Sleep-related Risk of Occupational Injuries in Japanese Small and Medium-scale Enterprises

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Abstract: A cross-sectional study evaluated the contribution of daily sleep habits to occupational injuries. A self-administered questionnaire solicited answers about sleep, symptoms of depression, occupational injury, demographics, presence of diseases and lifestyle factors from 2,903 workers between the ages of 16–83 (mean 45) yr in small and medium-scale enterprises. Eight sleep habits were queried and dichotomized: 1) less or more than 6 hr of daily sleep, 2) taking more or less than 30 min to fall asleep (Difficulty initiating sleep; DIS), 3) awakening during sleep more or less than 3 times/wk (Difficulty maintaining sleep; DMS), 4) early morning awakening more or less than 3 times/wk (EMA), 5) definitely/somewhat difficulty waking up or not, 6) sleeping very poorly/not so well at night or not, 7) definitely/somewhat insufficient nightly sleep or not, and 8) difficulty in breathing during sleep more than once/week or less. Occupational injury was assessed by asking subjects ‘Have you ever been injured during your work, including minor scratches and cuts (Yes/No)?’ Both sleep and injury were assessed over the previous one year period. One-third of workers answered that they had experienced injury. Workers with sleep features of DIS, sleeping poorly at night, insufficient sleep, and insomnia had a significantly higher prevalence for injury after adjusting for multiple confounders. The findings suggest that poor nocturnal sleep habits are associated with self-reported occupational injury.

Key words: Sleep, Occupational injury, Safety, Small and medium-scale enterprise, Epidemiology

Introduction

Injuries and accidents related to work are a major occupational health problem in most industrialized countries. In Japan, numbers of non-fatal occupational injuries with sick leave for 4 d or more were 124,702 in a total of 63.3 million working people in 2002, recorded through the national survey by the Ministry of Health, Labor and Welfare1,2). Consequences of occupational injuries include increased absenteeism and use of medical care services, reduced productivity, lost working time, and disabilities. A number of occupational as well as social factors have been reported to be associated with the risk of being injured. These include poor work condition3), young age4–7), lack of experience or
training\textsuperscript{8}, shift
/night work\textsuperscript{9–11}, job stress\textsuperscript{12, 13}, long working hours\textsuperscript{14, 15}, fatigue\textsuperscript{16}, sleep problems\textsuperscript{17–22}, and unhealthy lifestyle (eg., smoking and alcohol consumption)\textsuperscript{23–25}. Leger\textsuperscript{26} suggested that as many as 52.5\% of all work-related accidents and injuries are potentially related to sleepiness in the US working population, indicating a strong contribution of sleep factors to the occurrence of accidents and injuries.

Sleepiness and reduced vigilance could be some of the most important risk factors for traffic and industrial accidents\textsuperscript{27}. Sleep loss, insufficient sleep during the night or having poor sleep habits undoubtedly induce sleepiness which could affect daytime functioning and performance and possibly impair safety at work. As sleep problems such as insomnia are highly prevalent (20–30\%) in most industrialized countries\textsuperscript{22, 28–31}, it is important to systematically investigate whether there is an association of sleep factors and occupational injuries. Balter and Ulenhuth\textsuperscript{17} compared accident rates between chronic insomniacs and controls and found 4.5 times higher rates in insomniacs. Leger et al.\textsuperscript{18} also found 7 times more work-related accidents in severe insomniacs than in good sleepers.

Recently, Chau et al.\textsuperscript{19} conducted a case-control study in the construction industry, and reported that workers under the age of 30 yr, current smokers, and those suffering from sleep disorders were significantly more likely to sustain occupational injuries. A connection between difficulties in sleeping and fatal accidents has been found in a large prospective study in Sweden\textsuperscript{20}. A recent study by Doi et al.\textsuperscript{21} observed a 30\% increase in accident rate in white-collar workers with poor sleep quality. These findings consistently suggest that poor sleep is closely related to the occurrence of accidents and injuries.

