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Obesity and sleep mismatch between weekends and weekdays in the Korean population according to working status

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ABSTRACT

Objectives: To investigate whether sleep mismatch between weekends and weekdays is correlated with obesity according to working status and sex in the Korean population.
Study design: This study was conducted using data from the Korea National Health and Nutritional Examination Survey (KNHANES) in 2016. A total of 5,684 subjects (2,453 men and 3,231 women) were divided into subgroups according to age, sex and working status. Sleep mismatch was defined as the difference in sleep duration between weekdays and weekends. In this study, multivariable logistic regression analysis was applied to obtain odds ratios (ORs) for obesity in those with sleep mismatch $\geq$ 90 min when referenced to those with sleep mismatch $<$ 90 min.
Main outcome measures: In the working group, adjusted ORs for obesity were mostly less than 1, but they were not statistically significant among any age or sex groups. However, for the non-working group, men over 60 years of age with sleep mismatch $\geq$ 90 min showed significantly increased ORs when referenced to those with sleep mismatch $<$ 90 min in every model; the OR in model 4 was 2.89. Women over 60 years of age with sleep mismatch $\geq$ 90 min also showed higher ORs but they were not statistically significant.
Conclusions: Men who are not working and over 60 years of age in Korea may be at increased risk of obesity if their sleep mismatch is $\geq$ 90 min. Therefore, it might be possible to lower the prevalence of obesity in the elderly population by correcting sleep irregularity or through reemployment.

1. Introduction

The prevalence of obesity has increased by about 10 % from 1999 to 2016 in the United States [1]. Many studies have shown that various factors are associated with obesity, i.e., genotype, socioeconomic status, general health behaviors including eating pattern, sleep quality and duration, alcohol consumption, and physical activity [2–4]. One of those factors is sleep duration and many studies including some meta-analyses showed that short sleep duration (less than 5 h) and long sleep duration (more than 9 h) are associated with obesity in adults [5,6]. In addition to sleep duration, some studies have examined the relationship between sleep irregularity and obesity [7,8]. In general, sleep irregularity contributes to obesity and unhealthy consequences such as increased insulin resistance [9]. One of the indications of sleep irregularity is the difference in sleep duration between weekends and weekdays. Previous studies mainly focused on longer sleep duration on weekends than weekdays, which is defined as the term ‘Catch-up sleep (CUS)’. These studies found that CUS is associated with decreased BMI and increased insulin sensitivity [10–12].

Similarly, obesity is also associated with working status [13]. In a Spanish study, retired people and homeworkers showed a higher prevalence of overweight and obesity than active workers [13]. According to the results of those studies, both sleep and working status might be associated with obesity. Sleep is influenced by various factors including sex, mood, and occupational factors such as employment status and job stress [14,15]. In a British study, non-workers showed shorter sleep duration, higher prevalence of sleep difficulties, and more frequent use of sleeping pills than workers [16].

In Korea, the prevalence of obesity has also been steadily increasing and it is predicted to reach 62 % for men and 37 % for women by 2030

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[17]. Obesity has become an important social problem in Korean society. A Korean study showed that CUS is associated with a lower risk for obesity [12], while there are still very few studies that has investigated the relationship between obesity and sleep mismatch in Korea. Importantly, sleep mismatch should be considered in a social context regarding working status. Therefore, this study was designed to see whether sleep mismatch, which is defined as the difference in sleep duration between weekends and weekdays, has any correlations with obesity according to working status (working or non-working).

2. Materials and methods

2.1. Study design

This study was conducted using data from Korea National Health and Nutritional Examination Survey (KNHANES) in 2016. The subjects in this study were divided into subgroups according to age, sex and working status. We analyzed the association between obesity and sleep mismatch in the subgroups, expressed in terms of odds ratios (ORs), by using multivariable logistic regression analysis.

