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ORIGINAL ARTICLE

Insomnia and depression: risk factors for development of depression in male Japanese workers during 2011–2013

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Abstract
Objectives This 3-year cohort study was conducted to investigate the relation between insomnia and development of depression in male workers, and to clarify the association between the severity of insomnia and the onset of depression.
Methods Self-administered questionnaire surveys on depression and insomnia were conducted on male workers for 3 years. Depression was assessed with the Center for Epidemiologic Studies Depression Scale (CES-D), and insomnia was examined using the Athens Insomnia Scale (AIS). The analysis was done with 840 men who had no depression at baseline.
Results Depression symptoms were newly found in 113 men during this study. Cox regression analyses showed that people with insomnia (AIS score of ≥ 1) at baseline had about a 7 times greater risk for onset of depression. Furthermore, compared with those with AIS score of 0 (no insomnia), people with AIS score of 1–3 had a 5.2-fold greater risk of depression and those with a score of 4 or higher indicated about tenfold greater risk.
Conclusions A new finding was that the risk for onset of depression increased with the severity of insomnia.

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Introduction

It is well known that depression is often accompanied by insomnia. On the other hand, recent researches have also shown that insomnia can be a risk for the development of depressive symptoms. In young adults, insomnia for more than 2 weeks was found to be a risk factor for future depression (Buysse et al. 2008). College students with insomnia symptoms had more mental health problems (depression, anxiety, etc.) than those without insomnia (Taylor et al. 2011). Elderly females with persistent insomnia were at increased risk for the development of new-onset depression (Perlis et al. 2006). In older adults aged 65 years or more, the risk of depression within the next 3 years was found to more than 3 times higher in those with insomnia (Riemann and Voderholzer 2003). In a community-based sample, people with insomnia were 9.82 times more likely to have depression than people who did not have insomnia (Taylor et al. 2005). In a 3-year follow-up study of community residents aged 65 years or more in Japan, the risk of developing depression was shown to be about 1.6 times higher, especially in those with difficulty falling asleep (Yokoyama et al. 2010).

Nevertheless, a systematic review has indicated that the etiological relationship between insomnia and the risk for development of depression remains unclear (Alvaro et al. 2013). Moreover, there have been very few studies on the increased risk of future depression in workers who have insomnia. The number of workers today who need to take leaves of absence or be reassigned as a result of mental disorders with depression or other depressive symptoms is

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not negligible. Effective preventive mental health measures for depression are an urgent matter for society, but as yet no specific methods have been established. For workers, eliminating insomnia also has other beneficial effects in terms of preventing drowsiness and decreased activity during work, and promoting safety. Thus, clarification of the association between insomnia and depressive symptoms in workers are important.

The aim of this 3-year cohort study was to clarify the association between insomnia and the development of depression in the future, and furthermore analyze the association between the severity of insomnia and the onset of depression among male workers.

Methods

Subjects

A 3-year cohort study was conducted on all male workers employed in a manufacturing company, Aichi, Japan. Self-administered questionnaire surveys on insomnia and depression were done over 3 years in 2011, 2012, and 2013, together with the usual annual health checkup.

The questionnaire was distributed to 1871 men, all male workers of the investigated company, in 2011, the baseline year. The questionnaire was distributed about 1 week before the annual health checkup, and was then collected on the day of the health checkup from May to July. Consent was obtained and responses to the questionnaire were received by 1608 men (response rate 85.9%). Among them, people with a history of or who were currently undergoing treatment for a psychiatric disorder and sleep apnea syndrome were excluded. Since the number of shift workers was very small, the study subjects were limited to the daytime workers only. Moreover, persons aged 61 or over were excluded, and the number of remaining daytime workers aged 60 years or under was then 1258 men in the baseline.

The Center for Epidemiologic Studies Depression Scale (CES-D) (Shima et al. 1985) was used for questions on depression. Additionally, we excluded the subjects who had depressive symptoms, i.e., those with total score of 16 points and more of the CES-D (Shima et al. 1985). Then, the final subjects in this study were 840 daytime workers who had no depressive symptoms (total CES-D score of less than 16) at baseline. Their mean age (standard deviations; SD) was 41.7 (11.5) years (range 20–59 years). The onset of their depressive symptoms in the future was then followed with the same questionnaire in 2012 and 2013, for a total of 1496 person-years.

This study was approved by the ethics committees of the Nagoya University Graduate School of Medicine and the Sugiyama Jogakuen University Department of Nursing.