Little information, however, is available about the way different sleep habits relate to accidents and injuries. Lavie et al.\textsuperscript{22} reported that workers complaining of excessive daytime sleepiness had the highest numbers of accidents (49.3\%) followed by frequent mid-sleep awakenings (42.9\%) and difficulty falling asleep (34.8\%). Also, Chau et al.\textsuperscript{19} reported that worker ‘sleeping poorly’ is more associated with occupational injury than merely ‘sleeping less than 6 h per day’. To provide further information on how sleep affects injuries and to plot strategies for preventing sleep-related injuries, it seems important to know the association of daily sleep habits with the incidence of accidents/injuries in detail.

In the present study, we conducted a cross-sectional survey in small and medium-scale enterprises, mainly consisting of manufacturing plants (92\%). We focused on this population because manufacturing in Japan had the highest number of occupational injuries among all industry sectors in 2002\textsuperscript{1, 2}. It also has been reported that small and medium scale enterprises were more likely to engage in dangerous and hazardous work, and suffer from occupational accidents and occupational health problems than large-scale enterprises\textsuperscript{22–35}. Daily sleeping hours, length of time to fall asleep, frequency of awakening during sleep, early morning awakening, difficulty waking up in the morning, sleeping well at night, sufficiency of sleep, and difficulty in breathing during sleep were investigated in this study. Sociodemographics, lifestyle, psychosocial and physical/psychological conditions were included as confounding factors. The hypothesis was that poor sleep habits are important risk factors for occupational injuries. We analyzed males and females individually in addition to both combined, since males are reported to have a higher incidence of injury compared to females\textsuperscript{36}.

**Subjects**

The data were collected in a cross-sectional study with a self-rating questionnaire from August to December 2002. The study subjects were small or medium-scale enterprises (1 to 158 workers) in two cities in Japan.

For A city, subjects were selected randomly based on the 2000 edition of the city commercial directory for a sampling of 6.4 to 18.9\% of workers corresponding to the distribution of types of businesses in the city. A city has the highest percentage of manufacturing plants and highest percentage of people working in manufacturing in Saitama prefecture. Employees and employers of 350 factories, a total of 3,514 people, were recruited as subjects. Questionnaires were distributed to 2,591 workers of 248 factories. The questionnaire could not be distributed (non-distributed number) to 923 workers for several reasons: the person responsible for the worksite did not have time to recruit workers, the workers declined participation, the factory was too far to visit, or the worker had retired. Finally, responses were obtained from 2,302 (response rate 88.8\%).

For B city, questionnaire was distributed to all employees and employers of small and medium-scale enterprises. This area is so-called an “industrial area”, which is known as one of the unique area with small and medium-scale enterprises. There were 52 enterprises with a total of 1,102 workers, including 30 manufacturing, 5 shipping, and 17 other businesses, which mostly employed fewer than 50 workers per factory. A total of 602 workers responded to the questionnaire (response rate 54.6\%).

A total of 2,903 workers from both districts responded
for an overall response rate of 78.6%. The workers completed a questionnaire asking about demographics, current job and business type (Table 1), occupational injury, sleep, symptoms of depression, lifestyle factors, and presence of diseases (Table 2). One hundred and twenty-seven workers were either shift or night workers. Questionnaires from 20 workers with a missing response to questions about demography and current job type were eliminated from the analyses. There were also some missing values for other individual items; for example, about 13.8% of the values for Center for Epidemiologic Studies Depression (CES-D) scale were missing. None of the other variables had a non-response rate of more than 5.4%. All participants signed an informed consent. The study protocol was approved by the Ethical Committee of the University of Tokyo, School of Medicine, Tokyo, Japan.

