



## **Original article**

Scand J Work Environ Health [2012;38\(5\):427-435](#)

doi:10.5271/sjweh.3269

### **The joint association of sleep duration and insomnia symptoms with disability retirement - a longitudinal, register-linked study**

by [Haaramo P](#), [Rahkonen O](#), [Lahelma E](#), [Lallukka T](#)

**Affiliation:** Hjelt Institute, Department of Public Health, PO Box 41, 00014 University of Helsinki, Finland. [peija.haaramo@helsinki.fi](mailto:peija.haaramo@helsinki.fi)

The following article refers to this text: [2017;43\(2\):109-116](#)

**Key terms:** [difficulty in initiating sleep](#); [difficulty in maintaining sleep](#); [disability](#); [disability retirement](#); [insomnia](#); [longitudinal study](#); [mental disorder](#); [musculoskeletal disease](#); [non-restorative sleep](#); [register-linked study](#); [sleep](#); [sleep disorder](#); [sleep duration](#); [sleep problem](#)

This article in PubMed: [www.ncbi.nlm.nih.gov/pubmed/22234460](http://www.ncbi.nlm.nih.gov/pubmed/22234460)



This work is licensed under a [Creative Commons Attribution 4.0 International License](http://creativecommons.org/licenses/by/4.0/).

## The joint association of sleep duration and insomnia symptoms with disability retirement – a longitudinal, register-linked study

by Peija Haaramo, MSocSci,<sup>1</sup> Ossi Rahkonen, PhD,<sup>1</sup> Eero Lahelma, PhD,<sup>1</sup> Tea Lallukka, PhD<sup>1</sup>

Haaramo P, Rahkonen O, Lahelma E, Lallukka T. The joint association of sleep duration and insomnia symptoms with disability retirement – a longitudinal, register-linked study. *Scand J Work Environ Health*. 2012;38(5):427–435. doi:10.5271/sjweh.3269

**Objective** The aim of this study was to examine the joint association of sleep duration and insomnia symptoms with subsequent disability retirement.

**Methods** Baseline survey data were collected in 2000–2002 from 40–60-year-old employees of the City of Helsinki, all working at baseline. Baseline data were linked with disability retirement data until the end of 2010, obtained from the Finnish Centre for Pensions registers (N=6042). Sleep duration and self-reported insomnia symptoms (non-restorative sleep and difficulties in initiating and maintaining sleep) were derived from the baseline surveys. All-cause disability retirement (N=561) and the most prevalent diagnostic groups – musculoskeletal diseases (43%) and mental disorders (26%) – were examined. Cox regression analysis was used to yield hazard ratios (HR) with 95% confidence intervals (95% CI).

**Results** A joint association of sleep duration and insomnia symptoms with disability retirement was found, implying a higher risk for those with frequent insomnia symptoms. HR for all-cause disability retirement ranged among those with frequent symptoms from 2.02 (95% CI 1.53–2.68, sleeping 7 hours) to 3.92 (95% CI 2.57–5.97, sleeping ≤5 hours). Adjusting for sociodemographic, work, and health-related factors attenuated the associations, which nevertheless remained. The associations were similar for the two diagnostic groups, although stronger for those with mental disorders.

**Conclusion** Frequent insomnia symptoms dominate the joint association of sleep duration and insomnia symptoms with subsequent disability retirement. Examining exclusively sleep duration would provide an incomplete understanding of the consequences of poor sleep.

**Key terms** difficulty in initiating sleep; difficulty in maintaining sleep; mental disorder; musculoskeletal disease; non-restorative sleep; sleep disorder; sleep problem.

Sleep duration and insomnia symptoms – such as difficulties in initiating and maintaining sleep as well as non-restorative sleep – are two complementary and interrelated characteristics of sleep. However, the relationship between the two is not linear and previous studies have shown them to be individual indicators with divergent effects (1). Therefore, on the one hand, this calls for separate examinations of the independent effects of sleep duration and insomnia symptoms, and, on the other hand, an examination of their joint effects.

Several studies on the association between sickness absence, which reflects work disability, and insomnia symptoms have been previously conducted [see eg, (2)].

The association between sleep and disability retirement – indicating permanent deterioration of work ability – has been less studied so far. No prior studies have examined the joint association of sleep duration and insomnia symptoms with disability retirement or other indicators of work disability. An association has been found between insomnia symptoms and disability retirement in some recent studies (1, 3–6). In line with these studies, a previous study by our group confirmed the association between insomnia symptoms and subsequent disability retirement, taking into account various types of symptoms and different disability diagnoses (7). Only one Norwegian study has examined the association between sleep duration and disability retirement

<sup>1</sup> Hjelt Institute, Department of Public Health, University of Helsinki, Helsinki, Finland.

Correspondence to: Peija Haaramo, Hjelt Institute, Department of Public Health, PO Box 41, 00014 University of Helsinki, Finland. [E-mail: peija.haaramo@helsinki.fi]

(1). Following a large sample of 40–45-year-old participants for four years, the study found that only long sleep duration was associated with all-cause disability retirement. As previous studies have shown that both sleep duration and insomnia symptoms are associated with subsequent disability retirement, it is presumable that by jointly examining these two key characteristics of sleep, we will gain a deeper understanding of the association between sleep and disability retirement.

