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Sleep duration and sleep difficulties as predictors of occupational injuries: a cohort study

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Abstract

Study objectives: To examine the association between sleep duration and sleep difficulties with different types and causes of workplace and commuting injuries.

Methods: The data were derived from the Finnish Public Sector Study including 89.543 participants (178.309 person-observations). Participants reported their sleep duration and sleep difficulties between 2000-2012. These were linked to occupational injury records from the national register maintained by the Federation of Accident Insurance Institutions. Risk of injuries was followed 1 year after each study wave. Logistic regression analysis with generalized estimating equations (GEE) was used to examine the association between sleep duration/difficulties and risk of injuries and multinomial logistic regression with GEE was used to examine the association with injury types and causes.

Results: Both sleep duration and difficulties were associated with injuries. Employees with short sleep (≤ 6.5 h hours) had 1.07-fold odd of workplace injuries (95 % CI 1.00-1.14) and 1.14 times higher odd of commuting injuries (95 % CI 1.04-1.26) compared to employees with normal sleep duration. For employees with disturbed sleep, the corresponding odd ratios were 1.09-fold (95 % CI 1.02-1.17) and 1.14-fold (95 % CI 1.04-1.26) compared to those without sleep difficulties, respectively. The risk of commuting injuries was higher among those who had difficulty to fall asleep (odds ratio 1.29, 95% CI 1.07-1.55), woke up too early (1.11, 95% CI 1.00-1.23) or had nonrestorative sleep (1.18, 95% CI 1.05-1.33).

Conclusions: Short sleep duration and sleep difficulties are associated with slightly increased risk of workplace and commuting injuries.

Keywords: Commuting injuries, occupational injuries, sleep difficulties, sleep duration, workplace injuries

What this paper adds

Occupational injuries are a global concern, which can lead to disabilities and deaths and disturbed sleep is suggested to be a risk factor for occupational injuries.

Short sleep duration and sleep difficulties predict higher risk for workplace and commuting injuries.

Early identification and proper treatment of insufficient sleep might help to prevent workplace and commuting injuries.

Introduction

Occupational injuries are a global concern, which can lead to disabilities and deaths. (1) In 2019, occupational injuries contributed globally up to 2.3% disability-adjusted life-years and approximately 250.000 deaths among working-age population. (1) In the same year 125.529 occupational injuries occurred in Finland, of which 23.260 were commuting injuries. (2) To effectively prevent occupational injuries, it is essential to identify their key modifiable risk factors.

Short sleep duration and sleep difficulties are suggested to be major risk factors for occupational injuries. (2) In particular, sleep-medication usage, breath-related sleep difficulties, impaired sleep quality and quantity as well as daytime sleepiness, appears to be associated with increased risk of occupational injury. (3) Furthermore, it has been suggested that the risk of occupational injury increases with increasing severity of sleep difficulties and that among different types of sleep difficulties problems initiating sleep is the strongest predictor of occupational injuries. (4) Several studies have focused on different sleep characteristics and occupational injuries in general, but only few studies have examined the association between sleep and specific characters of occupational injuries, such as location (workplace vs. while commuting from or to work), types (wounds, fractures etc.) and cause of injury (slipping, loss of control of machine etc.).

We are aware of only two smaller studies, one from Switzerland and on from France, of disturbed sleep and sleep duration as predictors of different types of occupational injuries. (5,6) However, the study population of both studies was small, ranging from 180 to 880 participants, and the data was cross-sectional. Thus, larger longitudinal studies with more detailed and precise information of occupational

injuries following sleep assessment is warranted to better understand the role of impaired sleep in the occurrence of different types of accidental injuries.

In this study of a large cohort of public sector employees from Finland, we examined associations of sleep duration and sleep difficulties with incident occupational injuries. The longitudinal data used in the analyses enabled us to examine the risk of injuries during one-year follow-up time after the assessment of sleep quality and quantity. Furthermore, we investigated the role of sleep in different types and causes of occupational injuries.