Measurement Methods

Sleep questionnaire

Eight questions about sleep habits during the previous year were selected from our self-administered sleep questionnaire developed in our previous study (Table 3). The subjects were queried on: daily hours of sleep; difficulty initiating sleep (DIS, defined by taking more than 30 min to fall asleep); difficulty maintaining sleep (DMS) and early morning awakening (EMA, both defined by an answer of “more than three times a week”); difficulty waking up in the morning (defined by “considerably difficult” or “somewhat difficult”); insufficient sleep (defined by an answer of “somewhat insufficient” or “definitely insufficient”); sleeping poorly at night (defined by an answer of “not so well” or “very poorly”); and difficulty breathing during sleep (defined by an answer of “more than once a week”). These questions were adapted and modified from those used in previous epidemiological studies of sleep.87–409

Occupational injury

A question to assess occupational injury was “Have you ever been injured during your work, including minor scratches and cuts in the previous year?” The possible response was either yes or no.

Depressive symptoms

Depressive symptoms were evaluated using the Center for Epidemiologic Studies Depression (CES-D) scale. The Japanese version of this scale was taken from the National Institute for Occupational Safety and Health (NIOSH) Generic Job Stress Questionnaire (GJSQ)40–42. The 20-item depressive symptom scale measures the level of depressive symptoms experienced in the past week. The CES-D scale cut-off score of 16 differentiates the depressed from the non-depressed patient with both high sensitivity and specificity.43 Cronbach’s alpha was 0.83 for this scale.

Other covariates

Other covariates included age, gender, marital status, years of education, smoking, alcohol consumption, caffeine intake (cups of coffee or tea/day), and presence of self-reported physical and/or psychological diseases (Table 2). Subjects were asked about the number of drinks that they consumed a week, where one drink consisted of about 9 g of pure ethanol (grams of ethanol/week). One item asked the number of cigarettes usually smoked a day. The subjects were also asked about history of physical and/or psychological diseases. These included hypertension, hyperlipemia, diabetes mellitus, depression, menopausal syndrome, and other diseases including heart disease, cancer, liver disease, renal disease, peptic ulcer, gastrointestinal diseases, neurological diseases, musculoskeletal disorders, and psychiatric illnesses.
Table 2. Occupational injuries, self-reported sleep habits, depressive symptoms, and other covariates of workers in small and middle-scale enterprises (n=2,486–2,840)

<table>
<thead>
<tr>
<th>Variable</th>
<th>N (%)</th>
<th>Mean (SD, range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>950 (33.7)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1,869 (66.3)</td>
<td></td>
</tr>
<tr>
<td>Subjective sleep habits during the last 1-yr period:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily sleep duration: Fewer than 6 h</td>
<td>1,115 (39.3)</td>
<td></td>
</tr>
<tr>
<td>6–8 h</td>
<td>1,584 (56.0)</td>
<td></td>
</tr>
<tr>
<td>More than 8 h</td>
<td>131 (4.7)</td>
<td></td>
</tr>
<tr>
<td>Taking more than 30 min to fall asleep (DIS)</td>
<td>479 (16.9)</td>
<td></td>
</tr>
<tr>
<td>Awakening during sleep more than 3 times/week (DMS)</td>
<td>231 (8.2)</td>
<td></td>
</tr>
<tr>
<td>Early morning awakening more than 3 times/week (EMA)</td>
<td>186 (6.6)</td>
<td></td>
</tr>
<tr>
<td>Difficulty waking up in the morning (Considerably/somewhat)</td>
<td>685 (24.2)</td>
<td></td>
</tr>
<tr>
<td>Sleeping poorly at night (very poorly/not so well)</td>
<td>465 (16.4)</td>
<td></td>
</tr>
<tr>
<td>Insufficiency of sleep (definitely/somewhat)</td>
<td>1,326 (47.0)</td>
<td></td>
</tr>
<tr>
<td>Difficulty breathing during sleep (more than once a week)</td>
<td>79 (2.8)</td>
<td></td>
</tr>
<tr>
<td>Insomnia symptomsa</td>
<td>663 (23.7)</td>
<td></td>
</tr>
<tr>
<td>Depressive symptoms (CES-D score)</td>
<td>15.4 (8.2, 0–52)</td>
<td></td>
</tr>
<tr>
<td>CES-D 16 &gt;=</td>
<td>960 (38.6)</td>
<td></td>
</tr>
<tr>
<td>Other covariates:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking (number of cigarettes smoked/day)</td>
<td>11.3 (13.7, 0–100)</td>
<td></td>
</tr>
<tr>
<td>Alcohol consumption (ethanol (g)/week)</td>
<td>73.6 (96.6, 0–972)</td>
<td></td>
</tr>
<tr>
<td>Caffeine intake (cups of coffee or tea/day)</td>
<td>3.2 (1.1, 0–6)</td>
<td></td>
</tr>
<tr>
<td>Presence of physical/psychological diseases (Yes)</td>
<td>777 (27.4)</td>
<td></td>
</tr>
</tbody>
</table>