Although there are no previous studies examining the joint association of sleep duration and insomnia symptoms with disability retirement, studies on morbidity and mortality have demonstrated the advantages of this approach (8–13). These studies have concluded that the combined measure of sleep duration and insomnia symptoms may be a stronger predictor of health outcomes than either component on its own (10). This might be due to the additive or synergistic effect of sleep duration and insomnia symptoms (12). Short or long sleepers or those having insomnia symptoms are not homogenous groups, but among them there are subgroups, which the field of sleep disorders medicine has attempted to define (12, 14). Short sleep duration might be adequate for the restorative physiologic processes accompanied by sleep for some people but not for others, depending on the quality of their sleep (13). Thus, to have a more comprehensive understanding of the associations of sleep duration and insomnia symptoms with subsequent ill-health, short and long sleepers need to be studied separately, based on presence or absence of reported insomnia symptoms.

Previous studies have shown that both sleep duration and insomnia symptoms are also associated with sociodemographic factors such as age, gender, marital status, socioeconomic position, work-related factors, and somatic and mental health (15–18). Therefore, these factors need to be taken into account as covariates when studying the joint association of sleep duration and insomnia symptoms with disability retirement.

Earlier studies have also indicated that the strength of the association and the order of causality between insomnia symptoms and ill-health depend on the disease studied (18, 19). As for sleep duration, some diseases have been found to be associated with short and others with long sleep (9, 13, 20). We examined musculoskeletal diseases and mental disorders, which, while accounting for the two-thirds of the disability retirements in our data, represent also two different types of diseases – somatic and mental ill-health.

The present study extends previous research by examining the joint association of sleep duration and insomnia symptoms with disability retirement. The effects of the above-mentioned covariates were taken into account. All the analyses were carried out for all-cause disability retirement, as well as for retirement due to musculoskeletal diseases and mental disorders.

## Methods

Data on self-reported insomnia symptoms, sleep duration, sociodemographic and work-related factors, and health were derived from the baseline surveys of the Helsinki Health Study (HHS), conducted in 2000, 2001, and 2002 (N=8960, overall response rate 67%) (21). Postal questionnaires were sent to all City of Helsinki employees who were turning 40, 45, 50, 55, or 60 in each year of the survey and working at baseline. The proportion of women in the study was 80%, reflecting the gender distribution among the employees of the City of Helsinki. As the largest employer in Finland, the City of Helsinki encompasses a wide variety of occupations. Non-response analysis showed that the HHS data broadly represented the target population (22).

Disability retirement data were obtained from the registers of the Finnish Centre for Pensions and linked longitudinally with the baseline survey data of the participants with written consent for such linkage (74%). The linkage was made using the personal identity numbers that are issued to all Finnish residents. According to non-response analysis, consenting to such linkage is unlikely to cause a substantial bias (22). The total number of respondents who gave their consent for the data linkage and for whom we had complete data on sleep duration, insomnia symptoms, and adequate responses to all covariates was 6042.

In Finnish retirement schemes, disability pension can be granted if an employee's work ability is assessed to have been continuously reduced due to illness, injury or impairment, by at least three-fifths (two-fifths for a partial disability pension) for  $\geq 12$  months (23). In practice, this requires a preceding sickness absence of  $\geq 300$  working days. A disability pension can be granted on a temporary or permanent and partial or full-time basis. The pensions register contains detailed information about all pension events, including their International Classification of Diseases (ICD-10)-based diagnoses (24). All disability retirement events until the end of 2010 were included in this study, with the mean follow-up time being 8.0 years. All-cause disability retirement was examined, as well as the two most prevalent diagnostic groups, musculoskeletal diseases (M00–M99) and mental disorders (F00–F99).

During the follow-up, 561 (9%) participants retired because of disability (table 1). Of these, 43% of retirements were due to musculoskeletal diseases and 26% to mental disorders. The mean age for disability retirement was 56.2 years (all-cause); it was 57.1 years among those who retired due to musculoskeletal diseases and 55.4 years in the mental disorders group (data not shown).

## Measurement of sleep duration and insomnia symptoms

The baseline survey contained a question concerning average sleep duration in hours during weekdays, and the responses were classified into 5 categories: (i)  $\leq 5$  hours; (ii) 6 hours; (iii) 7 hours; (iv) 8 hours; (v) and  $\geq 9$  hours. Insomnia symptoms during the previous 4 weeks were assessed using the 4-item Jenkins Sleep Questionnaire (25). This instrument measures difficulties in initiating and maintaining sleep, and non-restorative sleep. Six response alternatives were included: (i) not at all; (ii) 1–3 days; (iii) 4–7 days; (iv) 8–14 days; (v) 15–21 days; and (vi) 22–28 days. The frequency of insomnia symptoms was dichotomized into (i) no or occasional symptoms (any of the symptoms 1–14 days); and (ii) frequent symptoms ( $\geq 15$  days).

The joint variable of sleep duration and insomnia symptoms was created by dividing each sleep duration category into no or occasional insomnia symptoms and frequent insomnia symptoms. This new 10-class variable was used in the analyses, with 7-hour sleepers with no or occasional insomnia symptoms serving as the reference group. The 7-hour reference category is similar to previous studies examining sleep duration (11, 13).

## Covariates

Age and gender were adjusted for in all the analyses. Marital status was categorized as single; married or cohabiting; and previously married (divorced, separated, or widowed). Data on four hierarchical occupational classes were used: professionals and managers;

semi-professionals; routine non-manual employees; and manual workers.

Work arrangements included shift work and working overtime. Shift work was categorized into regular daytime work; shift work with no night shifts; shift work with night shifts, including regular night work; and other working arrangements. The cut-off point for working overtime was  $>40$  hours per week.

The assessment of physical working conditions was based on an inventory of 18 items. From this inventory, three factors were derived: physical workload; environmental exposure; and sedentary work with a computer. The details of this are reported elsewhere (17).