Methods

Study Population

The data were derived from the Finnish Public Sector Study (FPS), which is an ongoing prospective cohort study of employees working in ten towns and 21 hospitals in five hospital districts and one division of municipal health services in Finland. (7) The data in this study included participants who responded to questionnaires measuring sleep at survey waves conducted in 2000-2002 (n=48.598, response rate 68%), 2004 (n=48.076, response rate 66%), 2008 (n=52.891, response rate 71%) or 2012 (n=53.133, response rate 69%), in total 202.698 person-observations. We obtained sleep data from all available survey waves for each participant. 17.958 workers were not in the register after answering the questionnaires and 3.581 were not in employment relationship after answering the questionnaires, and thus were not included in this study**.** 2.580 participants lack the information about sleep difficulties or sleep duration and were therefore excluded. After excluding the observations with missing data (n=24.389) the analytic

sample consisted of 89.543 participants with 178.309 person-observations on sleep. Participants' responses to surveys were linked to injury records obtained from the Federation of Accident Insurance Institution from January 1st, 2000 until December 31st, 2013.

The FPS was approved by the Ethics Committee of the Hospital District of Helsinki and Uusimaa (HUS 1210/2016).

Assessment of sleep duration and sleep difficulties

Each study wave included identical questions about sleep duration and sleep difficulties. To assess sleep duration, the participants were requested to report how many hours they usually sleep per 24 hours using of the following options: '6 hours or less', '6.5 hours', '7 hours', '7.5 hours', '8 hours', '8.5 hours', ' 9 hours', '9.5 hours' or '10 hours or longer'. The sleep duration was categorized into three groups: 'short' sleep duration (≤ 6.5 hours of sleep), 'normal' sleep duration (7-8.5 hours of sleep) and 'long' sleep duration (≥ 9 hours of sleep) according to National Sleep Foundation's time duration recommendations. (8)

Sleep difficulties were measured with the Jenkins Sleep Problem Scale, (9) which consists of four items inquiring the occurrence of difficulties falling asleep, difficulties maintaining sleep during the night, waking up too early in the morning, and nonrestorative sleep. Sleep difficulties were categorized into two groups based on the most frequent symptom: 'no sleep difficulties' (≤ 4 nights per week) and 'sleep difficulties' (≥ 5 night per week). The categorization captures those who exceed the diagnostic criteria for an insomnia disorder (10) and it has been used in previous studies. (11,12) In addition, each type of sleep difficulty was dichotomized as: 'no

certain type of sleep difficulty' (≤ 4 nights per week) and 'certain type of sleep difficulties' (≥ 5 night per week).

Assessment of occupational injuries

Both workplace injuries and commuting injuries are regarded as occupational injuries in Finland and are compensated through a statutory insurance system. According to the applicable law in Finland the employer is required to take an insurance for all employees for case of occupational injuries and occupational diseases. Detailed description of the system is provided in the Supplemental material 1. Reported injuries are recorded in the national register maintained by the Federation of Accident Insurance Institutions and are collected to the statistics. The national personal identification numbers (unique number to assigned to all Finnish residents) were used to link the cohort members of the FPS study to these records until December 31, 2013. For the current study we used 1-year-follow-up after each study wave to capture relatively recent injuries after sleep measurements.

Information on the types and causes of workplace and commuting injuries were available from the Federation of Accident Insurance Institutions register. The categories for different types of workplace and commuting injuries used in the current study were: 1) 'Wounds and superficial injuries', 2) 'Dislocations, sprains and strains', 3) 'Bone fractures', 4) 'Concussions and internal injuries' and 5) 'Multiple injuries and other injury'. 'Burns, scalds, frostbites, poisonings and infections, drowning and asphyxiation' were combined with 'Multiple injuries and other injury' category, because the number of cases were small.

The following categorization for causes of workplace injuries were used: 1) 'Slipping, stumbling and falling or stepping on an object', 2) 'Sudden body movement with or without physical stress', 3) 'Loss of control of machine, handling equipment, handling tool or animal' and 4) 'Violence and other causes', which included 'shock, fright, aggression, threat and unexpected presence'. Categories for causes of commuting injuries were: 1) 'Slipping, stumbling and falling, stepping on an object', 2) 'Driving off the road and collision with a car, bicycle, motorcycle or train', and 3) 'Violence and other causes'.

Covariates

The chosen covariates are found to be associated with impaired sleep duration/sleep difficulties or workplace/commuting injuries. Age, gender and occupational title were derived from the employers' records. Age was categorized into five categories: '≤ 30', '31-40', '41-50', '51-60' and '> 60'. Occupational titles were into four groups: manual, service workers, lower non-manual and higher non-manual. (13)

Job demand was measured using the shorter version of Job Content Questionnaire and was based on three statements: "I have to work really hard", "I am expected to perform excessive amount of work" and "I do not have time to get my job done". Each participants' mean response (scale 1-5) was calculated. (14,15) Working time was self-reported and categorized into 'regular' working time (only day shifts) and 'shift work' (shift work with or without night work and permanent night work combined, by night work is meant that the bulk of the work shift is after midnight).

