Factors related with quality on sleep of daytime workers
Bu-il Kim, Seong-yong Yoon*, Jin-seok Kim, Kuck-Hyeun Woo, Seong-yong Cho, Ho Lee and Jong-min An

Abstract

Background: This study was conducted to identify the sleep status of daytime workers who do not work in shifts. This study analyzed factors affecting sleep duration and sleep quality.

Methods: This study was conducted on 1171 daytime workers at a manufacturing workshop. We used a self-administered questionnaire to investigate demographic variables, work type, working period, musculoskeletal symptoms and the Pittsburgh Sleep Quality Index to assess sleep. Regular health checkup was conducted for the worker's clinical examination.

Results: The mean sleep duration was 6.36 h and the mean score on the Pittsburgh Sleep Quality Index was 4.46. Work type and obesity were related to sleep duration. Age, obesity and musculoskeletal pain were significantly related to sleep quality. The prevalence ratio of researcher group for short sleep duration was 1.27 (95% confidence interval: 1.02–1.58). The prevalence ratio of those aged 50 years and over was 0.47 (0.25–0.91) and of those in their 40s was 0.56 (0.35–0.91) for poor sleep quality compared to those in their 20s. The prevalence ratio of the obesity group for poor sleep quality was 1.53 (1.10–2.12). The prevalence ratio of musculoskeletal pain group for poor sleep quality was 1.92 (1.29–2.84).

Conclusions: Age, obesity and musculoskeletal pain were factors affecting the poor quality on sleep of daytime workers. In addition, work type related to short sleep duration.

Keywords: Sleep, Daytime workers, Sleep quality, Sleep duration

Background

Sleep is essential for physical and mental health. Deep sleep for a particular number of hours is important for maintaining a normal human life. Interest in sleep is growing in today's world, as are the percentages of workers with sleep disorders those undergoing treatment for sleep disorders [1]. In a telephone survey of 3400 people aged 15 years or older in Korea, 17% of the respondents had sleep disorder symptoms [2]. According to another telephone survey of 5000 Korean adults, 22.8% of the respondents had sleep disorders [3].

Symptoms of sleep disorders include poor concentration, fatigue, anxiety, and disorientation. In particular, sleep disorders cause daytime sleepiness, reduce work efficiency, and increase the risk of accidents [4]. Sleep disorders contribute to the deterioration of an individual's quality of life and decrease the efficiency of a social organization. As sleep disorders are becoming increasingly common, many studies have been conducted on this subject. Moreover, there have been many studies on sleep disorders in shift workers. In Korea, Kim [4], Kim [5], and Son [6] have all studied shift workers and noted that shift work is associated with sleep disorders [7]. In a study on insomnia among middle-aged individuals in the UK, 18.8% of the respondents had a sleep disorders and the risk of sleep disturbance was higher in the night shift group [8]. Night shift is known to be an important factor interfering with workers' sleep. Previous studies on the sleep of workers was mostly about the risks of night shift. There have been many researches about sleep disturbance in workers. However, there have not been many studies on the sleep quality of Korean daytime workers. It seems that a study focusing only on daytime workers that do not work at night and shift work is needed.

* Correspondence: justicebear@hanmail.net
Department of Occupational and Environmental Medicine, Soonchunhyang University Gumi Hospital, 179 1gongdan-ro, Gumi, Gyeongsangbuk-do, Republic of Korea

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This study was conducted to identify the sleep quality and duration of daytime workers and the factors that impact their quality of sleep.

**Methods**

**Subjects**

This study investigated all workers of an electronic parts manufacturing workshop in Gumi, Gyeongsangbuk-do, Korea. Except for those responsible for security work, most worked during the daytime. After excluding 18 shift workers among the 1356 workers, 1338 daytime workers were investigated. After further excluding the 167 workers whose questionnaire responses were not detailed enough or lacking, 1171 were chosen as the final subjects. This study, conducted in June 2016, was approved by the institutional review board of Soonchunhyang University Hospital in Seoul, and the approval number is Medicine 2018–02.

**Questionnaire**

This study used a self-administered questionnaire to investigate demographic variables, work type, working period, sleep duration and quality and musculoskeletal symptoms. Regular health checkup was conducted for the workers’ clinical examination and physical measurements.

