness Scale [ESS], *n*=2 for Insomnia Severity Index [ISI], and *n*=6 for Pittsburgh Sleep Quality Index [PSQI]). Finally, 2,389 participants (49.1% males; age=47.9±16.3 years, age range=19−92 years) were included.

### Sociodemographic and health-related characteristics

We evaluated sociodemographic factors including age, sex, education, and income. Education level was categorized into <12 vs. ≥12 years. Income level was divided into two groups: higher and lower than the minimum monthly cost of living per person in South Korea (2 million KRW). Alcohol consumption and smoking status were classified as current, never, or former. Regular physical exercise was defined as engaging in at least 30 min of moderate aerobic exercise on ≥3 days a week. Body mass index (BMI, kg/m$^2$) was calculated as the self-reported body weight (kg) divided by height squared (m$^2$). Depression was assessed using the PHQ-9.[22] Validated cutoff values were used to categorize participants into the depressed (PHQ-9 score ≥10) and nondepressed (<10) groups.[23]

### Sleep questionnaires

Sleep timing, sleep duration, chronotype, and social jetlag (SJL) were analyzed by using the Munich Chronotype Questionnaire, which assesses self-reported sleep-wake behavior during workdays and free days over the previous 4 weeks. We extracted data on bedtime, wake-up time, and sleep onset latency. Time in bed was calculated by subtracting the bedtime from the wake-up time. Sleep onset time was calculated by adding the sleep latency time to the bedtime. Sleep duration was defined as the difference between the sleep onset and wake-up times. Average sleep duration was calculated using the following formula: ([workday sleep duration]×5+[free day sleep duration]×2)/7. Sleep efficiency was calculated using the following formula: (total sleep time)/(time in bed)×100. MSFsc, a chronotype phase marker, was calculated as midpoint of sleep on free days−0.5×(sleep duration on free days−[5×sleep duration on workdays+2×sleep duration on free days]/7). SJL was defined as the difference between the midpoints of sleep on free days and workdays.

Sleep quality was measured using the PSQI, which is a reliable indicator of overall sleep quality; scores >5 indicate a potential sleep problem.[24] Poor sleep was defined as PSQI >5. Perceived insufficient sleep was defined as a "no" response to the question "Are you satisfied with your sleep pattern?" The ESS was used to evaluate daytime sleepiness, with an ESS score >10 defined as excessive daytime sleepiness.[25] Moderate-to-severe clinical insomnia was screened using the ISI and determined as being present when the value was ≥15.[26]

### Statistical analyses

We compared the demographic characteristics, lifestyle habits, psychological health, and sleep patterns of the participants between the 2009 and 2018 surveys using the chi-square test and student's *t*-test. Considering demographic changes over a 10-year period, such as population structure by age and sex, subgroup analyses by age (19−29, 30−39, 40−49, 50−59, 60−69, and ≥70 years old) and sex were conducted to analyze sleep schedules including bedtime, wake-up time, and sleep duration on workdays and free days. Finally, multivariate logistic regression analyses were performed to estimate the associations between depression and sleep duration, which accounted for the substantial change in depression prevalence from 4.6% in 2009 to 8.4% in 2018. Using 7.0−8.9 h/day of sleep as the reference category, the logistic regression model was adjusted for sociodemographic characteristics (age, sex, employment status, education level, and monthly income), lifestyle variables (alcohol consumption, current smoking status, physical exercise, and BMI), and sleep characteristics (excessive daytime sleepiness, moderate to severe insomnia, chronotype, and SJL). These covariates were selected because previous studies found that they were associated with sleep duration. Descriptive analysis of the study variables was performed using SPSS Statistics software (version 25, IBM Corp., Armonk, NY, USA).

## RESULTS

### Changes in sociodemographic characteristics from 2009 to 2018

Table 1 lists the basic sociodemographic characteristics of the participants in the 2009 and 2018 surveys. The age increased slightly (44.5±15.0 vs. 47.9±16.3 years, *p*<0.01), while there was no significant difference in the sex ratio (48.5% vs. 49.1% males, *p*=0.67) between the two years. Employment status, education and income levels, and alcohol consumption increased, whereas regular physical exercise decreased. It was