Information on health-risk behaviors were obtained from the questionnaires. Body mass index (BMI), which was divided into three categories: 'Normal weight' (BMI <

25 kg/m2), ‘Over weight’ (BMI ≥25 kg/m2 and < 30 kg/m2) and ‘Obese’ (BMI ≥ 30 kg/m2). (16) There were only 1.808 (1%) low weight (BMI < 18.5) participants in the data so the ‘low weight’ and ‘normal weight’ categories were combined. Other covariates were: current smoking status (no vs. yes), alcohol risk-use (no vs. yes, ≥ 250 g of pure alcohol for men and ≥ 190 g pure alcohol for women per week), physical activity (low vs. high, ≥ 14 metabolic equivalent (MET) hours per week). (17,18)

Diabetes was identified by entitlements to special reimbursements of diabetes drugs (oral or insulin). (19) The identification of cardiovascular diseases was based on special reimbursements for coronary heart disease drug or on the hospital care of the coronary heart disease. Information about whether participant had depression was obtained based on the survey question: “Has your doctor ever told you that you have depression?” (yes vs. no).

Statistical analyses

Logistic regression analysis with generalized estimating equations (GEE) was used to examine the association between, any and specific types of sleep difficulties and sleep duration and workplace/commuting injuries. The GEE model controls for the intra-individual correlation between the repeated measurements. We tested different correlation structures for the GEE model (exchangeable, unstructured, independent and autoregressive) and found no significant differences in quasi-likelihood criterion and we selected to use exchangeable-correlation structure in the analyses. The standard errors are computed using the robust (‘sandwich’) estimators, which is default for SAS 9.4.

The association between sleep duration, any sleep difficulties and each different type of sleep difficulty and workplace/commuting injuries were analyzed separately in different models. ‘Any sleep difficulty’ means that the participants had any of the different types of sleep difficulties. The analyses were also conducted for combination of short sleep and sleep difficulties to examine how ‘high-risk group’, i.e. both short sleep duration and any sleep difficulty, was associated with workplace/commuting injuries. Multinomial logistic regression with GEE was used to examine the association of sleep problems and sleep duration with injury types and causes.

Results are shown as odds ratios (ORs) and 95 % confidence intervals (CI). The analyses were initially adjusted for demographic factors (age and gender). The second model was additionally adjusted for work factors (occupational status, shift work and job demands), health-related behaviors (smoking, heavy alcohol-use, physical activity) and health (diabetes, cardiovascular diseases, depression). In addition, we conducted additional analysis by adjusting for previous (one year before answering the questionnaires) workplace/commuting injuries.

Since occupational injuries are more common in men (20), we tested the interactions of gender with sleep duration and sleep difficulty on occupational injuries. The gender interactions with sleep duration and sleep difficulties were non-significant for workplace injuries ($p=0.25$ and $p=0.87$) and for commuting injuries ($p=0.46$ and $p=0.99$), respectively. Therefore, men and women were combined in the analysis.

All the analyses were conducted by using SAS 9.4.

Results

The characteristics of the entire study population and among those with occupational injuries are shown in *Table 1*. The mean age was 46.3 years (SD 9.5) and majority of the participants were women (80.8 %). There were 5.495 workplace injuries and 2.617 commuting injuries during the 1-year follow-up periods after each study wave.

As shown in *Table 2*, the risk of workplace injury was higher if the participants' sleep duration was short compared to normal sleep duration, or if participant had any sleep difficulty, difficulty to fall asleep, participant woke up too early, had non-restorative sleep or difficulty to maintain sleep compared to no difficulty after adjusting for age and gender (Model 1). In addition, the risk for workplace injury was higher if the participant had both short sleep duration and any sleep difficulty compared to having normal sleep duration and no sleep difficulties. When taking into account work-related and health-related behaviors and health (Model 2), short sleep duration, and having both short sleep duration and any sleep difficulty remained statistically significant. There was no association between long sleep duration and workplace injuries.

Short sleep duration, any type of sleep difficulty, difficulty to fall asleep, waking up too early, non-restorative sleep, difficulty to maintain sleep and having both short sleep duration and any sleep difficulty were all associated with higher risk of commuting injuries (Model 1) (*Table 3)*. After further adjusting for work-related and health-related factors and health (Model 2), all except the association between difficulty to maintain sleep and commuting injuries remained statistically significant.