2.2. Survey overview

The KNHANES used in this study is a national cross-sectional survey that represents overall health status in people of all ages in Korea and has been conducted by Korea Centers for Disease Control and Prevention (KCDC) since 1998. Data of KNHANES included socioeconomic indicators and various health indicators, i.e., smoking, alcohol-consumption, weight, height, disease, chemical biomarkers, and nutrition status. The trained interviewer gave a visit to each participant to obtain information through the structured questionnaire formed by specialists in the Mediation Advisory Committee and the Advisory Committee in Korea Centers for Disease Control and Prevention based on various references. The indicators were collected through Computer Assisted Personal Interviewing, Computer Assisted Self-Interviewing, physical examination, and laboratory methods [18].

2.3. Subjects

The target population of KNHANES was conceptually all citizens aged 1 or older of households residing in Korea. Sampling was designed by the Mediation Advisory Committee and the Advisory Committee in Korea Centers for Disease Control and Prevention. To obtain representative samples, the sampling plan followed a multi-stage clustered probability design for 1 year [18]. In the 2016 KNHANES, a sample was extracted in the data from Population and Housing Census in 2010 and Public housing price in 2011–2014 by using probability proportional to size sampling and systematic sampling.

The sampled number of households was 4,416 and the number of all subjects in the 2016 KNHANES was 8,150 (3,665 men and 4,485 women). The subjects aged under 19 years were excluded (n = 1,768). We excluded subjects who were pregnant or breastfeeding (n = 72), shift workers (n = 16), those who had insufficient data (n = 334), and those who were previously diagnosed with major depressive disorder by a doctor (n = 276). As a result, a total of 5,684 subjects (2,453 men and 3,231 women) were included in this study. The protocol of the original KNHANES was approved by the Institutional Review Board of the Korea Center for Disease Control and Prevention and was performed according to the Ethical Principles for Medical Research Involving Human Subjects as defined by the Declaration of Helsinki in 1964. All participants in the KNHANES provided informed consent.

2.4. Anthropometric measurements

Height (cm) and body weight (kg) were measured to the nearest 0.1 cm and 0.1 kg, respectively. Waist circumference (cm) was measured to the nearest 0.1 cm horizontally at the midpoint of the imaginary line between the lower borders of the rib cage and the iliac crest at the end of normal expiration.

2.5. General health behaviors and sociodemographic variables

The subjects responded to a self-administered interview that included sociodemographic categories (sex, age) and health behavior categories, i.e., current smoking (yes or no) and alcohol drinking (yes or no). A 'yes' response to 'alcohol drinking' was defined as those who had at least one drink per day except for taking a sip at a sacrifice or religious ceremony. Physical activity was surveyed by using the international physical activity questionnaire (IPAQ) [19]. Those who exercised more than 3 times a week with moderate intense level for more than 30 min/session or vigorous intense for more than 20 min/session were categorized into the 'regular exercise group'. Data about income, and education were collected by personal interviews. The response of 'yes' for the 'income (Q1)' had its definition that their earnings belonged to the lower 25 % of average annual incomes, and the 'yes' for 'education ≤13' that their education year were less than 13 years or no.

2.6. Definition of Sleep mismatch, obesity and working status

In this study, we defined 'sleep mismatch' as the difference in sleep duration between weekdays and weekends. Sleep mismatch was calculated as the absolute value of 'mean sleep duration on weekdays' minus 'mean sleep duration on weekends'. (i.e., 'sleep mismatch' = |'Mean sleep duration on weekdays' – 'Mean sleep duration on weekends'|) The subjects were divided into two subgroups. One subgroup contained the subjects who had a sleep mismatch over 90 min and the other contained the subjects who had a sleep mismatch under 90 min. We assumed that sleep mismatch over 90 min might reflect sleep irregularity better. (as the sleep cycle is about 90 min in general [20] and sleep variability over 90 min is associated with high risk of cardiovascular disease [21].) 'Obesity' was defined as BMI $\geq$ 25 kg/m^2, according to the 2018 Guideline for Obesity in Korea [22]. The working group included people who reported 'yes' to the question, 'Have you recently worked more than an hour in a week for any income, or are you an unpaid family worker for more than 18 h per week?'. The non-workers reported 'no' to the same question. Among male workers, the number of professionals and administrators were 336, followed by 314 clerks, 258 of craft, equipment, machine operating, assembling workers and 232 technicians and associated workers. Among female workers, 336 were professionals and administrators, followed by simple labors with 303, sales workers with 243 and services workers with 241 (Supplemental Table 1).