**Table 1.** Demographic characteristic of the cross-sectional participant samples

| | 2009 (*n*=2,658) | 2018 (*n*=2,389) | *p* |
|---|---|---|---|
| Sociodemographic variables | | | |
| Age, years | 44.5±15.0 | 47.9±16.3 | <0.01* |
| Sex, male | 1,290 (48.5) | 1,174 (49.1) | 0.67 |
| Employed, yes | 1,638 (61.6) | 1,580 (66.2) | <0.01* |
| Education level, >12 years | 1,016 (38.6) | 1,000 (41.9) | 0.02* |
| Income, KRW | | | |
| <2 million | 476 (17.9) | 241 (10.1) | <0.01* |
| ≥2 million | 2,182 (82.1) | 2,148 (89.9) | |
| Lifestyle variables | | | |
| Alcohol consumption | 1,701 (64.3) | 1,772 (74.2) | <0.01* |
| Smoking | 700 (26.4) | 582 (24.4) | 0.09 |
| Regular physical exercise | 705 (26.5) | 503 (21.1) | <0.01* |
| Body mass index, kg/m$^2$ | 23.0±3.0 | 23.1±2.8 | 0.54 |
| Psychological variables | | | |
| PHQ-9 score | 2.3±3.5 | 3.0±3.8 | <0.01* |
| Depressive mood | 121 (4.6) | 200 (8.4) | <0.01* |
| Sleep variables | | | |
| PSQI | 3.6±2.4 | 3.8±2.4 | 0.02* |
| Poor sleep | 479 (18.0) | 449 (18.8) | 0.48 |
| Perceived insufficient sleep, yes | 808 (30.4) | 1,057 (44.3) | <0.01* |
| ESS | 5.6±4.0 | 6.6±4.0 | <0.01* |
| Excessive daytime sleepiness | 311 (11.7) | 359 (15.0) | <0.01* |
| ISI | 3.9±4.8 | 5.1±4.6 | <0.01* |
| Moderate-to-severe insomnia | 122 (4.6) | 99 (4.1) | 0.44 |
| Workdays | | | |
| Bedtime, hh:mm | 23:35±01:44 | 23:25±01:10 | <0.01* |
| Wake-up time, hh:mm | 06:50±01:35 | 06:37±01:11 | <0.01* |
| Sleep onset latency, hh:mm | 00:07±00:24 | 0:15±0:13 | <0.01* |
| Sleep duration, hh:mm | 07:17±01:52 | 07:06±01:04 | <0.01* |
| Sleep efficiency, % | 99.1±3.3 | 98.1±5.0 | <0.01* |
| Free days | | | |
| Bedtime, hh:mm | 23:51±01:28 | 23:26±01:12 | <0.01* |
| Wake-up time, hh:mm | 07:37±02:02 | 07:49±01:42 | <0.01* |
| Sleep onset latency, hh:mm | 00:09±00:28 | 0:16±0:13 | <0.01* |
| Sleep duration, hh:mm | 07:51±01:53 | 07:49±01:21 | 0.40 |
| Sleep efficiency, % | 97.6±4.6 | 95.6±5.8 | <0.01* |
| Sleep duration, average | 07:27±01:38 | 07:08±01:05 | <0.01* |
| MSFsc, hh:mm | 03:37±01:56 | 03:38±01:38 | 0.82 |
| SJL, hh:mm | 00:42±01:29 | 00:51±00:52 | <0.01* |

Data are mean±standard-deviation values for continuous variables and *n* (%) values for categorical variables. *p* values are for differences between the two study groups using student's *t*-test or the chi-square test. *$p$<0.05.
ESS, Epworth Sleepiness Scale; ISI, Insomnia Severity Index; MSFsc, mid-sleep time on free days corrected for sleep debts on workdays; PHQ-9, Patient Health Questionnaire-9; PSQI, Pittsburgh Sleep Quality Index; SJL, social jetlag.

particularly interesting that the prevalence of self-reported moderate-to-severe depression nearly doubled from 2009 (4.6%) to 2018 (8.4%). Basic sociodemographic characteristics such as age, education and income levels, alcohol consumption, smoking, regular physical exercise differed between the sleep duration groups (Supplementary Table 1 in the online-only Data Supplement).

## Descriptive trends in sleep quality, excessive daytime sleepiness, and insomnia

Sleep quality assessed using the PSQI worsened (3.6%±2.4% in 2009 vs. 3.8%±2.4% in 2018, $p$=0.02), and the prevalence rates of perceived insufficient sleep (30.4% vs. 44.3%, $p$<0.01) and excessive daytime sleepiness (11.7% vs. 15.0%, $p$<0.01) increased. Although the prevalence of moderate to severe insomnia almost remained the same, the ISI (3.9±4.8 vs. 5.1±4.6, $p$<0.01) increased.

## Descriptive trends in sleep timing, sleep duration, chronotype, and SJL in the general population

Bedtimes in 2018 were advanced by 10 min on workdays and by 25 min on free days compared with in 2009. While the wake-up time on workdays was advanced in 2009 by 13 min, that on free days was delayed by 12 min. Sleep duration decreased by 11 min on workdays and by 2 min on free days. The average sleep duration decreased by 19 min between 2009 and 2018, from 7.45 to 7.13 h. Fig. 1 presents the changes in the proportions of participants with different sleep durations, categorized as <5, 5−6, 6−7, 7−8, 8−9, 9−10, and ≥10 h. The proportion of short sleepers (<7 h) increased from approximately 30.4% to 42.6%, whereas that of long sleepers (≥8 h) decreased from approximately 33.9% to 20.4%. Sleep onset latency increased by 8 min on workdays and by 7 min on free days from 2009 to 2018, while sleep efficiency decreased. Although the mean MSFsc did not change significantly, with the most frequent MSFsc being between 03:00 and 04:00, its distribution differed between 2009 and 2018.

As illustrated in Fig. 2, the adult South Korean population showed a pronounced phase shift toward eveningness between 2009 and 2018, with a decrease in the circadian preference toward morningness. SJL increased by 9 min, from 42 min in 2009 to 51 min in 2018. The proportions of participants with SJLs of 1−2 and ≥2 h increased by 8.2% and 1.4%, respectively (1−2 h, 20.8% vs. 29.0%; ≥2 h, 8.9% vs. 10.3%). The prevalence of SJL <1 h decreased by 9.6%, from 70.3% in 2009 to 60.7% in 2018 (data not shown). Differences in sleep patterns between participants with and without depression in 2009 and 2018 are summarized in Supplementary Table 2 (in the online-only Data Supplement). While depressed participants had later bedtimes on workdays and free days than nondepressed participants in 2009, depressed participants tended to go to bed earlier than nondepressed participants in 2018. Short sleep duration, especially in free days, was more prevalent in depressed than in nondepressed participants in 2018, but there was no difference in 2009.