As shown in *Table 4,* short sleep duration was associated with concussions and internal injuries as well as slipping, stumbling, falling and stepping on an object. Any sleep difficulty was associated with dislocations, sprains and strains. Having both short sleep duration and any sleep difficulty was associated with slipping, stumbling, falling and stepping on an object. There was no association between long sleep duration and different types and causes of injuries.

There were associations between short sleep duration, any sleep difficulty and having both short sleep duration and any sleep difficulty and dislocations, sprains and strains as well as slipping, stumbling and falling, stepping on an object (*Table 5*). There was no association between long sleep duration (≥ 9 h) and different injury causes or types during commuting.

When previous workplace injuries were taken into account, the association between short sleep duration and workplace injuries disappeared (*Supplement Table 1*). The associations between short sleep duration, sleep difficulties, difficulty to fall asleep, waking up too early, non-restorative sleep as well as having both short sleep duration and sleep difficulties with commuting injuries remained significant (*Supplement Table 2*). The associations between different types and causes of workplace and commuting injuries remained also significant.

The associations between each different type of sleep difficulty and different types and causes of workplace and commuting injuries can be found from *Supplement Tables 3-6.*

Discussion

In this study of over 170.000 measurements of sleep in 89.543 public sector workers either having short sleep duration and having sleep difficulties predicted higher risk for both workplace and commuting injuries compared to normal sleep duration and no sleep difficulties and the risk was little bit higher if the participant had both short sleep duration and any sleep difficulty. Furthermore, when analyzing the different types of sleep difficulties, incident commuting injuries were more common among those who had difficulty to fall asleep, woke up too early in the morning or had nonrestorative sleep even after controlling health- and work-related factors.

Work- and health related factors have been suggested to partially explain the association between insufficient sleep and occupational injuries. Firstly, the association of shift work, sleep disturbances and occupational injuries has been widely discussed in the literature. (21) The underlying mechanisms between shift work and occupational injuries have suggested to mainly relate to the unhealthy lifestyle and adverse health effects to which impaired sleep duration and poor sleep quality can predispose to. For example, shift work and insufficient sleep may influence negatively on eating patterns, smoking and alcohol-use, which can predispose to several chronic diseases (21). Moreover, impaired sleep duration and sleep difficulties, which are common among shift workers, impair glucose tolerance and insulin sensitivity which can lead to type 2 diabetes and obesity which are risk factors for occupational injuries. (19,21,22) Finally, mental health problems, which are common among shift workers and are considered to be a possible underlying reason for insufficient sleep, are known to increase the risk for occupational injuries. (23) However, in the current study, most of the associations between short sleep duration

and sleep difficulties and occupational injuries remained significant after controlling for work- and health-related confounders, suggesting that short sleep duration and sleep difficulties play a role as independent risk factors for both workplace and commuting injuries.

Insufficient sleep may have ‘immediate’ and ‘chronic’ effects on the risk of occupational injuries. For example, excessive fatigue and decreased vigilance due to insufficient sleep can immediately increase the injury risk. (3) On the other hand, chronic sleep difficulties and impaired sleep duration predispose to adverse health effects such as chronic diseases which can for its part increase the risk of occupational injuries. Our data enabled us to examine chronic effects of insufficient sleep because the information of participants’ sleep was gathered from one point where the participant reported sleep difficulties during past four weeks. Therefore, it is not certain that the participant had impaired sleep duration/sleep difficulties just before the incident injury, and thus the evaluation of ‘immediate’ effects of insufficient sleep on injury risk was not possible in the current study.

A novel feature of this study involves analyses of insufficient sleep duration and sleep difficulties for workplace and commuting injuries separately. It appears that short sleep duration and having sleep difficulties, especially difficulty to fall asleep, waking up too early in the morning or having a nonrestorative sleep, are slightly stronger predictors for commuting injuries than for workplace injuries. Possible reason for this might be that the safety regulations at workplaces are carefully followed in Finland. The reason for higher risk for an injury while commuting could lie in decreased vigilance and improper attention to surroundings. In the morning, injury risk may be increased due to insufficient sleep whereas at the end of the workday

worker might be tired especially after sleeping too little or poorly in the previous night. Early morning awakenings could also adversely affect the workers' vigilance during commuting. (24,25) Moreover, the weather conditions, darkness and slippery roads, especially during wintertime can further increase the risk for commuting injuries if the worker is not cautious in Nordic countries such as Finland. (26)