Karasek's Job Content Questionnaire was used in order to measure psychosocial job strain, which was classified into four categories using the median of job demands and job control as a cut-off point (26). The categories were: low strain; passive work; active work; and high strain.

Baseline health was measured using self-reported doctor-diagnosed lifetime diseases: asthma; diabetes; cardiovascular diseases (CVD) (eg, angina pectoris, myocardial infarction, cerebrovascular disorders, and intermittent claudication); musculoskeletal diseases (gout, osteoporosis, osteoarthritis, and rheumatoid arthritis); and depression, anxiety, or other mental disorders.

Smoking, heavy drinking, physical inactivity, and obesity were included in the preliminary analyses. Although they were associated with sleep duration, insomnia symptoms, and disability retirement, their contribution to the joint association of sleep duration and insomnia symptoms with disability retirement was negligible. Therefore, health behaviors were omitted from the final analyses.

## Statistical analysis

Descriptive analyses were conducted using cross-tabulations with chi-square tests. Cox regression analysis was used to calculate hazard ratios (HR) and their 95% confidence intervals (95% CI) for the first disability retirement event during the follow-up period. Participants who retired because of their age, died, or turned 63 years old during the follow-up were censored. The last mentioned censoring was applied because, in Finland, a disability pension cannot be awarded after the age of 63.

In the Cox regression analyses, the base model 1 was adjusted for age and gender. Model 2 was adjusted for the base model and marital status, occupational class, work arrangements, physical working conditions, and psychosocial job strain. Model 3 was adjusted for the base model and asthma, diabetes, CVD, and musculoskeletal diseases. Model 4 was adjusted for the base model and mental disorders. The contribution of each covariate was initially examined

**Table 1.** Distribution of the joint variable of sleep duration and insomnia symptoms and incidence of disability retirement among 40–60-year-old employees. P-value from Chi-square test. [MSD=musculoskeletal diseases; No/occ=No or occasional insomnia symptoms; Freq=frequent insomnia symptoms].

Sleep duration and insomnia symptoms	All respondents (N=6042)	Incidence of disability retirement					
		All-cause (N=561)		MSD (N=241)		Mental disorders (N=146)	
		%	P-value	%	P-value	%	P-value
$\leq 5$ hours, no/occ	1.2	14.7		8.0		4.0	
6 hours, no/occ	14.5	7.4		3.1		1.5	
7 hours, no/occ	40.2	6.8		2.8		1.5	
8 hours, no/occ	21.3	7.1		2.7		2.0	
$\geq 9$ hours, no/occ	2.9	9.3		4.1		1.2	
$\leq 5$ hours, freq	1.7	25.0		10.0		9.0	
6 hours, freq	5.9	18.8		8.7		5.6	
7 hours, freq	8.1	14.3		7.3		3.9	
8 hours, freq	3.5	19.4		7.1		6.2	
$\geq 9$ hours, freq	0.7	24.4		12.2		12.2	
Total	100.0	9.3	<0.001	4.0	<0.001	2.4	<0.001

in separate models (data not shown), and as none of them stood out, the covariates were fitted into the analyses as stated above. The separate effects of sleep duration and insomnia symptoms on disability retirement were examined using the age- and gender-adjusted model 1.

Multiplicative interactions were tested by adding an interaction term of sleep duration and insomnia symptoms in a model that included also their main effects. We found no statistically significant interaction between sleep duration and insomnia symptoms when examining disability retirement as the outcome (all-cause, as well as retirement due to musculoskeletal diseases and mental disorders). As the test used is non-specific, it is possible that there is an interaction that was not detected. We also tested the squared effects of sleep duration on disability retirement, stratified by insomnia symptoms. In these analyses, sleep duration was first centered at zero (7-hour sleepers), then used as a squared term in the age- and gender-adjusted model.

No multiplicative interactions were found between gender and sleep duration or insomnia symptoms. However, an interaction was detected between gender and the joint variable of sleep duration and insomnia symptoms in the analysis of disability retirement (data not shown). As the number of men in the sample was quite low, some categories were very small and the large standard errors prevented reliable interpretation of the possible interaction. The joint associations of sleep duration and insomnia symptoms with disability retirement were, nonetheless, broadly similar among women and men. Therefore, we pooled the data and used gender as a covariate in all the analyses.

We carried out control analyses to test the different follow-up and lag times (data not shown). In the control analyses of the lag times, we excluded all disability retirement events occurring 0–6 months, 0–12 months, or 0–18 months after the baseline. This was done to avoid possible protopathic bias if some participants were in the process of applying for disability retirement already while completing the baseline survey. The different lag times did not alter the main results, and a large part of the retirement events occurred later during the follow-up (7). Longer follow-up weakened the HR, but the associations remained.

The analyses were carried out using SAS software, version 9.2 (SAS Institute Inc, Cary, NC, USA).

### Ethical considerations

The ethics committees of the Department of Public Health at the University of Helsinki and the health authorities of the City of Helsinki, Finland, approved the HHS protocol.

## Results

### Sleep duration, insomnia symptoms, and the incidence of disability retirement

Frequent insomnia symptoms were reported by one-fifth of the participants (19.9%). Half of the participants reported an average of 7 hours of sleep per day (figure 1). The proportion of the participants having frequent insomnia symptoms was largest among those who slept  $\leq 5$  hours. Having no or only occasional symptoms was most prevalent among those who slept for 7 or 8 hours a day.