### Age- and sex-specific differences in trends of sleep timing, sleep duration, chronotype, and SJL in the general population

Fig. 3 presents several differences in sleep trends based on age and sex between the years 2009 and 2018. Advanced bedtimes on workdays and free days were more prominent in those aged 19–29, 30–39, 40–49, and 50–59 years in both sexes. Wake-up time on workdays was advanced among adults aged 19–29 and 30–39 years, while it was delayed in those aged ≥60 years in both sexes. Wake-up time on workdays was advanced in males relative to in females aged 40–49 years. Participants of both sexes and all age groups had delayed wake-up times on free days. The decrease in sleep duration on workdays and free days was prominent among those aged 19–29, 30–39, and 60–69 years. Unexpectedly, sleep duration on workdays was increased in males aged 50–59 years. Sleep duration on free days in females decreased in those aged 19–29, 29–30, and ≥70 years compared with the other age groups, but increased in males. Compared with males in the same age group, females aged 50–59 years demonstrated a greater increase in sleep duration on free days. Sleep onset latency increased and sleep efficiency decreased between 2009 and 2018 for all age groups and both sexes.

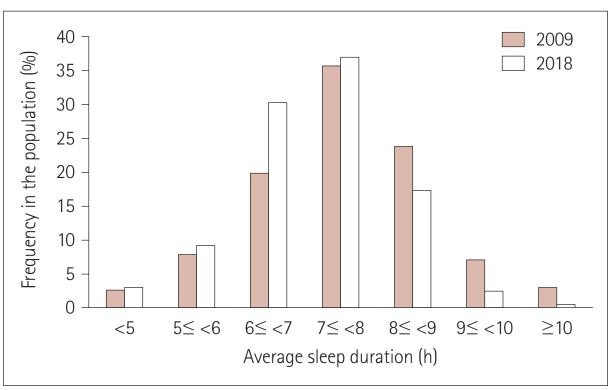


**Fig. 1.** Change in distribution of average sleep duration from 2009 to 2018.

### Dose–response association between sleep duration and depression risk

Using logistic regression models, we found reverse J-shaped association between sleep duration and depression risk in 2009 and a U-shaped one between the two in 2018, with the lowest depression risk in those with a sleep duration of 7–8 h/day (Fig. 4). The demographics-adjusted odds ratios (ORs) (95% confidence intervals [CIs]) of depression risk for individuals who reported <5, 5–6, 6–7, 8–9, and ≥9 h of sleep were 3.74 (1.51–9.26), 2.24 (1.15–4.36), 1.42 (0.80–2.51), 1.26 (0.72–2.22), and 1.32 (0.67–2.61) in 2009 (Fig. 4A), respectively, and 3.08 (1.47–6.44), 1.81 (1.04–3.16), 1.12 (0.73–1.71), 1.15 (0.69–1.90), and 2.53 (1.10–5.82) in 2018 (Fig. 4B), respectively. In 2009, female sex (OR=0.47 $p$=0.01), daytime sleepiness (OR=3.36, $p$<0.01), insomnia (OR=6.67, $p$<0.01), SJL (OR=1.13, $p$=0.01), and late chronotype (OR=1.09, $p$=0.01) were also independent risk factors for depression. In 2018, daytime sleepiness (OR=2.92, $p$<0.01) and insomnia (OR=4.78, $p$<0.01) were associated with depression, as detailed in Supplementary Table 3 (in the online-only Data Supplement).

## DISCUSSION

This was the first study to reveal trends in sleep characteristics including sleep-wake cycles, sleep duration, chronotype, SJL, and sleep-related problems (sleep quality, daytime sleepiness, and insomnia), and to examine the association between sleep duration and depression in South Koreans aged 19 years

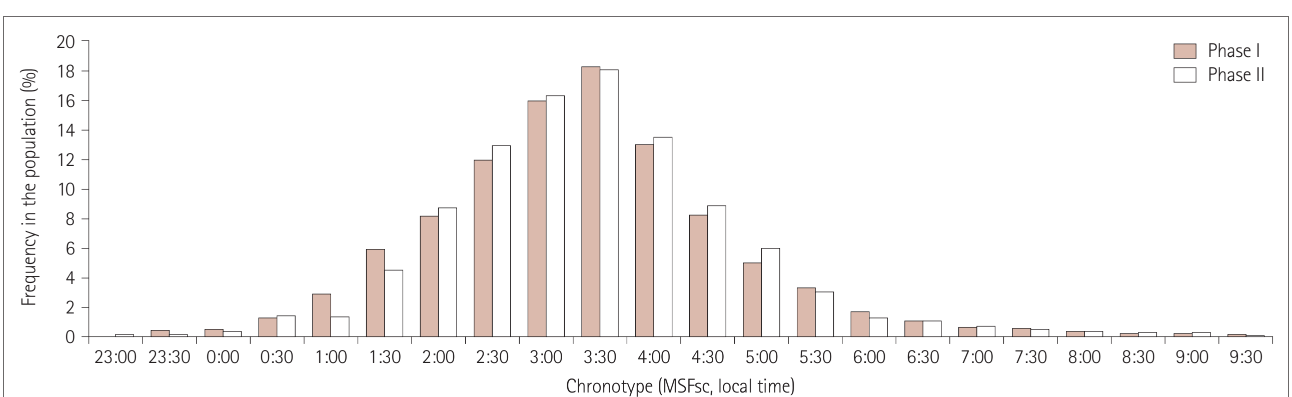


**Fig. 2.** Change in distribution of chronotype from 2009 to 2018. MSFsc, mid-sleep time on free days corrected for sleep debts on workdays.