SD, standard deviation; DIS, difficulty initiating sleep; DMS, difficulty maintaining sleep; EMA, early morning awakening; CES-D, Center for Epidemiologic Studies Depression scale. *Defined by at least one positive response to questions regarding DIS, DMS or EMA.

Table 3. Questions regarding sleep habits as stated on questionnaire

1. On the average, how much sleep per day did you usually take during the last year?
   1) less than 5 h  2) 5 to 6 h  3) 6 to 7 h  4) 7 to 8 h  5) 8 to 9 h  6) 9+ h

2. How long does it usually take you to fall asleep in bed?
   1) 0–10 min  2) 11–30 min  3) 31–59 min  4) 1–2 hours  5) 2+ h

3. How often do you have difficulty staying asleep?
   1) never (or almost never)  2) few times a year  3) more than once a month
   4) more than once a week  5) more than three times a week  6) almost every day

4. How often do you wake up too early and can’t fall asleep again?
   1) never (or almost never)  2) few times a year  3) more than once a month
   4) more than once a week  5) more than three times a week  6) almost every day

5. Do you feel difficulty waking up in the morning?
   1) considerably  2) somewhat  3) a little  4) not very  5) rarely  6) not at all

6. Do you think your daily sleep is sufficient?
   1) definitely insufficient  2) somewhat insufficient  3) fairly sufficient  4) very much sufficient

7. Do you usually sleep well at night?
   1) very poorly  2) not so well  3) fairly well  4) very well

8. Have you ever felt difficulty breathing during sleep or has anyone in your family told you that you have this?
   1) never (or almost never)  2) few times a year  3) more than once a month
   4) more than once a week  5) more than three times a week  6) almost every day
SLEEP HABITS AND OCCUPATIONAL INJURY

Statistical Methods

Associations of sleep habits and occupational injury were identified with a series of individual univariable and multivariable logistic regression analyses. The models were adjusted for age (continuous variable), gender, marital status, years of education, presence of diseases, smoking, alcohol drinking, caffeine intake, depressive symptoms, and job type in multiple logistic regression analyses. *Defined by at least one positive response to questions regarding DIS, DMS or EMA.

Results

Characteristic of workers

The age of participants ranged from 16 to 83 (mean 45) yr. Forty-five percent of workers were higher than 50 yr in age. Seventy-one percent of workers were males. As job types, manufacturing and managerial/clerical possessed more than 70% of all workers. Ninety-two percent of workers were working in manufacturing plants.

Prevalence of occupational injuries, poor sleep habits and depressive symptoms

The frequency of occupational injuries, subjective sleep habits, and depressive symptoms is shown in the Table 2. A total of 950 workers (33.7%) responded that they had experienced an occupational injury in the last 1-yr period (39.3% and 20.2% for males and females, respectively). Thirty-nine percent of workers slept fewer than 6 h, and the prevalence of DIS was 16.9%, DMS was 8.2%, and EMA was 6.6%. Twenty-four percent of this population showed insomnia symptoms. Nearly a quarter of the workers reported difficulty waking up in the morning, 16.4% reported sleeping very poorly and/or not so well at night, while 47.0% of the subjects reported sleep that was definitely and/or somewhat insufficient. The percentage of workers having difficulty breathing during sleep more than once a week was 2.8%. The average score for the CES-D scale was 15.4 and the prevalence of depressive symptoms (CES-D 16 >=) was 38.6% in this population.