**Variables**

For demographic characteristics, the factors considered were sex, age, alcohol drinking, smoking, and exercise. This study also conducted a health checkup for workers and performed a clinical examination of their height, weight, waist circumference, blood pressure, obesity status, blood sugar, and blood lipid levels. For metabolic syndrome, this study followed the criteria suggested in the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) [9]. To assess symptoms of musculoskeletal pain, this study used a questionnaire from the musculoskeletal risk factors survey guidelines in the Korea Occupational Safety and Health Agency’s KOSHA CODE H-9-2016 [10].

**Quality of sleep assessment**

The PSQI-K, a Korean version of the Pittsburgh Sleep Quality Index (PSQI) developed by the University of Pittsburgh, was used to measure the quality of sleep. In a study comparing the Korean version with the original PSQI to assess quality of sleep, the PSQI-K was determined to be reliable and valid [11]. The PSQI is a self-administered questionnaire that assesses the quality of sleep for a month. There are 19 questions belonging to 7 sub-categories. Each sub-category is rated on a scale of 0 to 3, and the total score for the sub-categories is 21 points. Higher scores indicate a lower quality of sleep. Sensitivity and specificity were found to be high when the total PSQI score exceeded the cut-off of 6 points. Hence, those with 6 or more points were categorized into the poor sleep group while those with 5 or fewer points were categorized into the good sleep group [12]. The 7 sub-categories of the PSQI are as follows: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, sleep medication use, and daytime dysfunction. Each category is rated from 0 to 3 points. To analyze the sub-categories that assess quality of sleep, this study categorized those who scored 0 or 1 point as those without sleep-related symptoms, and those with 2 or 3 points as those with sleep-related symptoms.

**Analyses**

**Classification of variables**

In this study, workers’ alcohol drinking per week was studied. They were divided into 3 groups: non-drinkers, 1 drink per week, and over 2 drinks per week. For smoking, this study categorized the subjects into non-smokers, ex-smokers, and current-smokers. Those who exercised at a moderate or intense level or walked 5 times per week were categorized as exercising workers and those who did not as non-exercising workers. For working period, the subjects were divided into 4 groups: 5 or fewer years, 6–10 years, 11–15 years, and 16 or more years. For work type, the subjects were divided into 3 groups: blue-collar worker, office worker, and researcher. Blue-collar is a worker working in electronics production and they work with manufacturing management, facility management and quality control. Office worker is in charge of planning, relations, finance, personnel, education and general works of company. A researcher is a worker who carries out product development, technology research and problem solving of product. In each type of work, the role and job description are different and the strength and stress of work are different.

The subjects who met Standard 2 (pain in one or more areas that has continued for more than a week or occurs at least once per month at a moderate or high level) classified by the US National Institute for Occupational Safety and Health were defined as those with musculoskeletal symptoms [13].

This study defined 6 or fewer hours of sleep as a short sleep duration. Studies on number of sleeping hours have defined the lack of sleep in various ways, including 7 h or fewer, 6 h or fewer, or 5 h or fewer; there is no consensus on the exact short sleep duration [14]. In general, however, many studies have categorized 6 h or fewer as lack of sleep, and that is the definition used in this study [15, 16].

**Statistical analyses**

This study performed a t-test and analysis of variance (ANOVA) to investigate the correlations the following
Results

With respect to sleep duration, the researchers had 6.17 h of sleep, which was significantly lower than that of blue-collar (6.42 h) and office worker (6.38 h). This study categorized sleep duration of 6 or fewer hours per day as short sleep duration. The number of researchers in the short sleep duration was 116 (57.4%), which was higher percentage than that of blue-collar was 262 (44.9%), office worker was 152 (52.2%). The number of those 50s or older in the short sleep duration was 87 (57.6%), of those in their 40s was 144 (53.9%), in their 30s was 232 (44.4%), and in their younger than 30 was 102 (49.3%). The number of metabolic syndrome in short sleep duration was 232 (44.4%), and in their younger than 30 was 102 (57.6%), of those in their 40s was 144 (53.9%), in their 30s was 232 (44.4%), and in their 50s or older was 12 (16.9%). As BMI increased, the percentage of poor sleep quality increased. Those BMI of 30 or higher in the poor sleep quality was 9 (40.9%), in their 25–30 was 64 (32.5%), in their 23–25 was 42 (25.1%), and in their fewer than 23 was 35 (20.1%) (Table 2).

The PR of researcher group for short sleep duration was 1.27 (95% CI: 1.02–1.58), which was higher than that of blue-collar and office worker.