We are not aware of explanations of why certain sleep difficulties are more strongly associated with determinants of commuting injuries than others. It is possible that persons with difficulty to initiate sleep are more sleep deprived and sleepier during workdays than persons with other types of sleep difficulties. (4) Early morning awakenings could be attributable to circadian rhythm disturbances, which can also cause daytime sleepiness and thus reduced vigilance. (24) Unfortunately, the available data did not allow us to determine specific mechanisms underlying the association between different types of sleep difficulties and workplace and commuting injuries which would be an important question to resolve in the future.

Large data and detailed register-based information on occupational injuries also enabled us to examine the association between different types and causes of workplace and commuting injuries. We found that those who slept under 6.5 hours had higher risk for internal injuries and concussions as well as the risk for slipping, stumbling, falling or stepping on an object at workplace. On the other hand, sleep difficulties were associated with dislocations, sprains and strains at the workplace. Regarding commuting injuries, both short sleep duration and sleep difficulties were associated with dislocations, sprains and strains as well as slipping, stumbling, falling or stepping on an object. One explanation for the observed association is that those who do not sleep well, are less physically active (27,28) which, in turn, may

lead to reduced muscle strength and impaired neuromuscular coordination thereby increasing the risk for injuries, especially slipping and falling.

Unexpectedly, sleep difficulties were not associated with vehicle-related injuries during commuting, although some studies suggest that sleep difficulties are risk factor for car accidents. (29) However, there were only 414 vehicle-related accidents documented in our data (15 %), thus statistical power to detect relatively weak associations may have been reduced. Moreover, we did not have information regarding the kind of transportation the participants used, so instead of driving their own car, they may have been passengers of the bus.

This study has several strengths. To our knowledge, this was the first prospective study with a large study population that examined the association between sleep length and sleep difficulties with occupational injuries at workplace and during commuting. By using the national injury register, we were able to determine objectively the timing, type and causes of the injuries. An additional strength is that we used 1-year-follow-up to capture relatively recent injuries after sleep measurements.

We also acknowledge some limitations in our study. Firstly, the information about sleep duration and difficulties was self-reported and are prone to reporting bias. Secondly, this study population consisted of Northern European public sector workers whose jobs are relatively safe, which may limit the generalizability of the results. Our categorization of sleep difficulties took into account only the most severe cases of sleep difficulties (sleep difficulties ≥ 5 nights per week), and thus it is possible that the effect of insufficient sleep is underestimated, as also minor sleep difficulties may increase the injury risk. We did not have information about sleep

apnea, which could be underlying reason for many of the sleep difficulties. Moreover, the information of sleep duration and sleep difficulties within four past weeks is from the point when the participants answered the questionnaire while the injury occurred during the 12 months following the sleep measurement, thus we cannot be certain that the participants' sleep was disturbed right before the injury. However, sleep disturbances and short sleep duration have been shown to be associated with a range of adverse outcomes, suggesting that chronic sleep problems are common among those who report recent sleep problems. (30) Thus, exposure misclassification is unlikely to be a major source of bias in our study although these data cannot be used to evaluate immediate effects of sleep difficulties and impaired sleep duration on injuries. Finally, we measured sleep by self-reports. Although more accurate ways to measure sleep would give more reliable evidence for relatively rare outcomes such as injuries, collecting objective sleep data would be extremely costly. Additionally, we did not evaluate the association of insufficient sleep with the severity of the injuries based on the length of the sickness absence or disability. That would deserve additional research. Further studies should confirm our findings about the association between different types and causes with workplace and commuting injuries as well as to expand the investigation in other types of working environments.

In conclusion, the association of short sleep duration and sleep difficulties with commuting injuries are stronger than for workplace injuries. Of different types of sleep difficulties, falling asleep is the strongest predictor for both workplace and commuting injuries.

Contributorship

MA, MH, JV and SS conceived the study idea. JE, MK and JV participated in acquisition of the data. MA and JP conducted the analyses. MA drafted the first version of the manuscript, with critical revisions from MH, JP, JE, MK, JV and SS. All authors approved the final version of the manuscript.

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Disclosure statement

This was not an industry supported study. The authors have indicated no financial conflicts of interests or competing interests.