The overall incidence of all-cause disability retirement was 9.3% (table 1). The incidence was highest among those who reported frequent insomnia symptoms and slept  $\leq 5$  hours (25.0%) or  $\geq 9$  hours (24.4%), meaning that the association between sleep duration and the incidence of disability retirement was U-shaped in this group. However, among the participants who had no or occasional insomnia symptoms, those who slept  $\leq 5$  hours had the highest incidence for both all-cause disability retirement (14.7%) and retirement due to musculoskeletal diseases or mental disorders.

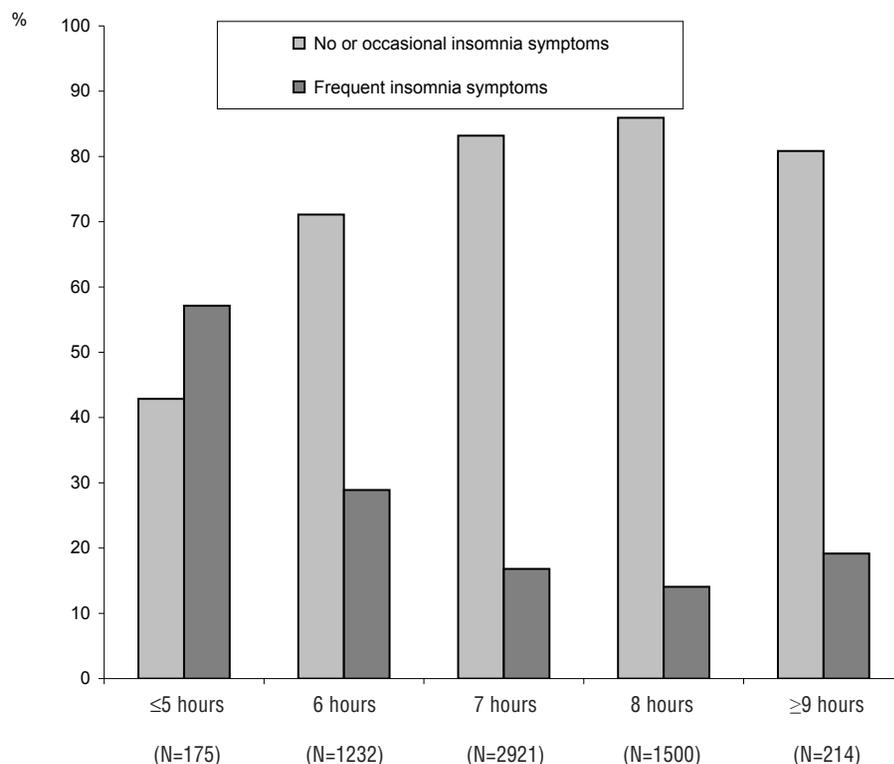
### Sleep duration and insomnia symptoms: separate effects

We examined age- and gender-adjusted separate effects of sleep duration and insomnia symptoms on disability retirement (table 2). Most likely to retire (all-cause) were the short ( $\leq 5$  hours, HR 2.43, 95% CI 1.71–3.45) and long sleepers ( $\geq 9$  hours, HR 1.53, 95% CI 1.02–2.30). Only short sleepers had significantly increased risk for retirement due to musculoskeletal diseases (HR 2.35, 95% CI 1.39–3.97) and mental disorders (HR 3.54, 95% CI 1.89–6.63). Reporting frequent insomnia symptoms was associated with all-cause disability retirement (HR 2.48, 95% CI 2.09–2.95), as well as retirement due to musculoskeletal diseases (HR 2.61, 95% CI 2.02–3.39) and mental disorders (HR 3.48, 95% CI 2.51–4.83).

### Joint association of sleep duration and insomnia symptoms with subsequent disability retirement

In the joint variable of sleep duration and insomnia symptoms, the estimates regarding disability retirement were stronger and reached statistical significance only among those with frequent insomnia symptoms (table 3). Within the group of participants with frequent insomnia symptoms, the most likely to retire were the short and long sleepers; the association between sleep duration and disability retirement therefore followed a U-shaped curve.

The examination of all-cause disability retirement showed that those who had frequent insomnia symptoms and slept  $\leq 5$  hours were the most likely to retire



**Figure 1.** Percentage of insomnia symptoms by sleep duration among 40–60-year-old employees (N = 6042).

**Table 2.** Separate effects of sleep duration and insomnia symptoms on disability retirement among 40–60-year-old employees, adjusted for age and gender (N=6042). [HR=hazard ratio; 95% CI=95% confidence interval; MSD=musculoskeletal diseases].

	Disability retirement					
	All-cause		MSD		Mental disorders	
	HR	95% CI	HR	95% CI	HR	95% CI
<b>Sleep duration</b>						
≤5 hours	2.43	1.71–3.45	2.35	1.39–3.97	3.54	1.89–6.63
6 hours	1.26	1.02–1.56	1.22	0.88–1.68	1.37	0.89–2.10
7 hours (reference)	1.00		1.00		1.00	
8 hours	1.16	0.93–1.43	0.97	0.69–1.36	1.44	0.96–2.18
≥9 hours	1.53	1.02–2.30	1.60	0.88–2.90	1.76	0.80–3.86
<b>Insomnia symptoms</b>						
No or occasional (reference)	1.00		1.00		1.00	
Frequent	2.48	2.09–2.95	2.61	2.02–3.39	3.48	2.51–4.83

(HR 3.92, 95% CI 2.57–5.97), followed by those who slept ≥9 hours (HR 3.73, 95% CI 1.97–7.06) (table 3, model 1). Compared with the reference group of 7-hour sleepers who reported no or occasional insomnia symptoms, also those participants who slept for 7 hours but had frequent symptoms had an increased likelihood of disability retirement (HR 2.02, 95% CI 1.53–2.68, model 1). Adjusting for baseline mental disorders (model 4) attenuated the joint association of sleep duration and insomnia symptoms with all-cause

disability retirement more than other factors, but the association nevertheless remained.