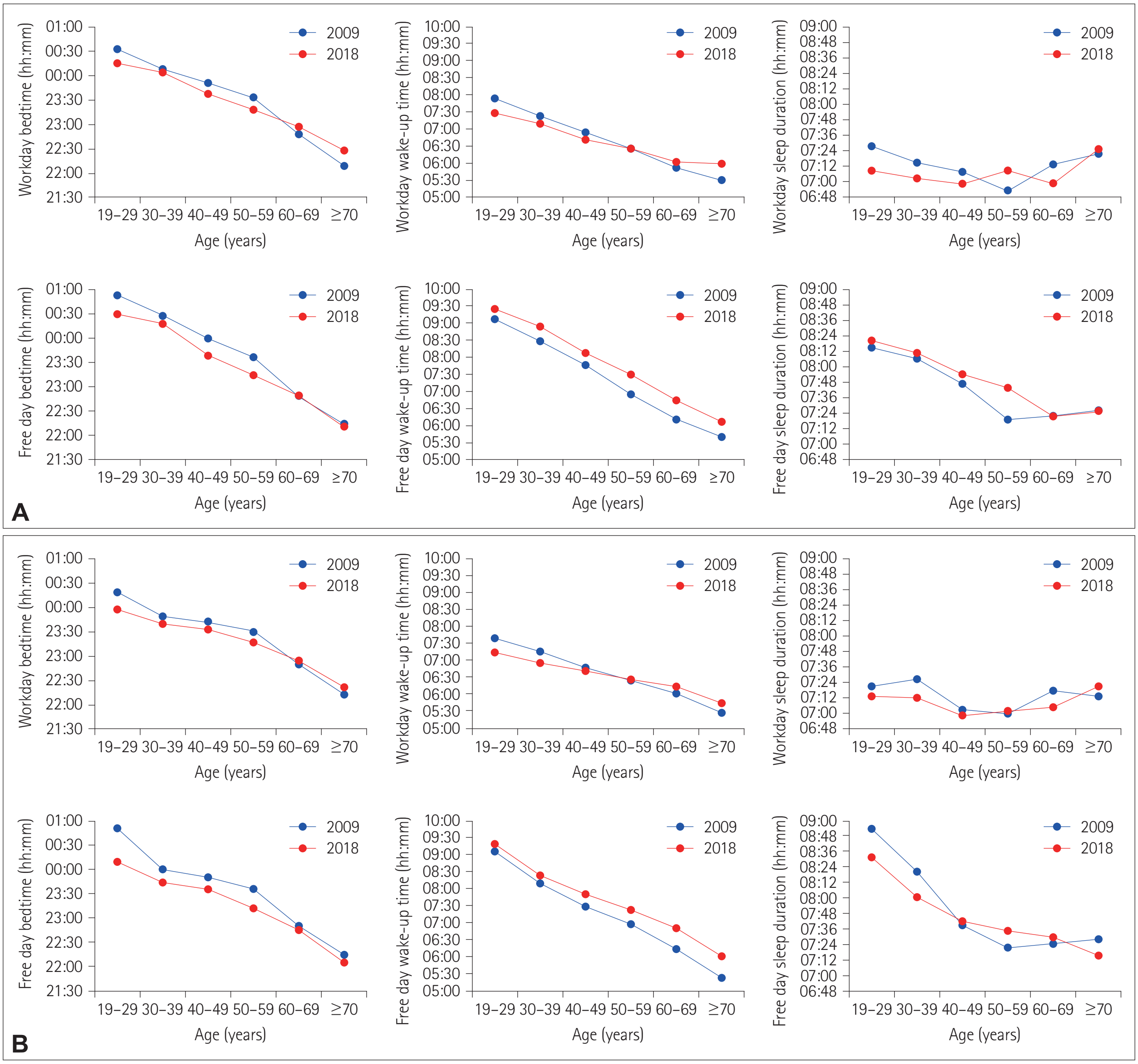


Fig. 3. Age- and sex-related differences in workday and free day sleep patterns from 2009 to 2018 for males (A) and females (B).