2.7. Statistical analysis

Subject general characteristics were analyzed using the independent *t*-test for continuous variables and chi-squared test for categorical variables. We applied multivariable logistic regression analysis to obtain odds ratios (ORs) between the two sleep mismatch groups. Model 1 was a univariate logistic regression, and models 2 through 4 were multivariable logistic regression adjusted control variables. Crude ORs were estimated to evaluate the non-adjusted relationships between obesity and sleep mismatch ($\geq$ 90 min or not). In model 2, we adjusted for smoking, alcohol, exercise, and 1-day food intake and in model 3, we adjusted for the covariates in model 2 plus income, and education. In final model (model 4), we adjusted for the covariates in model 3 plus sleep duration. All statistical analyses were performed using STATA v.15 (STATA, College Station, TX). For all analyses, the statistical significance level was set at 0.05 for a two-tailed test.

3. Results

Table 1 shows general subject characteristics. In men,

Table 1
General characteristic of subjects.

	Men (N = 2,453)	Women (N = 3,231)	P value
Age (yr)	50.84 ± 16.76	50.94 ± 16.68	0.589
Height (cm)	170.1 ± 6.69	157.18 ± 6.68	<0.001
Weight (cm)	71.01 ± 11.72	58.23 ± 9.54	<0.001
Waist circumference (cm)	86.57 ± 8.92	79.99 ± 10.01	<0.001
Body mass index (kg/m^2)	24.48 ± 3.35	23.58 ± 3.63	<0.001
Sleep duration (min)	433.43 ± 76.27	431.77 ± 81.17	0.216
Weekday sleep duration (min)	423.48 ± 80.34	421.61 ± 85.5	0.201
weekend sleep duration (min)	458.29 ± 91.37	457.16 ± 92.29	0.322
Sleep mismatch (min)	34.81 ± 75.97	35.54 ± 72.31	0.009
Calorie intake (kcal)	1807.59 ± 911.48	1391.91 ± 682.96	<0.001
Current smoking (yes,%)	35.75	5.39	<0.001
Alcohol drinking (yes,%)	65.27	50.29	<0.001
Regular exercise (yes,%)	31.72	20.86	<0.001
Income (Q1) (yes,%)	17.41	20.49	0.03
Education ≤13 (yes,%)	58.7	53.9	<0.001
Working status (yes,%)	72.77	49.83	<0.001
Obesity (yes,%)	40.11	30.76	<0.001

anthropometric factors such as height, weight, waist circumference, and BMI were significantly higher than those in women (all $p < 0.001$). Proportion of current smoking, alcohol drinking, regular exercise, the lowest income (Q1) and education ≤ 13 years, and calorie intake were higher in men than in women (all $p < 0.05$). Working status and prevalence of obesity were higher in men than women (both $p < 0.001$). For sleep behaviors, total, weekday, and weekend sleep duration were higher in men than women, but not statistically significantly. Sleep mismatch was slightly longer in women than in men (35.54 min and 34.81 min, respectively, and $p = 0.009$). We also analyzed general characteristics of subjects according to working status (Supplement Table 2). Of the total 5,684 analyzed subjects in the study, 3,395 were workers. Working subjects were younger and higher than non-working subjects. (both $p < 0.001$) Weight, body mass index, calorie intake, weekend sleep duration, and proportion of current smoking, alcohol drinking, regular exercise, and obesity were higher in working subjects than non-working subjects (all $p < 0.05$). Weekday sleep duration, and proportion of the lowest income (Q1) and education ≤ 13 years were higher in non-working subjects than working subjects (all $p < 0.001$).