Survey content

Baseline attributes and lifestyle habits

A self-administered questionnaire included items such as age, sex, work schedule (daytime or shift work), whether or not living with family, type of work, overtime work hours (average hours per week excluding days off), commuting time, average sleeping time (mean number of hours on working days), and whether or not the individual was currently being treated for an illness or taking medication. Whether or not subjects exercised regularly and if so the frequency, smoking status, alcohol consumption, how often they ate breakfast and other information was obtained from the health checkup medical interview sheet.

Quality of sleep

The Athens Insomnia Scale (AIS), an insomnia test used worldwide, was used for assessing quality of sleep (Soldatos et al. 2000, 2003). The AIS was devised by the World Health Organization based on criteria of the International Classification of Disease 10th Revision. The Japanese version of the AIS has been validated, with Cronbach α coefficients reported to be from 0.78 to 0.88 (Okajima et al. 2013). Some researches in Japan have also used the AIS to survey the status of insomnia (Soldatos et al. 2005; Yoshioka et al. 2008; Utsugi et al. 2005). The AIS consists of eight questions: time from lying down until falling asleep (sleep induction), awakenings during the night, awakening earlier than desired and not being able to get back to sleep (final awakening), sufficiency of total sleep duration (total sleep duration), satisfaction with overall quality of sleep regardless of how many hours slept (sleep quality), well-being during the day, functioning capacity during the day, and sleepiness during the day. Responses to questions are selected from four options: no problem (0 point), minor problem (1 point), considerable problem (2 points), and did not sleep at all (3 points). An assessment can be made with the total score for the eight questions on the AIS. A total score of less than 4 indicates no problem, a score of 4 or 5 indicates that a physician should be consulted if possible (there is some suspicion of insomnia), and 6 or more indicates that a physician needs to be consulted (suspected insomnia). The analysis was done by assessment of total score.

CES-D

The CES-D was developed by the US National Institute for Mental Health for the purpose of detecting depression in ordinary people. It consists of 20 questions and is a simple test with good reliability and verified validity. The Japanese version of the CES-D has been confirmed to have high equivalence with the original, and its reliability and validity have also been established (Shima et al. 1985). Subjects are asked the frequency of 20 symptoms in the week preceding the test, and respond on a 4 points scale of 0, 1, 2, or 3. The total score for all 20 questions is calculated, and higher scores may be considered to indicate stronger depression. The maximum score is 60 and the minimum score is 0. The cut-off point for the total score is taken to be 16. That is, depression is suspected in people with a total CES-D score of 16 or higher. It should be noted, however, that depression may also be suspected in some cases even when the CES-D score is below 16. The CES-D needs to be used with sufficient understanding of these characteristics and that it is a self-administered questionnaire (Shima et al. 1985).

The analysis in this study was done with a total CES-D score of 16 or more indicating depression, and less than 16 indicating no depression.

Statistical analysis

Baseline attributes and living habits were examined in 840 men who had no depression; that is, total CES-D scores of less than 16 in 2011. They had the follow-up surveys in 2012 and 2013. The risk for developing depression during this survey was firstly investigated for each factor of basic attributes and lifestyle habits using age-adjusted Cox regression analysis to select independent valuables relevant to developing depression. Then, multivariate Cox regression analysis was made to clarify between insomnia at baseline and newly developing depression during this study, adjusting the relevant factors at $p < 0.05$ shown in age-adjusted Cox regression analyses.

The total results showed that insomnia was the highest risk for future depression. Hence, Cox regression analysis was further made to examine the effect of the severity of insomnia (AIS score) or sleep factors in insomnia (sleep induction, awakenings during the night, final awakening, etc.) on developing depression.

All statistical analyses were performed with SPSS Statistics version 19.0 for Windows.

Results

Baseline attributes and lifestyle habits

The baseline attributes and living habits of the 840 men without depression at baseline were investigated. Their mean age (SD) was 41.7 (11.5) years and about 30% of them were smokers or consumed alcohol daily. About 22% exercised for 30 min or more at least two times a week, and had done so for more than 1 year. About 22% responded that they were undergoing treatment or taking medication for some disease. About 65% responded that they worked overtime, with mean overtime hours of 7.8 h per week. Average sleeping time was about 6 h. Mean (SD) AIS score was 2.7 (2.1) and mean (SD) CES-D score was 9.4 (3.9) (Table 1).