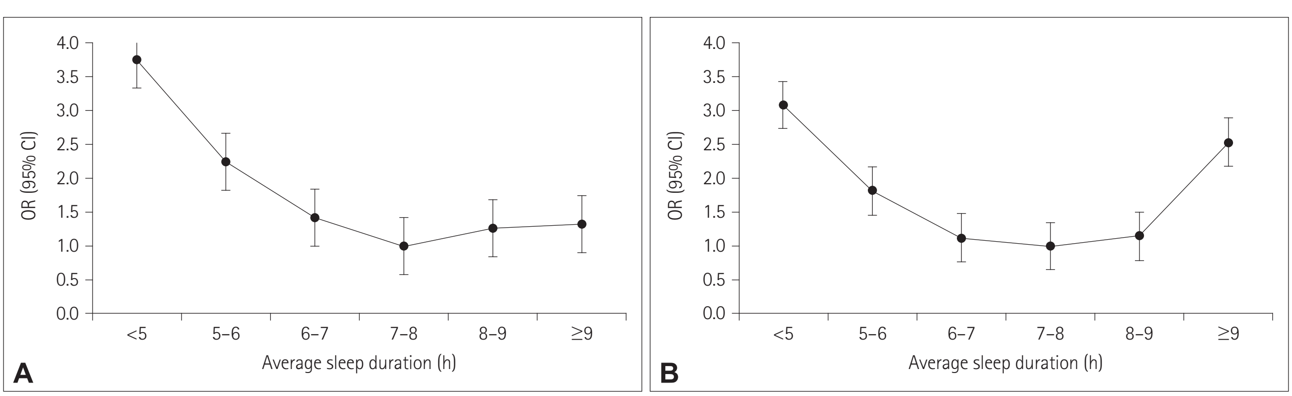


Fig. 4. Nonlinear dose–response association between sleep duration and depression risk in 2009 (A) and 2018 (B). CI, confidence interval; OR, odds ratio.

and older during 2009–2018. Over the 10-year study period, bedtimes on workdays and free days and wake-up times on workdays were advanced, but wake-up times on free days were delayed. The average sleep duration decreased significantly, reflecting decreased sleep duration on workdays, particularly in long sleepers (≥8 h); the proportion of short sleepers (<7 h) increased. Sleep onset latency increased along with a decrease in sleep efficiency. There was a trend in circadian preference toward eveningness and increased SJL. Age and sex differences in trends of sleep properties were also demonstrated. Particularly interesting findings included that the depression prevalence among the general population doubled from 4.6% in 2009 to 8.4% in 2018, and reverse J-shaped and U-shaped associations were observed between average sleep duration and depression in 2009 and 2018, respectively.

Our findings of advanced bedtimes and wake-up times on workdays differed from those of previous studies, which found delayed bedtimes but unchanged wake-up times. The bedtimes of Australian children aged 10–15 years were delayed by 26 min, but wake-up times were unchanged, between 1985 and 2004.[27] Delays in bedtimes have also been observed in children living in Finland, Norway, and Switzerland.[28] However, most studies have focused on exploring the sleep-wake patterns of young and old adults, with the findings having limited generalizability to the general population. A recent study involving the Finnish adult population obtained results similar to ours: average bedtimes were advanced on weekdays and weekends among those aged 25–34 years from 2012 to 2017.[15] This could reflect the impact of school or work on sleep-wake patterns, especially among young adults. Early school start times necessitate waking up early and may contribute to the trend of advanced bedtimes. Several studies have demonstrated strong dose–response relationships between school start times and time in bed, indicating that early school start times reduce time in bed while late school start times increase it.[29] The increased home-to-workplace travel time in modern society may also cause advanced bedtimes and wake-up times. Advancing bedtime could make it easier to wake up early for work and ultimately increase concentration during the day.

The increasing prevalence of insomnia, especially regarding difficulties in sleep onset and maintenance, can explain the increase in sleep latency and decrease in sleep efficiency in South Korean general population.[18,30] A large international study of European adolescents found an increase in the prevalence of sleep-onset difficulties by an average of 3% among 28 European countries over 12 years.[31] Many societal changes such as the looming 24-h society, excessive screen times, increases in irregular work hours, and increased work stress have been considered as the factors that contribute to insomnia.[30] Increased sleep onset latency from 2009 to 2018 may have also been caused by changes in modern society, and this increased sleep onset latency could lead to a reduced sleep efficiency.

We noted a transition toward an evening chronotype and an increase in SJL from 2009 to 2018, which was also observed in previous studies. Increased self-reported definite eveningness, as assessed using the Morningness-Eveningness Questionnaire, was found among Finnish adults aged 25–74 years, particularly among those aged 35–44 years.[15] Changes in societal and behavioral aspects could affect circadian preference. Shift workers are commonplace in modern societies, who prefer to stay up and sleep late.[9] Increased use of electronic devices also promotes circadian preference toward eveningness.[32] The light emitted by electronic devices might suppress levels of the sleep-promoting hormone melatonin and alter circadian rhythms, which would lead to altered sleep-wake behavior.[11] Increased SJL might reflect chronic sleep debt induced by a decreased sleep duration on workdays and increased frequencies of insufficient sleep and evening chronotype.[33] It was also interesting that we found an inconsistency between sleep-wake patterns and circadian preference in the co-occurrence of advanced sleep-wake patterns, especially on workdays, and increased prevalence of the eveningness chronotype. A possible explanation of these findings is that more-advanced MSFsc toward the extreme early chronotype in 2018 than in 2009 may lead to advanced sleep-wake patterns along with maintenance of the overall increase in eveningness chronotypes. Indeed, we found that MSFsc in the extreme early chronotype (defined as 2.5% at end of the distribution: ≤01:00) had the tendency to advance by 4 min in 2018 compared with in 2009 (00:38 vs. 00:42, $p$=0.17). One study found a conflicting relationship between sleep-wake pattern and circadian preference from 2007 to 2012, especially in young adults aged 25–34 years.[15] That study elucidated that these differences across time could arise due to increased SJL. The combination of very advanced sleep-wake patterns on workdays and compensatory extension of sleep duration mostly caused by late wake-up time on free days is another possible explanation of our results.