Data sharing/availability

We are allowed to share anonymised questionnaire data of the Finnish Public Sector Study by application for with bona fide researchers with an established scientific record and bona fide organizations. For information about the Finnish Public Sector Study contact Prof. Mika Kivimaki mika.kivimaki@helsinki.fi / Dr. Jenni Ervasti jenni.ervasti@ttl.fi.

Ethichs approval Statement

The Ethics committee of Helsinki and Uusimaa Hospital District approved the study (registration number HUS/1210/2016).

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Table 1. Characteristics of the participants in the Finnish Public Sector study and among those with workplace and commuting injuries during a one-year follow-up

	All observations, n (%)	Workplace injuries, n (%)	p value	Commuting injuries, n (%)	p value	No injuries, n (%)	p value
N	178.309	5.495		2.617			
Age (mean, SD)	46.3 (10)	46.1 (10)		47.7 (9)		46.3 (10)	
Age ≤ 30	12.269 (7)	384 (7)	0.012	149 (6)	<.0001	11.750 (7)	<.0001
Age 30-40	37.372 (21)	1.213 (22)		431 (17)		35.741 (21)	
Age 40-50	60.873 (34)	1.787 (33)		870 (33)		58.207 (34)	
Age 50-60	60.623 (34)	1.918 (35)		1.020 (39)		57.737 (34)	
Age > 60	7.208 (4)	193 (3)		147 (6)		6.873 (4)	
Gender							
Men	34.304 (19)	1.580 (29)	<.0001	278 (11)	<.0001	32.462 (19)	<.0001
Women	144.005 (81)	3.915 (71)		2.339 (89)		137.846 (81)	
Occupational status							
Higher non-manual	57.598 (33)	993 (18)	<.0001	643 (25)	<.0001	55.978 (33)	<.0001
Lower non-manual	58.543 (33)	1.303 (24)		894 (35)		56.373 (33)	
Service workers	38.038 (22)	1.701 (31)		681 (26)		35.698 (22)	
Manual	22.685 (13)	1.458 (27)		374 (14)		20.878 (12)	
Missing	1.445	40		25			
Body Mass Index							
< 25	91.212 (52)	2.363 (44)	<.0001	1.193 (47)	<.0001	87.708 (53)	<.0001
25-29 (Over weight)	58.076 (33)	1.987 (37)		884 (35)		55.241 (33)	
≥30 (Obese)	24.753 (14)	1.015 (19)		458 (18)		23.299 (14)	
Missing	4.268	130		82			
Smoking							
Yes	27.477 (16)	1.154 (22)	<.0001	386 (15)	0.37	25.961 (16)	<.0001
No or former	146.971 (84)	4.211 (78)		2.169 (85)		140.676 (84)	
Missing	3.861	130		62			
Alcohol use							
Risk-use	16.267 (9)	499 (9)	0.92	208 (8)	0.04	15.566 (9)	0.26
No risk-use	161.267 (91)	4.971 (91)		2.391 (92)		154.061 (91)	
Missing	722	25		18			
Physical activity							
Active (> 14 MET h)	116.391 (66)	3.453 (63)	0.0001	1.706 (65)	0.96	111.304 (66)	0.0011
Low active (≤ 14 MET h)	61.274 (34)	2.023 (37)		900 (35)		58.390 (34)	
Missing	644	19		11			
Depression							
Yes	21.657 (13)	801 (16)	<.0001	425 (17)	<.0001	20.455 (13)	<.0001
No	147.294 (87)	4.336 (84)		2.006 (83)		141.032 (87)	
Missing	9.358	358		186			

Job demands (1-5), mean (SD)	3.2 (1)	3.2 (0.88)		3.3 (1)		3.2 (1)	
Working time							
Regular	121.744 (69)	3.298 (61)	<.0001	1.757 (68)	0.12	116.751 (69)	<.0001
Shift work	54.534 (31)	2.136 (39)		840 (32)		51.605 (31)	
Missing	2.031	61		20			
Diabetes							
Yes	3427 (2)	154 (3)	<.0001	33 (2)	0.069	3.215 (2)	<.0001
No	174.882 (98)	5.341 (97)		2.554 (98)		167.093 (98)	
Cardiovascular disease							
Yes	1871 (1)	81 (2)	0.0017	28 (1)	0.92	1.764 (1)	0.008
No	176.438 (99)	5.414 (98)		2.589 (99)		168.544 (99)	

The association between categorical variables and workplace/commuting injuries were tested with chi-square test and for continuous variables with analyses of variance.