Fig. 1 shows the mean sleep duration and percentage of sleep mismatch ≥ 90 min according to BMI level. There was an inverted J-shaped correlation between BMI and mean sleep duration. The longest sleep duration was 439 min for BMI 18.5–23 kg/m^2 and the shortest sleep duration was 425 min for BMI > 25 kg/m^2 (Fig. 1 A, $p = 0.024$) However, the percentage of sleep mismatch ≥ 90 min tended to decrease as BMI levels increased (Fig. 1 B, $p = 0.006$).

Sleep mismatch according to age group, sex, and working status are shown in Fig. 2. According to age group, the proportion of sleep mismatch ≥ 90 min had a decreasing tendency as getting older and was lowest in those aged ≥ 60 years. ($p < 0.001$) According to sex, there was no significant difference in sleep mismatch ($p = 0.814$). According to working status, proportion of sleep mismatch < 90 min was higher in non-working group than working group, but, percentage of sleep mismatch ≥ 90 min was higher in working group than non-working group ($p < 0.001$).

Supplemental Table 3 shows general health behaviors such as smoking, drinking, exercise, and calorie intake according to working status and sleep mismatch. The working group with sleep mismatch ≥ 90 min showed higher proportion of current smoking and regular exercise than the group with sleep mismatch < 90 min. ($p = 0.022$ and $p = 0.010$, respectively). The non-working group with sleep mismatch ≥ 90 min showed more regular exercise than the sleep mismatch < 90 min. ($p > 0.001$). Calorie intake was higher in the working and non-working groups with sleep mismatch ≥ 90 min compared to the groups with

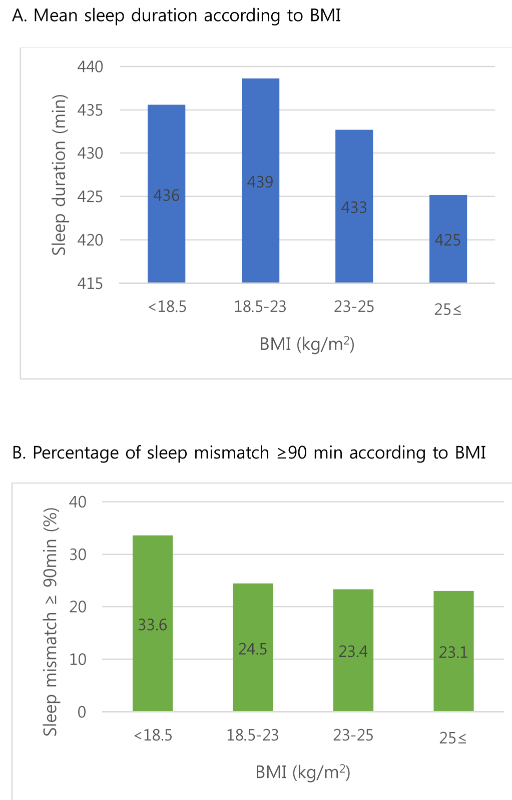

Fig. 1. Mean sleep duration and Percentage of population with sleep mismatch longer than 90 min according to BMI.
A. Mean sleep duration according to BMI.
P value = 0.024.
Body mass index; BMI.
B. Percentage of sleep mismatch ≥90 min according to BMI.
P value = 0.006.
Body mass index; BMI.

sleep mismatch < 90 min, but this was not statistically significant.

We analyzed the ORs for obesity according to sleep mismatch in the working and non-working groups (Table 2). In the working group, adjusted ORs for obesity were mostly less than 1, but they were not statistically significant among any age or sex groups in model 4. However, for the non-working group, men over 60 years of age with sleep mismatch ≥ 90 min showed significantly increased ORs when referenced to those with sleep mismatch < 90 min in every models (ORs = 2.8 in model 1, 2.95 in model 2, 2.88 in model 3, and 2.89 in model 4). In model 4, women over 60 years of age with sleep mismatch ≥ 90 min showed higher but not statistically significant ORs (OR = 1.52 and 95 % CI = 0.81−2.85 in model 4).