Those with a PSQI score of 6 or more were categorized into the poor sleep quality group, and the variables that had significant PRs included age, BMI of 25 or higher and musculoskeletal pain. For age, compared to those younger than 30, the PR of those in the 50s or older for poor sleep quality was 0.47 (0.25–0.91), and of those in their 40s was 0.56 (0.35–0.91). Compared to those with BMI lower than 25, the PR of those with BMI of 25 or higher for poor sleep quality was 1.53 (1.10–2.12). The PR of musculoskeletal pain for poor sleep quality was 1.92 (1.29–2.84) (Table 3).

This study performed a Cox regression analysis with the 7 sub-categories of the PSQI as dependent variables. For age, subjective sleep quality and daytime dysfunction were related. Compared to those in their 20s, the PR of those in their 40s was 0.51 (0.33–0.81), and of those in the 50s or older was 0.34 (0.17–0.65) for subjective sleep quality. With respect to daytime dysfunction, compared to those in their 20s, the PR of those in their 30s was 0.59 (0.40–0.86), in their 40s was 0.28 (0.16–0.51), and in their 50s was 0.09 (0.03–0.30). Compared to men, the PR of women for subjective quality of sleep was 1.97 (1.37–2.85), for sleep latency was 1.57 (1.03–2.40), and for habitual sleep efficiency was 2.68 (1.13–6.33). The PR of musculoskeletal pain group was 2.16 (1.57–2.98) for subjective sleep quality, 1.54 (1.09–2.17) for sleep latency, 9.28 (2.92–29.5) for sleep disturbance, and 2.09 (1.41–3.10) for daytime dysfunction (Table 4).

Discussion

This study investigated the relationship among demographic characteristics, working period, work type, metabolic syndrome, musculoskeletal symptoms and sleep of daytime workers. The mean sleep duration was 6.36 h and mean PSQI score was 4.46. Work type was related to sleep duration. Age, BMI and musculoskeletal pain were significantly related to sleep quality.

In this study, daytime workers’ mean sleep duration was 6.36 h. This is lower than the mean sleep duration of 6.78 h of the 17,638 people who provided their data in the Korean National Health and Nutritional Examination Survey [20]. A study on 1238 daytime workers found a mean sleep duration of 6.58 h [21]. In a study of sleep duration and subclinical arterial disease, there was
| Variables                        | Sleep duration Mean ± SD | p-valuea | Sleep duration Fewer than 6 h n (%) | Over than 6 h n (%) | p-valueb |
|---------------------------------|--------------------------|----------|-------------------------------------|---------------------|----------|
| Age (in years)                  |                          |          |                                     |                     |          |
| < 30                            | 6.37 ± 1.03              | 0.384    | 102 (49.3)                          | 105 (50.7)          | 0.009    |
| 30–39                           | 6.41 ± 0.96              |          | 232 (44.4)                          | 291 (55.6)          |          |
| 40–49                           | 6.32 ± 0.97              |          | 144 (53.9)                          | 123 (46.1)          |          |
| ≥ 50                            | 6.27 ± 1.09              |          | 87 (57.6)                           | 64 (42.4)           |          |
| Sex                             |                          | 0.570    |                                     |                     | 0.871    |
| Male                            | 6.36 ± 0.95              |          | 516 (49.1)                          | 534 (50.9)          |          |
| Female                          | 6.42 ± 1.32              |          | 49 (50.0)                           | 49 (50.0)           |          |
| Working period (years)          |                          | 0.502    |                                     |                     | 0.776    |
| ≤ 5                            | 6.43 ± 0.92              |          | 110 (47.2)                          | 123 (52.8)          |          |
| 6–10                           | 6.44 ± 0.99              |          | 74 (42.3)                           | 101 (57.7)          |          |