Nationally representative surveys have found conflicting trends in sleep duration, but most reported shortened sleep durations. From 1985 to 2012 in the US, sleep duration declined by 13 min, from 7.40 to 7.18 h, and the prevalence of short sleepers (≤6 h) increased from 22.3% to 29.2%.[13] The proportion of short sleepers (≤6 h) increased in Norway (from 2.6% in 1971 to 5.6% in 2000) and Italy (from 2.8% in 1989 to 6.6% in 2002), but decreased in Sweden (from 7.6% in 1990 to 4.7% in 2000). Analyses of sleep duration trends in the Netherlands, Germany, and Switzerland revealed no change in the proportion of short or long sleepers.[34] This inconsistency in results could be explained by limitations in the accuracy of self-reported data, such as recall bias. Most people tend to round up times to the nearest hour, half hour, or (rarely) quarter hour.[35] The dynamics of social and political forces that affect sleeping patterns could also explain these results. A dose–response relationship has been found between sleep characteristics, specifically sleep duration and the number of work hours.[36] Employment status also affects sleep duration, with unemployed individuals having shorter or longer sleep durations than employed individuals.[37] Working hours and employment rates vary across the world and change over time, which might affect sleep duration trends.[38,39]

Given the association between demographic factors and sleep physiology, age and sex should be considered confounding variables when interpreting the results of epidemiological studies. A 12-year longitudinal South Korean cohort study demonstrated that forms of sleep deterioration, such as short sleep duration, long sleep latency, and low sleep efficiency, tended to be more prominent in females than in males, and that sex-related differences in sleep trends were noticeable in those younger than 60 years.[40] We also found age- and sex-related differences in sleep trends; of note, the delayed bedtime and wake-up time on workdays in adults aged ≥60 years and a difference in sleep duration were also noticeable between males and females aged 50–59 years. This may be due to the growing trend toward early retirement during the age range of 50–60 years and a sex difference in employment rates.[41] Indeed, transitioning to retirement is typically associated with increased sleep duration, later bedtimes, and later wake-up times.[42] Breaking the habit of waking up early for work could allow for flexibility in bedtimes and/or wake-up times, thus leading to extended sleep duration.

Previous studies have found associations between sleep duration and sociodemographic, emotional, and behavioral factors. Both short (≤6 h) and long (≥9 h) sleep durations are associated with old age, frequent smoking, being single/divorced/widowed, unemployment, and living in an urban area.[43] It was particularly interesting that we found that sleep duration and depression risk were closely associated and that depression prevalence doubled from 4.6% in 2009 to 8.4% in 2018. An increase in systemic inflammation levels caused by inadequate sleep duration is considered to be among the main underlying mechanisms. Depression is also associated with a proinflammatory state; levels of inflammatory markers such as interleukin-6, interleukin-12, and C-reactive protein are elevated in patients with depression.[44,45] Furthermore, large epidemiological studies have found associations between short and long sleep durations and high inflammation levels.[46,47] Poor sleep quality caused by increased sleep fragmentation, frequent awakening during sleep, and prolonged sleep latency might lead to depression in people with short and long sleep durations. Dysregulation of emotional reactivity has been thought to mediate the association between poor sleep quality and depression.[48] Unexpectedly, a long sleep duration of >9 h was associated with depression in 2018, but not in 2009. Several studies that examined the association between sleep duration and depression have presented inconsistent results, especially in those with a long duration. A cross-sectional study in China found an inverse linear relationship between sleep duration and depression, in that a long sleep duration of >8 h was associated with a lower depression prevalence.[49] A 4-year longitudinal study of middle-aged and elderly individuals indicated that a long sleep duration of >9 h was not associated with depression prevalence.[50] These inconsistent results may be attributable to the different sample sizes, wide ranges of demographic and situational variables, and inadequate information on confounding factors. The difference in age distribution according to sleep duration between the phase I and phase II studies may have contributed to our results. Relatively older participants with sleep durations >9 h in phase II could be more likely to report depressive mood than those in phase I, considering that depression is more prevalent in older adults than in younger adults.[51] Also, given the prominent change in the difference of sleep duration between depressed and nondepressed participants in 2019 compared with 2009, sleep duration may be an important factor of sleep that contributes to the increased depression prevalence. Considering that depression has been linked to suicide as well as various physical and mental illnesses,[20] promoting an optimal sleep duration (7–8 h per night)[52,53] to improve sleep quality could help to improve public health.

Our findings must be interpreted while considering several potential limitations. Self-reported data could be affected by multiple biases, such as social desirability and recall bias. We also did not screen for sleep disorders such as insomnia and obstructive sleep apnea or the use of medications that affect sleep. Nevertheless, this study had several strengths. We used data from two large, nationally representative surveys of the South Korean general population and evaluated various sleep parameters and factors that affect sleep patterns in detail, such as sociodemographic characteristics and health behaviors. Furthermore, we observed a rapid increase in depression prevalence and an association between sleep duration and depression, suggesting that short or long sleep duration could be a risk factor for depression. Finally, this study has yielded empirical evidence on the historical, current, and forecasted sleep trends and provided epidemiological insight into the relationship between sleep and various diseases, which could aid in the development of preventive strategies.

In summary, we have produced novel information on sleep characteristic trends over a 10-year period using data from two large-scale cross-sectional surveys of the South Korean general population. Impaired sleep patterns that affect sleep quality and quantity and that could cause health problems have become steadily more common from 2009 to 2018. Given the deleterious effects of downward trends in sleep behaviors, nationwide sleep education and promotion should be regarded as public health strategies to increase the public awareness of sleep health. The contributions of sociodemographic factors such as age and sex to sleep physiology should also be considered while determining sleep problems and targeting prevention and intervention strategies to prompt sleep health.