4. Discussion

In this study, sleep mismatch ≥ 90 min was associated with 2. 89 times increased OR for obesity in men aged more than 60 years who were not working regardless of their sleep duration.

Previous studies have investigated the difference of sleep duration between weekends and weekdays. Most of those studies focused on longer sleep duration on weekends than on weekdays as a factor associated with obesity. A Chinese study showed that sleep compensation on weekends against short sleep duration < 8 h on weekdays was correlated with a lower risk of obesity among children and adolescents [11]. In a Korean study, adults who reported having CUS also showed a lower BMI, regardless of mean weekday sleep duration [12]. These previous results may be related with Fig. 1B showing that higher BMI was related to

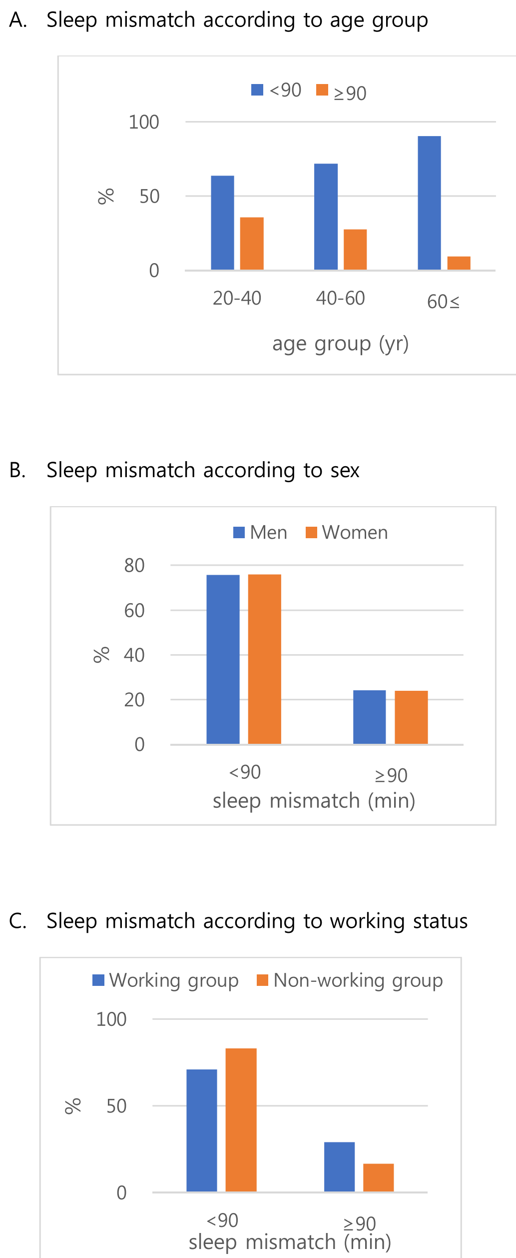

Fig. 2. Sleep mismatch according to age group, sex, and working status.
A. Sleep mismatch according to age group.
P < 0.001.
B. Sleep mismatch according to sex.
P $= 0.814$.
C. Sleep mismatch according to working status.
P < 0.001.

lower percentage of sleep mismatch ≥ 90 min. In this study, we focused on the difference in sleep duration between weekdays and weekends, which is similar to the already existing definition of 'CUS' but has an extended meaning that includes also longer sleep duration on weekdays than on weekends. We named such sleep difference as sleep mismatch, which represents the variability in sleep duration between weekends and weekdays. Some studies found that the irregularity in everyday sleep duration is associated with obesity in all age groups including children and older adults [7,23]. The association between sleep mismatch and obesity in our study was in a similar context to the results of the previous studies. Furthermore, based on this study, the meaning of irregularity could be expanded from the difference of daily sleep duration to the difference of sleep duration between weekend and weekday.