| 11–15                          | 6.38 ± 0.97              |          | 76 (46.6)                           | 87 (53.4)           |          |
| ≥ 16                           | 6.57 ± 1.10              |          | 39 (44.8)                           | 48 (55.2)           |          |
| Work type                       |                          | 0.006    |                                     |                     | 0.004    |
| Blue-collar                     | 6.42 ± 0.94              |          | 262 (44.9)                          | 322 (55.1)          |          |
| Office worker                   | 6.38 ± 1.09              |          | 152 (52.2)                          | 139 (47.8)          |          |
| Researcher                      | 6.17 ± 0.94              |          | 116 (57.4)                          | 86 (42.6)           |          |
| Smoking                         |                          | 0.171    |                                     |                     | 0.580    |
| Non-smoker                      | 6.42 ± 1.02              |          | 230 (46.8)                          | 261 (53.2)          |          |
| Ex-smoker                       | 6.44 ± 1.05              |          | 116 (47.5)                          | 128 (52.5)          |          |
| Current-smoker                  | 6.31 ± 0.89              |          | 172 (50.4)                          | 169 (49.6)          |          |
| Alcohol drinking                |                          | 0.703    |                                     |                     | 0.481    |
| Non-drinker                     | 6.42 ± 1.04              |          | 57 (44.9)                           | 70 (55.1)           |          |
| 1/week                          | 6.40 ± 0.97              |          | 241 (47.3)                          | 269 (52.7)          |          |
| Over 2/week                     | 6.36 ± 0.99              |          | 220 (50.2)                          | 218 (49.8)          |          |
| Exercise                        |                          | 0.187    |                                     |                     | 0.238    |
| No                              | 6.41 ± 1.00              |          | 332 (46.9)                          | 376 (53.1)          |          |
| Yes                             | 6.33 ± 0.95              |          | 186 (50.7)                          | 181 (49.3)          |          |
| BMI (kg/m²)c                    |                          | 0.308    |                                     |                     | 0.186    |
| < 23                            | 6.43 ± 0.97              |          | 179 (44.9)                          | 220 (55.1)          |          |
| 23–25                           | 6.37 ± 0.99              |          | 152 (49.7)                          | 154 (50.3)          |          |
| 25–30                           | 6.30 ± 1.00              |          | 204 (52.4)                          | 185 (47.6)          |          |
| ≥ 30                            | 6.30 ± 1.14              |          | 25 (52.1)                           | 23 (47.9)           |          |
| Metabolic syndrome              |                          | 0.115    |                                     |                     | 0.021    |
| No                              | 6.38 ± 0.96              |          | 477 (47.7)                          | 522 (52.3)          |          |
| Yes                             | 6.24 ± 1.20              |          | 83 (58.0)                           | 60 (42.0)           |          |
| Musculoskeletal Pain            |                          | 0.058    |                                     |                     | 0.126    |
| No                              | 6.39 ± 0.96              |          | 430 (48.2)                          | 463 (51.8)          |          |
| Yes                             | 6.24 ± 1.11              |          | 100 (54.3)                          | 84 (45.7)           |          |