## Supplementary Materials

The online-only Data Supplement is available with this article at https://doi.org/10.3988/jcn.2022.0268.

### Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.


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### Conflicts of Interest

Min Kyung Chu, a contributing editor of the *Journal of Clinical Neurology*, was not involved in the editorial evaluation or decision to publish this article. All remaining authors have declared no conflicts of interest.


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## REFERENCES


1. Itani O, Jike M, Watanabe N, Kaneita Y. Short sleep duration and health outcomes: a systematic review, meta-analysis, and meta-regression. *Sleep Med* 2017;32:246-256.
2. Jike M, Itani O, Watanabe N, Buysse DJ, Kaneita Y. Long sleep duration and health outcomes: a systematic review, meta-analysis and meta-regression. *Sleep Med Rev* 2018;39:25-36.
3. Scheer FA, Hilton MF, Mantzoros CS, Shea SA. Adverse metabolic and cardiovascular consequences of circadian misalignment. *Proc Natl Acad Sci U S A* 2009;106:4453-4458.
4. Lee S, Mu CX, Wallace ML, Andel R, Almeida DM, Buxton OM, et al. Sleep health composites are associated with the risk of heart disease across sex and race. *Sci Rep* 2022;12:2023.
5. Wallace ML, Buysse DJ, Redline S, Stone KL, Ensrud K, Leng Y, et al. Multidimensional sleep and mortality in older adults: a machine-learning comparison with other risk factors. *J Gerontol A Biol Sci Med Sci* 2019;74:1903-1909.
6. Miner B, Kryger MH. Sleep in the aging population. *Sleep Med Clin* 2020;15:311-318.
7. Bank W. Population ages 65 and above (% of total population) [Internet]. Washington, DC: World Bank; 2019 [cited 2021 Oct 1]. Available from: https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS.
8. Kreitzman L. *The 24 Hour Society*. 1st ed. London: ProfileBooks, 1999; 176.
9. Hittle BM, Gillespie GL. Identifying shift worker chronotype: implications for health. *Ind Health* 2018;56:512-523.
10. Gradisar M, Wolfson AR, Harvey AG, Hale L, Rosenberg R, Czeisler CA. The sleep and technology use of Americans: findings from the National Sleep Foundation's 2011 sleep in America poll. *J Clin Sleep Med* 2013;9:1291-1299.
11. Chang AM, Aeschbach D, Duffy JF, Czeisler CA. Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness. *Proc Natl Acad Sci U S A* 2015;112:1232-1237.
12. Matricciani L, Olds T, Petkov J. In search of lost sleep: secular trends in the sleep time of school-aged children and adolescents. *Sleep Med Rev* 2012;16:203-211.
13. Ford ES, Cunningham TJ, Croft JB. Trends in self-reported sleep duration among US adults from 1985 to 2012. *Sleep* 2015;38:829-832.
14. Jean-Louis G, Williams NJ, Sarpong D, Pandey A, Youngstedt S, Zizi F, et al. Associations between inadequate sleep and obesity in the US adult population: analysis of the national health interview survey (1977-2009). *BMC Public Health* 2014;14:290.
15. Merikanto I, Partonen T. Increase in eveningness and insufficient sleep among adults in population-based cross-sections from 2007 to 2017. *Sleep Med* 2020;75:368-379.
16. Ford ES, Cunningham TJ, Giles WH, Croft JB. Trends in insomnia and excessive daytime sleepiness among U.S. adults from 2002 to 2012. *Sleep Med* 2015;16:372-378.
17. Lee YH, Lee YH, Wu YH, Liu CT, Chang YC. A 10-year trend of sleeping patterns, geographical, and community disparities among Chinese older adults. *J Appl Gerontol* 2022;41:1301-1311.
18. Otsuka Y, Kaneita Y, Spira AP, Mojtabai R, Itani O, Jike M, et al. Trends in sleep problems and patterns among Japanese adolescents: 2004 to 2017. *Lancet Reg Health West Pac* 2021;9:100107.
19. Wiebe ST, Cassoff J, Gruber R. Sleep patterns and the risk for unipolar depression: a review. *Nat Sci Sleep* 2012;4:63-71.
20. You BS, Jeong KH, Cho HJ. Regional suicide rate change patterns in Korea. *Int J Environ Res Public Health* 2020;17:6973.
21. Im HJ, Baek SH, Chu MK, Yang KI, Kim WJ, Park SH, et al. Association between weekend catch-up sleep and lower body mass: population-based study. *Sleep* 2017;40:zsx089.

22. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med* 2001;16:606-613.
23. Manea L, Gilbody S, McMillan D. Optimal cut-off score for diagnosing depression with the patient health questionnaire (PHQ-9): a meta-analysis. *CMAJ* 2012;184:E191-E196.
24. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res* 1989;28:193-213.
25. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep* 1991;14:540-545.
26. Cho YW, Song ML, Morin CM. Validation of a Korean version of the insomnia severity index. *J Clin Neurol* 2014;10:210-215.
27. Dollman J, Ridley K, Olds T, Lowe E. Trends in the duration of school-day sleep among 10- to 15-year-old South Australians between 1985 and 2004. *Acta Paediatr* 2007;96:1011-1014.
28. Matricciani L, Bin YS, Lallukka T, Kronholm E, Dumuid D, Paquet C, et al. Past, present, and future: trends in sleep duration and implications for public health. *Sleep Health* 2017;3:317-323.
29. Nahmod NG, Lee S, Buxton OM, Chang AM, Hale L. High school start times after 8:30 am are associated with later wake times and longer time in bed among teens in a national urban cohort study. *Sleep Health* 2017;3:444-450.
30. Garland SN, Rowe H, Repa LM, Fowler K, Zhou ES, Grandner MA. A decade's difference: 10-year change in insomnia symptom prevalence in Canada depends on sociodemographics and health status. *Sleep Health* 2018;4:160-165.
31. Ghekiere A, Van Cauwenberg J, Vandendriessche A, Inchley J, Gaspar de Matos M, Borraccino A, et al. Trends in sleeping difficulties among European adolescents: are these associated with physical inactivity and excessive screen time? *Int J Public Health* 2019;64:487-498.
32. Fossum IN, Nordnes LT, Storemark SS, Bjorvatn B, Pallesen S. The association between use of electronic media in bed before going to sleep and insomnia symptoms, daytime sleepiness, morningness, and chronotype. *Behav Sleep Med* 2014;12:343-357.
33. Roenneberg T, Pilz LK, Zerbini G, Winnebeck EC. Chronotype and social jetlag: a (self-) critical review. *Biology (Basel)* 2019;8:54.
34. Bin YS, Marshall NS, Glozier N. Sleeping at the limits: the changing prevalence of short and long sleep durations in 10 countries. *Am J Epidemiol* 2013;177:826-833.
35. Hoyos C, Glozier N, Marshall NS. Recent evidence on worldwide trends on sleep duration. *Curr Sleep Medicine Rep* 2015;1:195-204.
36. Nakashima M, Morikawa Y, Sakurai M, Nakamura K, Miura K, Ishizaki M, et al. Association between long working hours and sleep problems in white-collar workers. *J Sleep Res* 2011;20(1 Pt 1):110-116.
37. Blanchflower DG, Bryson A. Unemployment and sleep: evidence from the United States and Europe. *Econ Hum Biol* 2021;43:101042.
38. Dolton P. Working hours: past, present, and future [Internet]. Bonn: IZA World of Labor; 2017 [cited 2021 Oct 1]. Available from: https://wol.iza.org/articles/working-hours-past-present-and-future.
39. Brochu P, Armstrong CD, Morin LP. The 'trendiness' of sleep: an empirical investigation into the cyclical nature of sleep time. *Empir Econ* 2012;43:891-913.
40. Kim HJ, Kim REY, Kim S, Kim SA, Kim SE, Lee SK, et al. Sex differences in deterioration of sleep properties associated with aging: a 12-year longitudinal cohort study. *J Clin Sleep Med* 2021;17:964-972.
41. Yoon HS. Korea: balancing economic growth and social protection for older adults. *Gerontologist* 2013;53:361-368.
42. Hagen EW, Barnet JH, Hale L, Peppard PE. Changes in sleep duration and sleep timing associated with retirement transitions. *Sleep* 2016;39:665-673.
43. Patterson F, Grandner MA, Lozano A, Satti A, Ma G. Transitioning from adequate to inadequate sleep duration associated with higher smoking rate and greater nicotine dependence in a population sample. *Addict Behav* 2018;77:47-50.
44. Osimo EF, Pillinger T, Rodriguez IM, Khandaker GM, Pariante CM, Howes OD. Inflammatory markers in depression: a meta-analysis of mean differences and variability in 5,166 patients and 5,083 controls. *Brain Behav Immun* 2020;87:901-909.
45. Prather AA, Vogelzangs N, Penninx BW. Sleep duration, insomnia, and markers of systemic inflammation: results from the Netherlands study of depression and anxiety (NESDA). *J Psychiatr Res* 2015;60:95-102.
46. Dowd JB, Goldman N, Weinstein M. Sleep duration, sleep quality, and biomarkers of inflammation in a Taiwanese population. *Ann Epidemiol* 2011;21:799-806.
47. Patel SR, Zhu X, Storfer-Isser A, Mehra R, Jenny NS, Tracy R, et al. Sleep duration and biomarkers of inflammation. *Sleep* 2009;32:200-204.
48. O'Leary K, Bylsma LM, Rottenberg J. Why might poor sleep quality lead to depression? A role for emotion regulation. *Cogn Emot* 2017;31:1698-1706.
49. Li W, Yin J, Cai X, Cheng X, Wang Y. Association between sleep duration and quality and depressive symptoms among university students: a cross-sectional study. *PLoS One* 2020;15:e0238811.
50. Sun Y, Shi L, Bao Y, Sun Y, Shi J, Lu L. The bidirectional relationship between sleep duration and depression in community-dwelling middle-aged and elderly individuals: evidence from a longitudinal study. *Sleep Med* 2018;52:221-229.
51. Mitchell AJ, Rao S, Vaze A. Do primary care physicians have particular difficulty identifying late-life depression? A meta-analysis stratified by age. *Psychother Psychosom* 2010;79:285-294.
52. Kim HM, Lee SW. Beneficial effects of appropriate sleep duration on depressive symptoms and perceived stress severity in a healthy population in Korea. *Korean J Fam Med* 2018;39:57-61.
53. Dong L, Xie Y, Zou X. Association between sleep duration and depression in US adults: a cross-sectional study. *J Affect Disord* 2022;296:183-188.