The joint variable of sleep duration and insomnia symptoms was associated with retirement due to musculoskeletal diseases in a similar way to all-cause disability retirement (table 3). Most likely to retire were those who had frequent insomnia symptoms and slept ≤5 hours (HR 3.63, 95% CI 1.87–7.06) or ≥9 hours (HR 4.47, 95% CI 1.80–11.07) (model 1). The effects of the adjustments differed in accordance with sleep duration. For those who slept ≤7 hours, adjusting for sociodemographic and work-related factors (model 2) attenuated the associations more than other factors, while, for those who slept >7 hours, this adjustment attenuated the associations least. Model 3, which included the doctor-diagnosed lifetime asthma, diabetes, CVD, and musculoskeletal diseases attenuated the associations that nevertheless remained.

Compared with all-cause disability retirement and retirement due to musculoskeletal diseases, the joint variable of sleep duration and insomnia symptoms was most strongly associated with retirement due to mental disorders (table 3). Of the participants who had frequent insomnia symptoms, those most likely to retire were once again those who slept ≤5 hours (HR 6.58, 95% CI 3.17–13.69) or ≥9 hours (HR 8.56, 95% CI 3.36–21.80) (model 1). Adjusting for baseline mental disorders (model 4) attenuated the associations more than other factors.

**Table 3.** Joint association of sleep duration and insomnia symptoms with disability retirement among 40–60-year-old employees (N=6042), reference 1.00=sleeping 7 hours with no or occasional insomnia symptoms. [HR=hazard ratios; 95% CI=95% confidence intervals; No/occ=No or occasional insomnia symptoms; Freq=frequent insomnia symptoms.]

	Model 1 <sup>a</sup>		Model 2 <sup>b</sup>		Model 3 <sup>c</sup>		Model 4 <sup>d</sup>	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
<b>All-cause disability retirement</b>								
≤5 hours, no/occ	1.78	0.97–3.28	1.61	0.87–2.99	1.77	0.96–3.26	1.60	0.87–2.95
6 hours, no/occ	1.00	0.75–1.34	0.95	0.71–1.27	0.94	0.70–1.25	0.99	0.74–1.32
7 hours, no/occ	1.00		1.00		1.00		1.00	
8 hours, no/occ	1.10	0.85–1.42	1.07	0.83–1.38	1.07	0.83–1.38	1.10	0.85–1.42
≥9 hours, no/occ	1.37	0.82–2.29	1.28	0.77–2.15	1.20	0.71–2.00	1.37	0.82–2.29
≤5 hours, freq	3.92	2.57–5.97	3.08	2.00–4.74	3.38	2.21–5.18	3.06	2.00–4.68
6 hours, freq	2.79	2.10–3.71	2.41	1.81–3.22	2.25	1.69–3.01	2.38	1.78–3.17
7 hours, freq	2.02	1.53–2.68	1.87	1.41–2.48	1.66	1.24–2.20	1.78	1.34–2.36
8 hours, freq	2.98	2.12–4.20	2.96	2.09–4.18	2.78	1.97–3.93	2.55	1.81–3.60
≥9 hours, freq	3.73	1.97–7.06	4.00	2.08–7.68	3.14	1.65–5.99	2.42	1.27–4.62
<b>Musculoskeletal diseases</b>								
≤5 hours, no/occ	2.21	0.96–5.08	2.02	0.87–4.68	2.22	0.96–5.14	2.10	0.91–4.84
6 hours, no/occ	0.98	0.63–1.52	0.93	0.59–1.46	0.95	0.61–1.48	0.97	0.62–1.51
7 hours, no/occ	1.00		1.00		1.00		1.00	
8 hours, no/occ	0.99	0.66–1.49	0.94	0.63–1.42	0.97	0.65–1.46	0.99	0.66–1.49
≥9 hours, no/occ	1.42	0.65–3.09	1.31	0.60–2.86	1.19	0.54–2.61	1.42	0.65–3.10
≤5 hours, freq	3.63	1.87–7.06	2.99	1.52–5.88	3.08	1.57–6.03	3.27	1.68–6.39
6 hours, freq	2.94	1.92–4.49	2.49	1.62–3.84	2.27	1.47–3.50	2.75	1.80–4.23
7 hours, freq	2.34	1.56–3.50	2.21	1.47–3.33	1.70	1.12–2.58	2.23	1.49–3.35
8 hours, freq	2.44	1.39–4.27	2.73	1.55–4.81	2.24	1.27–3.92	2.29	1.30–4.01
≥9 hours, freq	4.47	1.80–11.07	6.25	2.44–16.02	4.18	1.68–10.43	3.66	1.45–9.22
<b>Mental disorders</b>								
≤5 hours, no/occ	2.31	0.71–7.53	2.04	0.62–6.72	2.09	0.64–6.84	1.75	0.54–5.69
6 hours, no/occ	0.93	0.49–1.76	0.85	0.45–1.60	0.89	0.47–1.69	0.89	0.47–1.67
7 hours, no/occ	1.00		1.00		1.00		1.00	
8 hours, no/occ	1.42	0.85–2.35	1.44	0.87–2.39	1.38	0.83–2.29	1.41	0.85–2.34
≥9 hours, no/occ	0.79	0.19–3.26	0.82	0.20–3.41	0.78	0.19–3.25	0.78	0.19–3.22
≤5 hours, freq	6.58	3.17–13.69	4.98	2.35–10.56	6.57	3.14–13.74	3.34	1.60–6.99
6 hours, freq	3.96	2.29–6.84	3.19	1.83–5.56	3.64	2.09–6.36	2.46	1.42–4.28
7 hours, freq	2.62	1.50–4.57	2.33	1.33–4.09	2.42	1.38–4.25	1.75	1.00–3.07
8 hours, freq	4.55	2.41–8.60	4.33	2.28–8.22	4.59	2.42–8.69	2.87	1.51–5.44
≥9 hours, freq	8.56	3.36–21.80	7.22	2.73–19.12	6.66	2.57–17.27	3.11	1.21–8.00