Table 2
OR for obesity in subjects with sleep mismatch≥90 min according to sex and age in working group and non-working group.

	Age group	OR (95 % CI) Model 1	Model 2	Model 3	Model 4
A. Working group					
Men	20~40	1.18 (0.83–1.67)	1.07 (0.72–1.61)	1.07 (0.72–1.61)	1.04 (0.69–1.56)
	40~60	0.85 (0.63–1.15)	0.79 (0.56–1.13)	0.77 (0.54–1.10)	0.78 (0.54–1.12)
	60≤	1.16 (0.68–1.98)	1.02 (0.57–1.81)	1.04 (0.58–1.88)	0.98 (0.53–1.80)
Women	20~40	0.71 (0.44–1.17)	0.64 (0.38–1.09)	0.64 (0.38–1.12)	0.12 (0.39–1.16)
	40~60	0.76 (0.54–1.09)	0.79 (0.54–1.15)	0.82 (0.56–1.21)	0.81 (0.55–1.19)
	60≤	0.88 (0.47–1.66)	0.93 (0.47–1.88)	0.96 (0.47–1.98)	0.95 (0.46–1.97)
B. Non-working group					
Men	20~40	1.4 (0.74–2.66)	1.45 (0.68–3.12)	1.53 (0.70–3.39)	1.57 (0.71–3.52)
	40~60	2.41 (0.62–9.30)	1.26 (0.20–7.83)	0.5 (0.05–5.47)	0.43 (0.04–5.19)
	60≤	2.8 (1.10–6.26)	2.95 (1.05–7.32)	2.88 (1.02–7.25)	2.89 (1.03–7.27)
Women	20~40	0.71 (0.43–1.20)	0.76 (0.44–1.32)	0.77 (0.44–1.36)	0.76 (0.43–1.35)
	40~60	1.1 (0.71–1.71)	1.19 (0.75–1.92)	1.35 (0.83–2.21)	1.21 (0.73–1.99)
	60≤	1.47 (0.83–2.60)	1.55 (0.85–2.85)	1.49 (0.80–2.78)	1.52 (0.81–2.85)

Model 1 : no adjusted.
Model 2 : adjusted for smoking, alcohol, exercise and calorie intake.
Model 3 : adjusted for the covariates of model 2 plus income and education.
Model 4 : adjusted for the covariates of model 3 and sleep duration.

An US population study reported that working status including employment status and job types are associated with obesity and sleep [13,24,25]. Based on this study, we additionally focused on the effect of working status on the relationship between sleep mismatch and obesity. Non-working elderly men who had sleep mismatch ≥ 90 min showed an increased OR for obesity in this study. In general, men over 60 years of age are expected to be retired in Korea. Retirement is associated with weight gain in people who retired from a physically active job and the effect of retirement itself on weight gain is greater than the effect of age on weight gain for the population over 62 years of age, according to an US study [25]. Some studies showed that unemployment is associated with increased BMI, especially in women [13], whereas other studies showed association between unemployment and underweight in male job-seekers [26]. In other words, the association of obesity and unemployment status including retirement seems controversial but still unemployment is associated with unhealthy body weight status. The results of our study may be explained by effect of lifestyle that is related with working status and sleep mismatch. Our study is a cross-sectional study, which brings to the limitation of explaining the causality why the population with sleep mismatch ≥ 90 min had unhealthy lifestyle. However, the subjects with sleep mismatch ≥ 90 min showed higher proportion of current smoking and calorie intake than those with sleep mismatch < 90 min in supplementary Table 3. In addition, in a Japanese study, unemployed men have unhealthy lifestyles that include increased alcohol consumption, increased smoking, and decreased exercise compared to the employed men [27]. Although there was no statistical significance, calorie intake was higher in both working and non-working groups with sleep mismatch ≥ 90 min compared to sleep mismatch < 90 min in this study. Weight gain after retirement is associated with lifestyle such as decreased fruit intake, increased frequency of having a breakfast and increased consumption of sugar-containing beverages. [28]. In addition, high sleep variability is related to irregular eating pattern, increased calorie intake and increased consumption of sugar-containing beverages [7].