aCalculated using t-test and ANOVA
bCalculated using chi-square test
BMI Body Mass Index
### Table 2 General and occupational characteristics of study subjects by sleep quality

| Variables                        | PSQI score<sup>a</sup> Mean ± SD | p-value<sup>b</sup> | Sleep quality                        | Good n (%) | Poor n (%) | p-value<sup>c</sup> |
|----------------------------------|----------------------------------|---------------------|--------------------------------------|-------------|-------------|---------------------|
| Age (in years)                   |                                  |                     |                                      |             |             |                     |
| < 30                             | 4.81 ± 2.53                      | 0.059               |                                      | 66 (62.9)   | 39 (37.1)   | 0.005               |
| 30–39                            | 4.60 ± 2.25                      |                     |                                      | 173 (71.2)  | 70 (28.8)   |                     |
| 40–49                            | 4.24 ± 1.95                      |                     |                                      | 114 (79.7)  | 29 (20.3)   |                     |
| ≥50                              | 4.04 ± 2.11                      |                     |                                      | 59 (83.1)   | 12 (16.9)   |                     |
| Sex                              |                                  | 0.003               |                                      |             |             | 0.082               |
| Male                             | 4.40 ± 2.18                      |                     |                                      | 386 (74.2)  | 134 (25.8)  |                     |
| Female                           | 5.48 ± 2.57                      |                     |                                      | 26 (62.9)   | 16 (38.1)   |                     |
| Working period (years)           |                                  | 0.219               |                                      |             |             | 0.610               |
| ≦5                               | 4.33 ± 2.02                      |                     |                                      | 79 (71.8)   | 31 (28.2)   |                     |
| 6–10                             | 4.67 ± 2.48                      |                     |                                      | 54 (68.4)   | 25 (31.6)   |                     |
| 11–15                            | 5.05 ± 2.59                      |                     |                                      | 48 (64.0)   | 27 (36.0)   |                     |
| ≥16                              | 4.56 ± 2.15                      |                     |                                      | 29 (74.4)   | 10 (25.6)   |                     |
| Work type                        |                                  | 0.463               |                                      |             |             | 0.290               |
| Blue-collar                      | 4.52 ± 2.34                      |                     |                                      | 203 (71.0)  | 83 (29.0)   |                     |
| Office worker                    | 4.31 ± 2.05                      |                     |                                      | 113 (77.9)  | 32 (22.1)   |                     |
| Researcher                       | 4.65 ± 2.06                      |                     |                                      | 71 (74.7)   | 24 (25.3)   |                     |
| Smoking                          |                                  | 0.428               |                                      |             |             | 0.881               |
| Non-smoker                       | 4.56 ± 2.36                      |                     |                                      | 174 (73.1)  | 64 (26.9)   |                     |
| Ex-smoker                        | 4.26 ± 2.00                      |                     |                                      | 97 (74.6)   | 33 (25.4)   |                     |
| Current-smoker                   | 4.55 ± 2.25                      |                     |                                      | 113 (72.0)  | 44 (28.0)   |                     |
| Alcohol drinking                 |                                  | 0.145               |                                      |             |             | 0.593               |
| Non-drinker                      | 4.37 ± 2.21                      |                     |                                      | 47 (75.8)   | 15 (24.2)   |                     |
| 1/week                           | 4.42 ± 2.14                      |                     |                                      | 194 (74.3)  | 67 (25.7)   |                     |
| Over 2/week                      | 4.94 ± 2.25                      |                     |                                      | 142 (70.6)  | 59 (29.4)   |                     |
| Exercise                         |                                  | 0.437               |                                      |             |             | 0.266               |
| No                               | 4.54 ± 2.23                      |                     |                                      | 251 (74.7)  | 85 (25.3)   |                     |
| Yes                              | 4.38 ± 2.27                      |                     |                                      | 132 (70.2)  | 56 (29.8)   |                     |
| BMI (kg/m²)<sup>d</sup>         |                                  | 0.081               |                                      |             |             | 0.021               |
| ≦23                              | 4.25 ± 2.06                      |                     |                                      | 139 (79.9)  | 35 (20.1)   |                     |
| 23–25                            | 4.35 ± 2.07                      |                     |                                      | 125 (74.9)  | 42 (25.1)   |                     |
| 25–30                            | 4.73 ± 2.37                      |                     |                                      | 133 (67.5)  | 64 (32.5)   |                     |
| ≥30                              | 5.14 ± 3.01                      |                     |                                      | 13 (59.1)   | 9 (40.9)    |                     |
| Metabolic syndrome               |                                  | 0.135               |                                      |             |             | 0.415               |
| No                               | 4.43 ± 2.16                      |                     |                                      | 358 (73.8)  | 127 (26.2)  |                     |
| Yes                              | 4.84 ± 2.59                      |                     |                                      | 52 (69.3)   | 23 (30.7)   |                     |
| Musculoskeletal pain             |                                  | 0.000               |                                      |             |             | 0.000               |
| No                               | 4.32 ± 2.15                      |                     |                                      | 347 (76.8)  | 105 (23.2)  |                     |
| Yes                              | 5.50 ± 2.31                      |                     |                                      | 40 (54.1)   | 34 (45.9)   |                     |

<sup>a</sup>PSQI Pittsburgh Sleep Quality Index  
<sup>b</sup>Calculated using t-test and ANOVA  
<sup>c</sup>Calculated using chi-square test  
<sup>d</sup>BMI Body Mass Index
that of those in their 50s or older was 6.27 h. In this sleep duration of those in their 20s was 6.37 h, while
crease as age increases. Additionally, in this study, the
ation with age. Sleep duration has been known to de-

4.37 and women scored 5.74 [26].

average PSQI scores in a study with 2144 adults were
and women scored 4.77 on the PSQI. The scores in this
workers in a manufacturing workshop, men scored 4.15
scored 4.4 and women scored 5.48. In a study with 1008
 ease, diabetes mellitus [23], and hypertension [24]. The
sleep hours could be a risk factor for coronary heart dis-

day [22]. The mean sleep duration for subjects in this
study was shorter than that sleep duration. This lack of

a low risk of cardiovascular disease at 7 h of sleep per
day [22]. The mean sleep duration for subjects in this
study was shorter than that sleep duration. This lack of
sleep hours could be a risk factor for coronary heart dis-
dease, diabetes mellitus [23], and hypertension [24]. The
average PSQI score in this study was 4.46 points: men
scored 4.15 and women scored 4.4. In a study with 1008
workers in a manufacturing workshop, men scored 4.15
and women scored 4.77 on the PSQI. The scores in this
study were higher than those in that study [25]. The
average PSQI scores in a study with 2144 adults were
also similar to those in this study, where men scored
4.37 and women scored 5.74 [26].