<sup>a</sup> Adjusted for age and gender.<sup>b</sup> Model 1 + marital status, occupational class, work arrangements, physical working conditions, and psychosocial job strain.<sup>c</sup> Model 1 + asthma, diabetes, cardiovascular disease, and musculoskeletal diseases.<sup>d</sup> Model 1 + mental disorders.

## Discussion

This study examined the joint association of sleep duration and insomnia symptoms with subsequent disability retirement. We found that frequent insomnia symptoms were dominant in this joint association, being strongly associated with all-cause disability retirement. Among those with frequent insomnia symptoms, short and long sleepers were more likely to retire. Adjusting for covariates attenuated the studied associations, but they nevertheless remained. Broadly similar joint associations were found concerning disability retirement due to musculoskeletal diseases and mental disorders.

Our previous study on the association between sleep and disability retirement focused only on insomnia symptoms (7). The present study extended the examina-

tion also to sleep duration, especially jointly analyzed with insomnia symptoms. Only one study has previously examined the association between sleep duration and disability retirement (1) while no studies have been conducted on the joint association of sleep duration and insomnia symptoms with disability retirement.

### Main findings in relation to previous studies

Disability retirement results from an assessment of health and work ability. To be entitled to a disability pension, employees must be diagnosed with a disease that seriously reduces the individual's ability to continue working (23). By examining insomnia symptoms together with sleep duration, we found that insomnia symptoms in particular contributed to the deterioration of work ability, eventually leading to retirement due to disability.

Therefore, sleep duration per se, even when notably different from what is considered to be average or optimal, was much less of a threat to an employee's work ability if frequent insomnia symptoms were not present. Similarly, even those with average sleep duration had an increased risk of disability retirement if they had insomnia symptoms.

The control analyses testing the squared effects of sleep duration on disability retirement supported our main findings. They showed that both short and long sleep duration were significantly associated with disability retirement (especially all-cause and retirement due to mental disorders) among those with frequent insomnia symptoms.

There is a lack of studies on the joint association of sleep duration and insomnia symptoms with disability retirement or other indicators of work disability. However, our results are in accordance with previous joint association studies on morbidity and mortality (9–13). Whether the highest risk was found among short or long sleepers varied between the studies, but in all of them, the risks were increased the most among those also reporting insomnia symptoms. One previous study did not find a clear association between all-cause mortality and jointly examined sleep duration and insomnia symptoms (8). However, there was an association between mortality and sleep duration.

There have been some studies on the association between insomnia symptoms and disability retirement, although they did not take sleep duration into account (3–7). The results of the present study are in accordance with these previous ones in that insomnia symptoms were found to be strongly associated with subsequent disability retirement, even after other risk factors were taken into account. The only previous study that examined sleep duration and disability retirement found that only long sleep was associated with disability retirement – in contrast with our findings – however, the joint association of insomnia symptoms and sleep duration was not examined in this study (1).

In our previous study, we found that insomnia symptoms were associated with subsequent disability retirement (7). The present study showed that the associations were even stronger when sleep duration was also taken into account. Our earlier results indicated that the associations between the individual insomnia symptoms – difficulties in initiating sleep, difficulties maintaining sleep, and non-restorative sleep – and disability retirement were largely similar.

As previous studies have shown that sociodemographic and work-related factors and mental health are associated with sleep duration and insomnia symptoms, their confounding and attenuating effects, shown by the analyses, could be expected (15–18). Adjusting for previous somatic diseases attenuated the associations

somewhat, especially when the outcome examined was disability retirement due to musculoskeletal diseases. Our control analyses showed this effect to be mainly derived from the previous musculoskeletal diseases included in the model.

Alongside all-cause disability retirement, we were also able to examine the two largest diagnostic groups, ie, musculoskeletal diseases and mental disorders. The main results found for all-cause retirement largely applied to these diagnostic groups as well. Overall, the joint association of sleep duration and insomnia symptoms with disability retirement was strongest for those who retired due to mental disorders. This finding is in line with previous studies on sleep and mental health, which have shown strong associations between the two, especially between sleep and depression (18, 19), the most prevalent diagnosis among those retiring due to mental disorders in this study.

Our findings highlight the association between sleep and subsequent work disability. Poor sleep has considerable societal impact, owing especially to large costs for the employer and the society due to work disability and the increased use of healthcare services (27–29). Better understanding of poor sleep and its consequences is important while seeking new ways to support the ageing working population's health and longer work careers.

#### Limitations and strengths

Sleep duration and insomnia symptoms were based on self-reports and measured only at baseline. The response alternatives for sleep duration included only whole hours as units. Compared with objective assessments, such as actigraphs and polysomnography, self-reported sleep duration has been found to be prone to certain bias (30). In addition, insomniacs tend to underestimate their sleep duration more than those sleeping well (14). However, it is generally not feasible to use objective assessments in large-scale epidemiological studies. A previous study of the present data found sleep duration to be relatively unchanged for a large proportion of the participants over a follow-up period of 5–7 years (31). Self-report measures are regarded as suitable for research into insomnia symptoms, and the Jenkins inventory used in this study has been validated and developed for clinical and epidemiological research purposes (25, 32).