Living habits associated with onset of depression in the future

Depression symptoms were newly found in 113 men during this study. We investigated factors for developing depression using Cox regression analysis adjusted for age (Table 2). The results showed that people with an AIS insomnia score of 1 or more had a 6.92 times greater risk than those with a score of 0 for depression. Hazard ratios (HR) and 95% confidence intervals (CI) were 6.92 (95% CI 2.20–21.80). Those who had a smoking habit also had a 1.50 times higher risk of depression than those who did not (HR 1.50; 95% CI 1.03–2.20). No significant differences were seen in other lifestyle habits, such as exercise, drinking alcohol, or average sleeping time on workdays.

Next, multivariate Cox regression analysis for the risk of developing depression was further conducted to analyze the relation to AIS and smoking habit, adjusting for age (Table 3). The results showed that the onset of depression was significantly associated with AIS total score of 1 or more (HR 7.11; 95% CI 2.26–22.41; $p = 0.001$) and also smoking habit (HR 1.56; 95% CI 1.06–2.29; $p = 0.023$) (Table 3).

Severity of insomnia and onset of future depression

A detailed investigation was further carried out to investigate the association between the severity of insomnia and the onset of future depression. The severity of insomnia was divided by AIS scores of 0, 1–3, 4–5, and 6 or more. According to the AIS scores at baseline, 840 subjects were distributed in 138 (16.4%) with 0 points, 140 (16.7%) with

Table 1 Basic attributes and lifestyle of 840 subjects without depression at baseline in Japan, 2011–2013

Attribute	Value
Age, years[a]	41.7 (11.5)
Lives with family[b]	660 (78.6)
One-way commute time, minutes[a]	36.4 (28.3)
Smokes[b]	256 (30.5)
Exercises ($\geq$ 30 min, $\geq$ 2 times/week for more than 1 year)[b]	181 (21.5)
Daily alcohol consumption[b]	247 (29.4)
Skips breakfast $\geq$ 3 times/week[b]	92 (11.0)
Works overtime[b]	542 (64.5)
Overtime work hours, h/week[a]	7.8 (10.9)
Average sleeping time[a]	6.4 (0.9)
Undergoing treatment or taking medication[b]	184 (21.9)
Mean AIS (the Athens Insomnia Scale) score[a]	2.7 (2.1)
Mean CES-D score[a]	9.4 (3.9)

AIS the Athens Insomnia Scale, *CES-D* the Center for Epidemiologic Studies Depression Scale

[a] Mean (standard deviations)

[b] Number of subjects (percentage)

Table 2 Risk of developing depression associated with each baseline attribute and living habit, based on age-adjusted Cox regression analysis in Japan, 2011–2013

Attribute (at baseline)	HR[a]	95% CI[b]	*p* value[c]
Job type	0.98	0.67–1.42	0.912
Lives with family	0.77	0.49–1.20	0.250
One-way commute time	1.00	1.00–1.01	0.378
Smokes	1.50	1.03–2.20	0.037
Exercises ($\geq$ 30 min, $\geq$ 2 times/week for more than 1 year)	1.10	0.70–1.73	0.673
Daily alcohol consumption	1.14	0.73–1.78	0.563
Skips breakfast $\geq$ 3 times/week	0.64	0.31–1.31	0.217
Does/does not work overtime	0.93	0.62–1.38	0.715
Overtime work $\geq$ 8 h/week	0.88	0.51–1.50	0.634
Sleeping time $<$ 6 h/night	1.07	0.64–1.79	0.801
Undergoing treatment or taking medication	1.39	0.88–2.20	0.160
Total AIS (the Athens Insomnia Scale) score $\geq$ 1	6.92	2.20–21.80	0.001

AIS the Athens Insomnia Scale

[a] Hazard ratios

[b] 95% confidence intervals

[c] Adjusted for age

Table 3 Risk of developing depression according to multivariate Cox regression analysis in Japan, 2011–2013

Attribute (baseline)	HR[a]	95% CI[b]	*p* value[c]
Smokes	1.56	1.06–2.29	0.023
Total AIS (the Athens Insomnia Scale) score $\geq$ 1	7.11	2.26–22.41	0.001