Sleep duration had no statistically significant associ-
ation with age. Sleep duration has been known to de-
crease as age increases. Additionally, in this study, the
sleep duration of those in their 20s was 6.37 h, while
that of those in their 50s or older was 6.27 h. In this
univariate analysis, as age increased, the group of short
sleep duration was significantly increased. But, age was
not significantly related to sleep duration in multivariate
analysis. A population-based study of 1042 adults in Brazil
reported that as age increased, there was a decrease in
sleep efficiency, the percentage of rapid eye movement
sleep, and slow wave sleep [27]. A meta-analysis of sleep
studies showed that sleep duration and efficiency reduced
as age increased [28]. Since this study was conducted on
relatively younger workers, the age gap was not as large as
in other studies, which might be why there was no signifi-
cant decrease in sleep duration with an increase in age.

Sleep quality significantly increased as age increased.
Compared to those in their 20s, the PR of those in their
50s or older for poor sleep quality was 0.47. In addition,
compared to the 7 PSQI sub-categories, subjective sleep
quality improved and daytime dysfunction decreased as
age increased. Buysse and the other PSQI developers
found that age was associated with subjective sleep qual-
ity and daytime dysfunction [12], which is consistent
with the results of this study. Therefore, as age in-
creased, the quality of sleep became better. This means
that younger workers were more dissatisfied with their
sleep and perceived that sleep limited their activities
during the daytime. A sleep study of 5090 white-collar
workers in Japan found that the percentage of those with
sleep disorders decreased as age increased, which was
consistent with this study’s results [29]. Meanwhile, a co-
hort study of 2406 adults in the UK found that the older
group was more likely to have poor sleep quality, which
contradicts this study’s findings. The cohort study
assessed depression after retirement, reduced energy,
and poor mental health as major causes of sleep disor-
ders [30]. This study was conducted only with workers
who are still working. Thus, their age was relatively low
compared to those in the cohort study, and there were
no retired individuals. These differences may account for
the fact that this study had different results than the co-
hort study [31].

Researchers had shorter sleep duration than blue-collar
and office worker. Depending on the type of work, there
are differences in working conditions and types of job
stress. Blue-collar workers reported being stressed owing
to the physical environment, interpersonal conflicts, and job
insecurity, whereas researchers had a high level of stress
owing to continuous technology development and research
activities, problem-solving, job demands, organizational in-
justice, and occupational climate [32]. Researchers’ sleep
duration may be relatively shorter as a result of these differ-
ences in job stress factors.

Obesity is an additional factor that influences daytime
workers’ sleep. Group with BMI of 25 or higher had no
statistically significant association with short sleep dur-

age (in years)

BMI (kg/m²)b

Metabolic syndrome

Musculoskeletal pain

Table 3 Prevalence ratio (PR) of factors related to short sleep
duration and sleep quality

| Variables                 | Short Sleep duration (fewer than 6 h) | Sleep quality (poor) |
|---------------------------|---------------------------------------|----------------------|
|                           | PRa 95% CI                             | PR 95% CI            |
| Age (in years)            |                                       |                      |
| < 30                      | 1.00 1.00                              | 1.00 1.00            |
| 30–39                     | 0.90 0.72–1.14                        | 0.79 0.53–1.17       |
| 40–49                     | 1.10 0.85–1.43                        | 0.56 0.35–0.91       |
| ≥50                       | 1.18 0.88–1.58                        | 0.47 0.25–0.91       |
| Sex                       |                                       |                      |
| Male                      | 1.00 1.00                              | 1.00 1.00            |
| Female                    | 1.07 0.80–1.45                        | 1.30 0.77–2.20       |
| Work type                 |                                       |                      |
| Blue-collar               | 1.00 1.00                              | 1.00 1.00            |
| Office worker             | 1.12 0.91–1.38                        | 0.86 0.57–1.32       |
| Researcher                | 1.27 1.02–1.58                        | 0.90 0.57–1.43       |
| Exercise                  |                                       |                      |
| No                        | 1.00 1.00                              | 1.00 1.00            |
| Yes                       | 1.07 0.89–1.29                        | 1.21 0.86–1.71       |
| BMI (kg/m²)b              |                                       |                      |
| < 25                      | 1.00 1.00                              | 1.00 1.00            |
| ≥25                       | 1.14 0.96–1.36                        | 1.53 1.10–2.12       |
| Metabolic syndrome        |                                       |                      |
| No                        | 1.00 1.00                              | 1.00 1.00            |
| Yes                       | 1.18 0.93–1.50                        | 1.36 0.87–2.15       |
| Musculoskeletal pain      |                                       |                      |
| No                        | 1.00 1.00                              | 1.00 1.00            |
| Yes                       | 1.16 0.93–1.45                        | 1.92 1.29–2.84       |