The 4-item inventory used in order to measure insomnia symptoms did not include daytime impairment (25). This information would be a valuable addition. Daytime impairment is also considered to be a prerequisite in the current Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) criteria for insomnia (33). Another limitation is that our measures did not include sleep disorders such as sleep apnea or restless legs syndrome. Nevertheless, the frequency of

both of these disorders in the general population is estimated to be considerably lower than 20%, which was the prevalence of frequent insomnia symptoms in our study.

Some of the results might be lacking statistical power as there were <100 participants in certain classes of the joint variable of sleep duration and insomnia symptoms. Nevertheless, the main results remained consistent and statistically significant throughout the analyses concerning both the separate effects of sleep duration and insomnia symptoms as well as their joint associations.

Due to the low proportion of men in our sample, there were few disability retirement events among men and the analyses were conducted by pooling and adjusting for both genders. Further studies are needed to confirm whether the associations that we found differ according to gender.

There have been some previous studies on the association between either sleep duration or insomnia symptoms and disability retirement. This study extended this examination to include the joint association of these two key characteristics of sleep, thus providing novel evidence. Further strengths include the use of a large and contemporary dataset with a prospective design. We were able to use the disability retirement register data, which are highly accurate and objective and originally gathered to be used as a basis for pension payments. In addition, data about the leading diagnoses of disability – musculoskeletal diseases and mental disorders – were available.

### Concluding remarks

We found that the joint association of sleep duration and insomnia symptoms with subsequent disability retirement was strongly dominated by frequent insomnia symptoms. This held true for all-cause retirement as well as retirement due to musculoskeletal diseases and mental disorders. Sleep duration also plays a role in this association; among those with frequent insomnia symptoms, short and long sleepers were more likely to retire. This study deepened our understanding of the role of poor sleep in pushing people towards early retirement due to disability. Insomnia symptoms in particular need to be considered in occupational healthcare in order to be able to prevent early exit from the workforce.

### Acknowledgements

The HHS is supported by grants from the Academy of Finland (#1121748, #1129225), the Finnish Work Environment Fund (#107281, #4701347), the Yrjö Jahnesson Foundation, and the Finnish Cultural Foundation. T Lallukka (#1133434) and E Lahelma (#1135630) are

supported by the Academy of Finland and P Haaramo by the Juho Vainio Foundation.

The authors declare no conflicting interests.

### References

1. Sivertsen B, Øverland S, Pallesen S, Bjorvatn B, Nordhus IH, Mæland JG, et al. Insomnia and long sleep duration are risk factors for later work disability. The Hordaland Health Study. *J Sleep Res.* 2009;18:122–128. <http://dx.doi.org/10.1111/j.1365-2869.2008.00697.x>.
2. Åkerstedt T, Kecklund G, Selén J. Disturbed sleep and fatigue as predictors of return from long-term sickness absence. *Ind Health.* 2010;48:209–214. <http://dx.doi.org/10.2486/indhealth.48.209>.
3. Sivertsen B, Overland S, Neckelmann D, Glozier N, Krokstad S, Pallesen S, et al. The long-term effect of insomnia on work disability: the HUNT-2 historical cohort study. *Am J Epidemiol.* 2006;163:1018–1024. <http://dx.doi.org/10.1093/aje/kwj145>.
4. Salo P, Oksanen T, Sivertsen B, Hall M, Pentti J, Virtanen M, et al. Sleep disturbances as a predictor of cause-specific work disability and delayed return to work. *Sleep.* 2010;33:1323–1331.
5. Eriksen W, Natvig B, Bruusgaard D. Sleep problems: a predictor of long-term work disability? A four-year prospective study. *Scand J Public Health.* 2001;29:23–31. <http://dx.doi.org/10.1177/14034948010290010701>.
6. Overland S, Glozier N, Sivertsen B, Stewart R, Neckelmann D, Krokstad S, et al. A comparison of insomnia and depression as predictors of disability pension: the HUNT Study. *Sleep.* 2008;31:875–880.
7. Lallukka T, Haaramo P, Lahelma E, Rahkonen O. Sleep problems and disability retirement: a register-based follow-up study. *Am J Epidemiol.* 2011;173:871–881. <http://dx.doi.org/10.1093/aje/kwq462>.
8. Hublin C, Partinen M, Koskenvuo M, Kaprio J. Sleep and mortality: a population-based 22-year follow-up study. *Sleep.* 2007;30:1245–1253.
9. Suzuki E, Yorifuji T, Ueshima K, Takao S, Sugiyama M, Ohta T, et al. Sleep duration, sleep quality and cardiovascular disease mortality among the elderly: a population-based cohort study. *Prev Med.* 2009;49:135–141. <http://dx.doi.org/10.1016/j.ypmed.2009.06.016>.
10. Chandola T, Ferrie JE, Perski A, Akbaraly T, Marmot MG. The effect of short sleep duration on coronary heart disease risk is greatest among those with sleep disturbance: a prospective study from the Whitehall II cohort. *Sleep.* 2010;33:739–744.
11. Chien K, Chen P, Hsu H, Su T, Sung F, Chen M, et al. Habitual sleep duration and insomnia and the risk of cardiovascular events and all-cause death: report from a community-based cohort. *Sleep.* 2010;33:177–184.