Table 2. Association between sleep duration and different types of sleep difficulties and workplace injuries.

	N/n	%		Model 1			Model 2	
Sleep duration				OR	95 % CI		OR	95 % CI
Short ≤ 6.5 h	43.232/1.536	3.6		**1.20**	**1.12-1.27**		**1.07**	**1.00-1.14**
Normal 7-8.5 h	129.588/3.796	2.9		1 (ref)			1 (ref)	
Long ≥ 9 h	5.489/163	3.0		1.03	0.88-1.21		0.92	0.78-1.10
Sleep difficulties								
Any sleep difficulty								
Yes	42.964/1.438	3.4		**1.13**	**1.07-1.21**		1.06	0.99-1.13
No	135.439/4.057	3.0		1 (ref)			1 (ref)	
Difficulty to fall asleep				**1.31**	**1.16-1.49**		1.12	0.98-1.28
Yes	7.427/292	3.9						
No	170.882/5.203	3.0		1 (ref)			1 (ref)	
Waking up too early								
Yes	31.056/1.021	3.3		**1.11**	**1.03-1.19**		1.02	0.95-1.11
No	147.253/4.474	3.0		1 (ref)			1 (ref)	
Non-restorative sleep								
Yes	22.059/769	3.5		**1.16**	**1.07-1.26**		1.05	0.96-1.15
No	156.250/4.726	3.0		1 (ref)			1 (ref)	
Difficulty to maintain sleep								
Yes	17.583/600	3 4		**1.15**	**1.06-1.26**		1.05	0.95-1.15
No	160.726/4.895	3.0		1 (ref)			1 (ref)	
Short sleep duration and/or sleep difficulties								
Either	51.593/1.734	3.4		**1.17**	**1.10-1.24**		**1.08**	**1.02-1.16**
Both	17.289/620	3.6		**1.25**	**1.15-1.37**		**1.11**	**1.01-1.22**
None	109.427/3.141	2.9		1 (ref)			1 (ref)	

Notes: N=number of participants, n=number of workplace injuries. Reference group for sleep duration is 7-8.5 h, for sleep difficulties “no sleep difficulties” and for short sleep duration and/or sleep difficulties sleep duration 7-8.5 h and “no sleep difficulties”.

Model 1 is adjusted for age and gender

Model 2 is adjusted for age, gender, occupational status, job demands, shift work, smoking, heavy alcohol use, physical activity, depression, diabetes and cardiovascular diseases

Table 3. Association between sleep duration and different types of sleep difficulties and commuting injuries.

	N/n	%		Model 1			Model 2	
Sleep duration				OR	95 % CI		OR	95 % CI
Short ≤ 6.5 h	43.232/730	1.7		**1.19**	**1.09-1.30**		**1.14**	**1.03-1.25**
Normal 7-8.5 h	129.588/1.803	1.4		1 (ref)			1 (ref)	
Long ≥ 9 h	5.489/84	1.5		1.09	0.88-1.37		0.99	0.77-1.26
Sleep difficulties								
Any sleep difficulty								
Yes	42.964/744	1.7		**1.20**	**1.10-1.30**		**1.13**	**1.03-1.24**
No	135.439/1.873	1.4		1 (ref)			1 (ref)	
Difficulty to fall asleep								
Yes	7.427/161	1.2		**1.43**	**1.21-1.69**		**1.29**	**1.07-1.55**
No	170.882/2.456	1.4		1 (ref)			1 (ref)	
Waking up too early								
Yes	31.056/551	1.8		**1.18**	**1.07-1.30**		**1.11**	**1.00-1.24**
No	147.253/2.066	1.4		1 (ref)			1 (ref)	
Non-restorative sleep								
Yes	22.059/398	**1.8**		**1.26**	**1.13-40**		**1.18**	**1.05-1.34**
No	156.250/2.219	1.4		1 (ref)			1 (ref)	
Difficulty to maintain sleep								
Yes	17.583/327	1.9		**1.22**	**1.08-1.37**		1.09	0.95-1.24
No	160.726/2.290	1.4		1 (ref)			1 (ref)	
Short sleep duration and/or sleep difficulties								
Either	51.593/834	1.6		**1.18**	**1.09-1.29**		**1.17**	**1.06-1.28**
Both	17.289/320	1.9		**1.31**	**1.16-1.48**		**1.20**	**1.05-1.38**
None	109.427/1.463	1.3		1 (ref)			1 (ref)	

Notes: N=number of participants, n=number of commuting injuries. Reference group for sleep duration is 7-8.5 h, for sleep difficulties “no sleep difficulties” and for short sleep duration and/or sleep difficulties sleep duration 7-8.5 h and “no sleep difficulties”.