*PR Prevalence Ratio by using Cox regression analysis

BMI: Body Mass Index
times greater risk for poor sleep quality than those with a BMI lower than 25. Meta-analysis of 45 cross-sectional or prospective studies of adults or children found a pooled obesity-short sleep OR of 1.6 for adults [33]. A study of 2006 young adults found that the risk of short sleep duration increased in the overweight and obese male group [34]. A study on sleep and obesity found that obesity had a significant correlation with sleep quality, more specifically with subjective sleep quality, duration, disturbance, and daytime dysfunction [35]. In this study, obesity had a significant association with poor sleep quality but, no significant association with PSQI sub categories. It is well known that obesity is associated with risk factors such as cardiovascular disease, cerebrovascular disease, hypertension, and diabetes mellitus. This study was able to identify that obesity was related to sleep quality.

This study found that workers with musculoskeletal pain had shorter sleeping hours and were more likely to have poor sleep quality. In this study, those with musculoskeletal pain were 1.92 times more likely than others to have poor sleep quality. A previous study on musculoskeletal pain and sleep found that the former was significantly related to short sleep duration and decreased sleep efficiency [36]. A quality of sleep study of 1650 patients with acute back pain revealed that the quality of sleep dropped by one step when the pain level doubled [37]. A study of 657 firefighters found that those with musculoskeletal pain were 2.89 times more likely than those without such pain to have poor sleep quality, which was consistent with this study’s results [38]. Among other sub-categories of the PSQI, musculoskeletal pain had a significant association with subjective sleep quality, sleep latency, sleep disturbance, and daytime dysfunction. A study of 40 people with shoulder impingement syndrome found that shoulder pain had a significant association with subjective sleep quality, latency, duration, efficiency, and disturbance [39]. A study of 1147 adolescents with musculoskeletal pain and sleep, poor subjective sleep perception was found to be associated with chronic musculoskeletal regional pain [40]. Musculoskeletal pain can affect a poor subjective sleep quality and causes sleep disturbance due to persistent pain. Poor sleep quality can make musculoskeletal pain worse, which can cause a vicious cycle of pain and sleep disturbances.

Many previous studies on workers’ sleep disorders have focused on day-night shift workers and compared the sleep status of shift and non-shift workers. This study investigated only daytime workers. This has important implications in that there are few studies on sleep quality and quantitative analysis PSQI of Korean daytime workers.

This study has the following limitations. First, being a cross-sectional study, it was not possible to determine causal relationships between the factors related to sleep duration and sleep quality. In the future, a follow-up study should be conducted to investigate the factors that affect daytime workers’ sleep. Second, the sleep quality of the workers could be affected by many physical and