12. Vgontzas AN, Liao D, Bixler EO, Chrousos GP, Vela-Bueno A. Insomnia with objective short sleep duration is associated with a high risk for hypertension. *Sleep*. 2009;32:491–497.
13. Hoevenaer-Blom MP, Spijkerman AMW, Kromhout D, van den Berg JF, Verschuren WMM. Sleep duration and sleep quality in relation to 12-year cardiovascular disease incidence: the MORGEN Study. *Sleep*. 2011;34:1487–1492.
14. Means MK, Edinger JD, Glenn DM, Fins AI. Accuracy of sleep perceptions among insomnia sufferers and normal sleepers. *Sleep Med*. 2003;4:285–296. [http://dx.doi.org/10.1016/S1389-9457\(03\)00057-1](http://dx.doi.org/10.1016/S1389-9457(03)00057-1).
15. Grandner MA, Patel NP, Gehrman PR, Xie D, Sha D, Weaver T, et al. Who gets the best sleep? Ethnic and socioeconomic factors related to sleep complaints. *Sleep Med*. 2010;11:470–478. <http://dx.doi.org/10.1016/j.sleep.2009.10.006>.
16. Stranges S, Dorn JM, Shipley MJ, Kandala NB, Trevisan M, Miller MA, et al. Correlates of short and long sleep duration: a cross-cultural comparison between the United Kingdom and the United States: the Whitehall II Study and the Western New York Health Study. *Am J Epidemiol*. 2008;168:1353–1364. <http://dx.doi.org/10.1093/aje/kwn337>.
17. Lallukka T, Rahkonen O, Lahelma E, Arber S. Sleep complaints in middle-aged women and men: the contribution of working conditions and work-family conflicts. *J Sleep Res*. 2010;19:466–477. <http://dx.doi.org/10.1111/j.1365-2869.2010.00821.x>.
18. Sivertsen B, Krokstad S, Øverland S, Mykletun A. The epidemiology of insomnia: associations with physical and mental health. The HUNT-2 study. *J Psychosom Res*. 2009;67:109–116. <http://dx.doi.org/10.1016/j.jpsychores.2009.05.001>.
19. Roth T. Comorbid insomnia: current directions and future challenges. *Am J Manag Care*. 2009;15:S6–S13.
20. Buxton OM, Marcelli E. Short and long sleep are positively associated with obesity, diabetes, hypertension, and cardiovascular disease among adults in the United States. *Soc Sci Med*. 2010;71:1027–1036. <http://dx.doi.org/10.1016/j.socscimed.2010.05.041>.
21. Lahelma E, Martikainen P, Rahkonen O, Roos E, Saastamoinen P. Occupational class inequalities across key domains of health: results from the Helsinki Health Study. *Eur J Public Health*. 2005;15:504–510. <http://dx.doi.org/10.1093/eurpub/cki022>.
22. Laaksonen M, Aittomäki A, Lallukka T, Rahkonen O, Saastamoinen P, Silventoinen K, et al. Register-based study among employees showed small nonparticipation bias in health surveys and check-ups. *J Clin Epidemiol* 2008;61:900–906. <http://dx.doi.org/10.1016/j.jclinepi.2007.09.010>.
23. Huunan-Seppälä A, Järvisalo J, Laine A, Pirttimäki R, Rissanen P, Seppälä M-L, et al. The prevention of problems related to disallowed disability pensions: a report commissioned by the Parliamentary Trustees of the Social Insurance Institution, Finland. 2003;26:1–43.
24. World Health Organization. International Statistical Classification of Diseases and Related Health Problems, The ICD-10, Volume 1. Second Edition, Tenth Revision. Geneva: World Health Organization; 2004.
25. Jenkins CD, Stanton BA, Niemcryk SJ, Rose RM. A scale for the estimation of sleep problems in clinical research. *J Clin Epidemiol* 1988;41:313–321. [http://dx.doi.org/10.1016/0895-4356\(88\)90138-2](http://dx.doi.org/10.1016/0895-4356(88)90138-2).
26. Karasek R, Gordon G, Pietrokovsky C, Frese M, Pieper C, Schwartz J, et al. Job content questionnaire: questionnaire and users' guide. Lowell: University of Massachusetts; 1985.
27. Kessler RC, Berglund PA, Coulouvrat C, Hajak G, Roth T, Shahly V, et al. Insomnia and the performance of US workers: results from the America insomnia survey. *Sleep*. 2011;34:1161–1171.
28. Sivertsen B, Lallukka T, Salo P. The economic burden of insomnia at the workplace. An opportunity and time for intervention? *Sleep*. 2011;34:1151–1152.
29. Daley M, Morin CM, LeBlanc M, Gregoire JP, Savard J. The economic burden of insomnia: direct and indirect costs for individuals with insomnia syndrome, insomnia symptoms, and good sleepers. *Sleep*. 2009;32:55–64.
30. Lauderdale DS, Knutson KL, Yan LL, Liu K, Rathouz PJ. Sleep duration: how well do self-reports reflect objective measures? The CARDIA Sleep Study. *Epidemiology*. 2008;19:838–845. <http://dx.doi.org/10.1097/EDE.0b013e318187a7b0>.
31. Lyytikäinen P, Rahkonen O, Lahelma E, Lallukka T. Association of sleep duration with weight and weight gain: a prospective follow-up study. *J Sleep Res*. 2010;20:298–302.
32. Moul DE, Hall M, Pilkonis PA, Buysse DJ. Self-report measures of insomnia in adults: rationales, choices, and needs. *Sleep Med Rev*. 2004;8:177–198. [http://dx.doi.org/10.1016/S1087-0792\(03\)00060-1](http://dx.doi.org/10.1016/S1087-0792(03)00060-1).
33. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, 4th edition, text revision. Washington, DC: American Psychiatric Association; 2000.

Received for publication: 5 September 2011