Association of sleep habits with occupational injury

The unadjusted logistic regression analyses indicate that workers with sleep features of DIS, difficulty waking up in the morning, sleeping very poorly at night, insufficient sleep, and insomnia had a significantly higher prevalence for occupational injury (Table 4). In the multivariable logistic regression analyses, DIS (odds ratio (OR) 1.5, 95% confidence interval (CI) 1.2–1.8), sleep poorly at night (OR 1.5, 95%CI 1.1–2.0), sleep insufficiency (OR 1.3, 95%CI 1.1–1.7), and insomnia symptoms (OR 1.5, 95%CI 1.1–1.9) remained significant. In males, this tendency was similar, while females showed a weaker relationship, as shown in the Table 5.

Table 4. Association of self-reported sleep habits with occupational injuries in workers in small and medium-scale enterprises (n=2,486–2,840)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Occupational injury (Yes)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted</td>
</tr>
<tr>
<td></td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td>Sleep habits:</td>
<td></td>
</tr>
<tr>
<td>Less than 6 hr of daily sleep (yes vs. no)</td>
<td>1.0 (0.8–1.1)</td>
</tr>
<tr>
<td>Over 30 min to fall asleep (DIS) (yes vs. no)</td>
<td>1.5 (1.2–1.8)**</td>
</tr>
<tr>
<td>Awakening during sleep more than 3 times/wk (DMS) (yes vs. no)</td>
<td>1.2 (0.9–1.6)</td>
</tr>
<tr>
<td>Early morning awakening more than 3 times/wk (EMA) (yes vs. no)</td>
<td>1.1 (0.8–1.5)</td>
</tr>
<tr>
<td>Considerably/somewhat difficulty waking up in the morning (yes vs. no)</td>
<td>1.3 (1.1–1.6)**</td>
</tr>
<tr>
<td>Sleeping very poorly or not so well at night (yes vs. no)</td>
<td>1.5 (1.2–1.8)**</td>
</tr>
<tr>
<td>Definitely or somewhat insufficiency in sleep (yes vs. no)</td>
<td>1.4 (1.2–1.7)**</td>
</tr>
<tr>
<td>Difficulty breathing during sleep more than once a week (yes vs. no)</td>
<td>1.0 (0.6–1.7)</td>
</tr>
<tr>
<td>Insomnia symptoms* (yes vs. no)</td>
<td>1.4 (1.2–1.7)**</td>
</tr>
</tbody>
</table>

OR, odds ratio; CI, confidence interval; DIS, difficulty initiating sleep; DMS, difficulty maintaining sleep; EMA, early morning awakening. *p<0.05, **p<0.01, ***p<0.001. *Reference category is no occupational injuries in the last 1-year period. *Adjusted for age, gender, marital status, years of education, presence of diseases, smoking, alcohol drinking, caffeine intake, depressive symptoms, and job type in multiple logistic regression analyses. *Defined by at least one positive response to questions regarding DIS, DMS or EMA.
accident rate (OR of 1.48) was found in subjects reporting previous studies. Balter and Ulenhuth compared past-occupational injuries. The results are consistent with several initiations sleep, were associated with the occurrence of occupational injuries in this population.

The past 1-yr period, suggesting a high prevalence of workers experienced some sort of occupational injuries in small and medium-scale enterprises. A weak association was also found between difficulty waking up in the morning and occupational injuries. Males showed a similar pattern associated with the occurrence of occupational injuries, while females showed a weaker association. It is also noteworthy that one in three

was also found between difficulty waking up in the morning and occupational injuries. In either case, the data suggest sleep difficulties are associated with injuries in the working population.

In this study, insomnia symptoms and its subtype, difficulty initiating sleep, were associated with the occurrence of occupational injuries. The results are consistent with several previous studies. Balter and Ulenhuth compared past-year prevalence rates for serious accidents/injuries in subjects with chronic untreated insomnia and normal controls and found 4.5 times higher rates in insomniacs (2% and 9%, respectively). Leger et al. also reported that severe insomniacs had more problems at work such as decreased concentration, difficulty performing duties, and work-related accidents than good sleepers. In the construction industry, where accidents tend to be serious, sleep disorders were reported to be the major factor contributing to occupational injuries. Also, in white-collar workers, an increased accident rate (OR of 1.48) was found in subjects reporting poor sleep quality using Pittsburgh Sleep Quality Index, but the finding was not statistically significant because of the small number of accident cases. Our study, together with those of others, suggests that insomnia symptoms could be an important risk factor for the occurrence of injuries.