### Table 4

| Variables                  | Subjective sleep quality | Sleep latency | Sleep duration | Habitual sleep efficiency | Sleep disturbances | Sleep medication | Daytime dysfunction |
|----------------------------|--------------------------|---------------|----------------|---------------------------|--------------------|-----------------|---------------------|
| **Age (in years)**         |                          |               |                |                           |                    |                 |                     |
| < 30                       | 1.00                     | 1.00          | 1.00           | 1.00                      | 1.00               | 1.00            | 1.00                |
| 30–39                      | 0.87 (0.62–1.22)         | 0.94 (0.65–1.35) | 0.90 (0.72–1.14) | 0.83 (0.35–1.93) | 0.00 (0.00–0.00) | 0.20 (0.02–2.24) | 0.59 (0.40–0.86) |
| 40–49                      | 0.51 (0.33–0.81)         | 0.75 (0.48–1.18) | 1.10 (0.85–1.43) | 0.69 (0.24–2.02) | 0.00 (0.00–0.00) | 1.71 (0.30–9.77) | 0.28 (0.16–0.51) |
| ≥50                        | 0.34 (0.17–0.65)         | 0.92 (0.55–1.53) | 1.18 (0.88–1.58) | 0.21 (0.03–1.71) | 0.00 (0.00–0.00) | 0.75 (0.06–8.71) | 0.09 (0.03–0.30) |
| **Sex**                    |                          |               |                |                           |                    |                 |                     |
| Male                       | 1.00                     | 1.00          | 1.00           | 1.00                      | 1.00               | 1.00            | 1.00                |
| Female                     | 1.97 (1.37–2.85)         | 1.57 (1.03–2.40) | 1.07 (0.80–1.45) | 2.68 (1.13–6.33) | 0.00 (0.00–0.00) | 1.96 (0.22–17.3) | 1.41 (0.87–2.28) |
| **BMI (kg/m²)**            |                          |               |                |                           |                    |                 |                     |
| < 25                       | 1.00                     | 1.00          | 1.00           | 1.00                      | 1.00               | 1.00            | 1.00                |
| ≥25                        | 1.09 (0.82–1.47)         | 1.07 (0.80–1.43) | 1.14 (0.96–1.36) | 1.48 (0.72–3.06) | 1.52 (0.49–4.74) | 1.16 (0.27–4.94) | 0.88 (0.61–1.27) |
| **Musculoskeletal pain**   |                          |               |                |                           |                    |                 |                     |
| No                         | 1.00                     | 1.00          | 1.00           | 1.00                      | 1.00               | 1.00            | 1.00                |
| Yes                        | 2.16 (1.57–2.98)         | 1.54 (1.09–2.17) | 1.15 (0.93–1.45) | 0.79 (0.29–2.13) | 9.28 (2.92–29.5) | 4.51 (0.95–21.3) | 2.09 (1.41–3.10) |

*PSQI* Pittsburgh Sleep Quality Index

**PR** Prevalence Ratio by using Cox regression analysis

**BMI** Body Mass Index
mental health conditions, as well as socio-demographic, occupational characteristics and environmental factors. We analyzed the relationships of worker’s medical conditions, such as hypertension, diabetes mellitus, hyperlipidemia and hepatic enzyme abnormalities, with sleep quality. However, none of these were found to be significantly related to sleep quality. Work-related variables in this study included only work type and working period. However, other factors such as job stress, residence environmental, marital status and other medical condition could be important factors affecting sleep quality. This was also a major limitation of this study. Therefore, additional study on job stress, environmental factor and other medical condition is needed. Third, this study was conducted with relatively young workers in only one electronics workshop. Thus, the results were limited in terms of generalizability to the entire population. Fourth, there was a possibility that responses to the questionnaire could have been overestimated or underestimated owing to limitations associated with the subjective nature of the self-administered questionnaire. More specifically, the possibility of overestimated responses to sleep disturbance and musculoskeletal pain cannot be entirely excluded.

Conclusions
The factor that had an effect on daytime workers’ sleep duration were the type of work. The factors that affected their sleep quality were age, obesity and musculoskeletal pain. Sleep problems due to age and type of work are difficult to solve because they cannot be controlled. However, controlling body weight for daytime workers can improve sleep quality. Body weight loss is not only effective in preventing various diseases caused by obesity, but also is a way to solve sleep problems in obese workers. It is necessary to plan a program that can manage obesity in the workplace and to have a practical effect on the workers. It should also be able to control musculoskeletal pain of daytime workers. It is needed to conduct periodic investigations of musculoskeletal hazards for heavy-weight handled and repetitive workers. In addition, there is a need for program to treat musculoskeletal pain in the workplace.

Abbreviations
BMI: Body mass index; PR: Prevalence ratio; PSQI: Pittsburgh Sleep Quality Index

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Availability of data and materials
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Authors’ contributions
BIK was responsible for the study design, data analysis, interpretation of the data, and drafting of this manuscript. SYY played a role in the data collection, data analysis, interpretation of the data and revision of the manuscript. JSK performed the data collection, study design and revision of the manuscript. KHW helped to analyze data and revise manuscript. SYC helped to collect and interpret the data. HL and JMA performed data interpretation and revised the manuscript. All the authors have read and approved the final manuscript.

Ethics approval and consent to participate
Written consent form was obtained from participants. Ethical approval is obtained by Institutional Review Board (IRB) of Soonchunhyang University Hospital in Seoul. IRB number is Medicine 2018-02.

Consent for publication
Not applicable

Competing interests
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