AIS the Athens Insomnia Scale

[a] Hazard ratios

[b] 95% confidence intervals

[c] Adjusted for age

1 points, 162 (19.3%) with 2 points, 145 (17.3%) with 3 points, 174 (20.7%) with 4–5 points, and 81 (9.6%) with 6 or more. As compared with a score of 0, there was found to be a significant difference in future depression with a score of 1–3 (HR 5.15; 95% CI 1.61–16.51). There were also significant differences in future depression with a score of

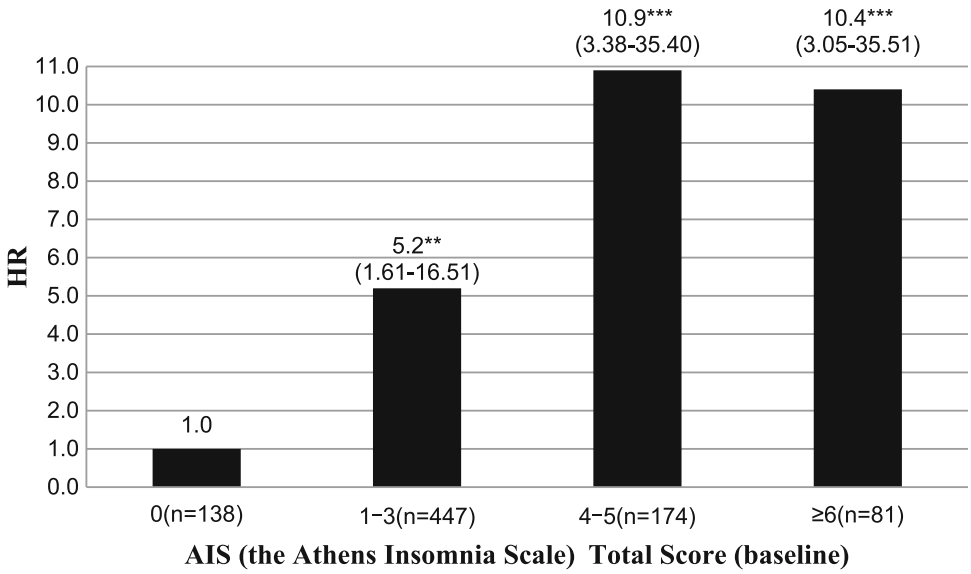

Fig. 1 Risk of developing depression by severity of insomnia, based on Cox regression analysis (adjusted for age and smoking habit) in Japan, 2011–2013. *HR* hazard ratios. *AIS* the Athens Insomnia Scale. ***$p < 0.001$, **$p < 0.01$. (): 95% confidence intervals

4–5 (HR 10.94; 95% CI 3.38–35.40). With scores of 6 and higher (HR 10.40; 95% CI 3.05–35.51), the hazard ratio for depression increased as the AIS score became higher (Fig. 1).

When examining each sleep factor in insomnia (Table 4), the factors with hazard ratios over 2.00 were found to be awakenings during the night (HR 2.25; 95% CI 1.46–3.47), functioning capacity during the day (HR 2.36; 95% CI 1.57–3.53), and sleepiness during the day (HR 2.03; 95% CI 1.29–3.19). Significant risks were seen for the other factors as well.

Table 4 Risk of developing depression associated with each AIS (the Athens Insomnia Scale) sleep factor, based on Cox regression analysis in Japan, 2011–2013

Sleep factor (baseline)	HR[a]	95% CI[b]	*p* value[c]
Sleep induction	1.79	1.19–2.70	0.005
Awakenings during the night	2.25	1.46–3.47	< 0.001
Final awakening	1.65	1.11–2.45	0.013
Total sleep duration	1.57	1.07–2.32	0.022
Sleep quality	1.71	1.18–2.49	0.005
Well-being during the day	1.97	1.28–3.03	0.002
Functioning capacity during the day	2.36	1.57–3.53	< 0.001
Sleepiness during the day	2.03	1.29–3.19	0.002

AIS the Athens Insomnia Scale

[a] Hazard ratios

[b] 95% confidence intervals

[c] Adjusted for age and smoking habit

Discussion

In this cohort study, we investigated the risk of developing depressive symptoms over 3 years in male workers without depressive symptoms at baseline. The present findings showed that people with insomnia (AIS score of ≥ 1) at baseline had about a 7.1 times greater risk of depression than people without insomnia. In addition, the severity of insomnia was associated with the onset of future depression. Compared with those without insomnia (AIS score of 0), people with a total AIS score of 1–3 had an 5.2-fold greater risk of developing depression and those with a score of 6 or higher indicated an 10.4-fold greater risk. Thus, the risk for onset of depression could increase with the severity of insomnia. The severity of insomnia based on AIS scores may help to assess the risk of the future development of depression.