The results of this study can be biologically explained by insulin resistance, circadian rhythm and hypothalamus, pituitary gland, and adrenal glands axis (HPA). Sleep irregularity including sleep mismatch leads to increased insulin resistance and thereby causes circadian misalignment [8]. This means that the period of exposure to light gets irregular, confusing the circadian rhythm and constantly resetting the central oscillator [23]. This changes the eating pattern and the peripheral oscillators in each metabolic tissues gets unsynchronized, which decreases level of leptin and increases ghrelin. Eventually, this leads to weight gain [23]. In addition, retirement brings various depressive symptoms to men, activating the HPA axis [29,30]. This could increase the level of cortisol which is associated with obesity [30].

This study has several strengths. First, it was performed on a representative large number of Korean people. Second, our study could provide one more evidence for the association between sleep irregularity and obesity showed in previous studies. In addition, this study extended the concept of sleep irregularity from daily sleep irregularity to sleep irregularity between weekends and weekdays. Third, from a social point of view, the results of this study may give an implication that economic activity in the elderly could be helpful not only for socio-economic but also for their overall health. In Korea, the number of elderly people has increased rapidly among the OECD countries and there are problems with socioeconomic stress in this population. Furthermore, it is well known that an aging society and the increasing incidence of obesity will lead to numerous socioeconomic and health-related issues in the future. The results of our study may give information to the upcoming studies and show the direction of various policies for the elderly. Fourth, this study provides evidence that individual sleeping patterns, such as sleep mismatch, could be one of the important factors to consider with respect to the increasing prevalence of obesity.

Nonetheless, several limitations exist in this study. First, since this study is cross-sectional, it is not possible to identify the causality between sleep mismatch, obesity, and working status. Second, the cause of sleep mismatch could not be determined because sleep mismatch is affected by various factors such as lifestyle and personal characteristics. Third, these factors of lifestyle such as sleep duration, smoking and working status were derived via self-reported questionnaire, indicating that there may have been a recall bias.

5. Conclusion

In conclusion, sleep mismatch was associated with increased risk for obesity in men over 60 years of age who were not working. Therefore, physicians should pay attention to the obese elderly patients about their working status if they showed sleep irregularity. It is helpful to recommend that elderly men who are retired or unemployed should endeavor to avoid irregularity in sleep duration and maintain a regular sleep pattern to lower their risk of obesity. Policies such as giving the retired elderly people a new chance to work again or extending the retirement age may be also beneficial to lower the prevalence of obesity among the elderly. Further prospective studies based on objective sleep measurements such as sleep pattern and time in socio-economically diverse groups are needed to elucidate the relationship between sleep mismatch and obesity.

Contributors

Minhee Seo contributed to study conception and design, analysis and interpretation, and drafting of the article.

Jaeman Park contributed to study conception and design, and drafting of the article.

Sojeong Kim contributed to study conception and design, and drafting of the article.

Heewon Jung contributed to study conception and design, and drafting of the article.

Minsung Sohn contributed to data collection and statistical analysis, analysis and interpretation, and critical revision of the article.

Yang-Hyun Kim contributed to study conception and design, data collection and statistical analysis, analysis and interpretation, and drafting and critical revision of the article, and has overall responsibility.

Conflict of interest

The authors declare that they have no conflict of interest.

Funding

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Ethics

The KNHAHES produced government-designated statistics based on Article 17 of Statistical Law (Approval No. 117002). The protocol of the original KNHAHES was approved by the Institutional Review Board of the Korea Center for Disease Control and Prevention and was performed according to the Ethical Principles for Medical Research Involving Human Subjects as defined by the Helsinki Declaration. All subjects provided informed written consent.

Data sharing and collaboration

There are no linked research data sets for this paper. Data will be made available on request.

Provenance and peer review

This article was not commissioned and was externally peer reviewed.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.maturitas.2020.11.008.

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