We observed a strongest association between DIS and occurrence of occupational injuries, while no significant association existed between DMS or EMA subtypes of insomnia symptoms. In contrast, Lavie et al. reported that frequent mid-sleep awakenings were more strongly associated with incidence of injuries than difficulty falling asleep (42.9% and 34.8%, respectively). It should be noted, however, that our definition of DIS was based on taking a more strict definition of ‘more than 45 min’ to fall asleep while Lavie et al. used a more strict definition of ‘more than 45 min’ to fall asleep. In either case, the data suggest sleep difficulties are associated with injuries in the working population.

Sleeping poorly at night also was significantly related to occupational injury with an OR of 1.5. The results are in agreement with the previous study by Chau et al. suggesting that individuals who are ‘not sleeping well’ reported a higher incidence of occupational injury. They recorded an incidence of injuries that was twice as high in cases than in controls. Åkerstedt et al. also observed difficulties in sleeping strongly predicted fatal accidents. The strong predictors were male gender (OR 2.3, 95%CI 1.6–3.4), difficulties in sleeping (OR 1.9, 95%CI 1.2–2.9), and non-day work (OR 1.6, 95%CI 1.1–2.5). Workers with poor sleep should be cautious especially when they are engaged in dangerous and
While a significant relationship was found between insufficiency of sleep and occupational injuries, no significant relationship emerged with daily sleep of fewer than 6 h. Although sleep duration is in most cases closely related to sufficiency of sleep, our data suggested that 'efficiency of sleep' may be as important as or more important than mere sleep duration.

A weak association between difficulty waking up in the morning and occupational injuries was found in the current study. Difficulty waking up could be induced either by sleeping poorly at night, insufficiency of sleep, or insomnia symptoms. Chronic fatigue may also induce difficulty waking up. However, the results of this study suggest that if one finds oneself having extreme difficulty in waking up in the morning, accidents or injuries may happen during the beginning of the work shift or even the work commute. Further studies should be undertaken to confirm this hypothesis.

The results of this study showed gender differences in the relationship between sleep habits and occurrence of injuries, though females report sleep problems more often than males about various sleep problems. Females showed significant associations only by unadjusted OR. The weaker association compared to male workers could be explained by the following reasons. First, females may be less likely to engage in dangerous work than males in this population. Secondly, females had one-half of injury rates compared to males (20.2% and 39.3% for females and males, respectively).

No significant association between difficulty breathing during sleep and occurrence of injuries was found. However, it has been reported that males suffering from obstructive sleep apnea syndrome showed 50% increase in occupational accidents which may relate to difficulty in breathing during sleep. In order to learn more about this topic, we attempted to analyze the data splitting at different criteria response (more than a few times/year versus never or almost never) in the 8th sleep question (Table 3). As a result, we found about 4-fold increase of injury rate (OR 4.5, 95%CI 1.0–21.2, p=0.054). Treatment of difficulty breathing during sleep may reduce the number of injuries at work.

Several limitations of this study should be noted. First, the study design was cross-sectional, making it possible to identify only associations, but not directional relationships. Second, the record of occupational injury was self-reported. Third, some confounding variables that may have an impact on both sleep and injury, such as hours of working and habitual exercise, were not included.

In summary, the present study showed that poor nocturnal sleep, such as difficulty maintaining sleep, insomnia symptoms, sleeping poorly at night, and insufficient sleep are related to occupational injury, which may have direct impact on safety at work, and long term business productivity. Feasible strategies such as taking a brief nap for 15–20 min during lunch time or reducing job stress may be helpful in preventing sleep-related injuries at work.

Acknowledgements

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