The present study indicated that the presence of insomnia (AIS total score of 1 or more) can be about sevenfold risk for future development of depression. Previous studies also showed a strong association between insomnia and depression (Nakata et al. 2004; Fukunishi et al. 1997; Motohashi and Takano 1995) and indicated that the possibility of developing depression in the future is high with continued insomnia (Yokoyama et al. 2010; Breslau et al. 1996; Roberts et al. 2000). Persistent insomnia is also shown to increase the risk of suicidal ideation as well as that of depression (Suh et al. 2013). A study reported that non-depressed people with insomnia had a twofold risk to develop depression, based on the databases from 1980 to 2010 (Baglioni et al. 2011). In Japan, a 3-year follow-up survey of community-dwelling elderly aged 65 years or more showed that the risk of developing depression was about 1.6 times higher in people with insomnia (Yokoyama et al. 2010). Another Japanese study with 2 years follow-up reported that insomnia could be a risk factor for the new onset (7.0 times risk) of

depression (Okajima et al. 2012). The previous study used Pittsburgh Sleep Quality Index (PSQI) and CES-D to assess insomnia and depressive symptoms, respectively. The cut-off point for the PSQI score was set at 7.5 (Okajima et al. 2012). Although there were differences in the study subjects and the meaning method of insomnia, the findings of the present study were similar with those of the study on a Japanese rural cohort. Insomnia can be is a risk factor to be predictive of depression (Taylor et al. 2003).

Additionally, this study demonstrated a dose–response relationship between the severity of insomnia and the onset of depression: the stronger the severity of insomnia, the higher was the risk of developing depression. Although earlier studies have shown the relationship between insomnia and developing depression, there were few studies on relation between the severity of insomnia and the onset of depression. There was only one study showing a significant relationship between the severity of insomnia and incidents of depression, following up with telephone interview for 7.5 years (Fernandez-Mendoza et al. 2015). In the present study, the severity of insomnia was assessed using AIS total scores. Compared with those with AIS score of 0 (no insomnia), people with AIS score of 1–3 had a 5.2-fold greater risk of depression and those with a score of 4 or higher indicated about tenfold greater risk. It is, hence, suggested that even AIS score of 1-3 may have some risk for future depression. The severity of insomnia based on AIS total scores can be an indicator to assess the risk of the future development of depression.

Next, with respect to each sleep factor in insomnia, a previous study with elderly subjects showed that the risk of depression was about 1.6 times higher only in those with difficulty falling asleep (Yokoyama et al. 2010). Earlier surveys have also indicated that depressive symptoms are related to sleepiness during the day (Fukunishi et al. 1997; Doi and Minowa 2003). In the present study, the factors with hazard ratios over 2.00 were found to be awakenings during the night (HR 2.25), functioning capacity during the day (HR 2.36), and sleepiness during the day (HR 2.03). Sleep induction or difficulty falling sleep had about 1.8-times higher risk for depression. These findings were in accordance with earlier studies. However, this study showed that the presence of insomnia (AIS total score of 1 or more) can be about sevenfold risk for future development of depression. Hence, the AIS total scores may be more useful to assess insomnia than each factor of AIS.

The present study also showed that smoking habits were associated with the onset of depressive symptoms, which was in accord with earlier findings. Adults with depression were more likely to be cigarette smokers than those without depression (Pratt and Brody 2010). Passive smoking and current smoking was reportedly associated with higher levels of depressive symptoms among Japanese workers, using a CES-D cut-off point of 16 (Nakata et al. 2008). A prospective cohort study also reported that smoking was associated with increased risk of developing depression (Flensborg-Madsen et al. 2011). Smoking may in part contribute to developing depressive symptoms.

The limitations of this study are thought to be the following. First, the results were all obtained in a survey using a self-administered questionnaire. Second, workplace stress may be associated with insomnia, but we did not examine the relationship of job stress factors, including quantitative workload, qualitative workload, job latitude, etc., in this study. Further studies will be required to clarify the association among job stress, insomnia and depression. Finally, the subjects were male daytime workers in only one manufacturing industry company. It may be necessary to study this issue in people in other types of work, in shift workers, and in female workers as well. Future interventional studies are also warranted to clarify whether improving sleep status can reduce the risk of developing depression.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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