Model 1 is adjusted for age and gender

Model 2 is adjusted for age, gender, occupational status, job demands, shift work, smoking, heavy alcohol use, physical activity, depression, diabetes and cardiovascular diseases

Table 4. Association between sleep duration and sleep difficulties and workplace injury types and causes.

	Short	**Normal**						
Short ≤ 6.5 h vs. 7-8.5 h	**N=43.232**	**N=129.588**		**Model 1**			**Model 2**	
Type of injury	**Injuries (3.6 %)**	**Injuries (2.9 %)**		**OR**	**95 % CI**		**OR**	**95 % CI**
Wounds and superficial injuries	408 (0.9)	1.060 (0.8)		**1.15**	**1.02-1.29**		1.00	0.88-1.14
Dislocations, sprains and strains	625 (1.5)	1.573 (1.2)		**1.18**	**1.07-1.30**		1.02	0.92-1.34
Bone fractures	92 (0.2)	216 (0.2)		1.17	0.91-1.52		1.15	0.87-1.51
Concussions and internal injuries	290 (0.7)	645 (0.5)		**1.33**	**1.15-1.53**		**1.24**	**1.06-1.45**
Multiple injuries and other injuries	121 (0.3)	302 (0.2)		1.20	0.97-1.48		1.10	0.87-1.38
Injury causes								
Slipping, stumbling and falling, stepping on an object	316 (0.7)	706 (0.5)		**1.25**	**1.09-1.43**		**1.21**	**1.04-1.40**
Sudden body movement	251 (0.6)	648 (0.5)		1.16	0.99-1.35		1.03	0.88-1.21
Loss of control of machine, handling equipment, handling tool, animal	395 (0.9)	966 (0.8)		**1.21**	**1.07-1.36**		1.07	0.94-1.22
Violence, other	148 (0.3)	421 (0.3)		1.10	0.91-1.33		1.06	0.87-1.29
Any sleep difficulty vs. no sleep difficulty	426 (1.0)	1.055 (0.8)		**1.21**	**1.08-1.36**		0.98	0.86-1.12
Type of injury	Sleep difficulties, N=42.939, Injuries (3.4 %)	No sleep difficulties, N=135.370, injuries (2.9 %)						
Wounds and superficial injuries	378 (0.9)	1.140 (0.8)		1.07	0.98-1.20		0.98	0.86-1.12
Dislocations, sprains and strains	611 (1.4)	1.656 (1.2)		**1.21**	**1.10-1.33**		**1.12**	**1.01-1.25**
Bone fractures	71 (0.2)	242 (0.2)		0.91	0.69-1.18		0.85	0.64-1.13
Concussions and internal injuries	254 (0.6)	712 (0.5)		1.14	0.99-1.32		1.07	0.91-1.26
Multiple injuries and other injuries	124 (0.3)	307 (0.2)		1.29	1.04-1.60		1.17	0.92-1.48
Injury causes								
Slipping, stumbling and falling, stepping on an object	283 (0.7)	772 (0.6)		1.11	0.97-1.27		1.10	0.95-1.28
Sudden boby movement without or with physical stress	247 (0.6)	683 (0.5)		1.18	1.02-1.37		1.06	0.90-1.25
Loss of control of machine, handling equipment, handling tool, animal	375 (0.9)	1.025 (0.8)		1.18	1.04-1.33		1.08	0.95-1.34
Violence, others	158 (0.4)	427 (0.3)		1.21	1-00-1.46		1.14	0.93-1.40
Missing	375 (0.9)	1.150 (0.9)		1.09	0.97-1.22		0.97	0.85-1.11
Both short sleep duration and sleep difficulties vs. none	Both	No sleep difficulties or no short sleep duration						
Type of injury	N= 17.289	N=109.427						
Wounds and superficial injuries	160 (0.9)	892 (0.8)		1.15	0.97-1.37		0.97	0.80-1.18

Dislocations, sprains and strains	265 (1.5)	1.296 (1.2)		**1.33**	**1.16-1.53**		1.12	0.96-1.31
Bone fractures	32 (0.2)	182 (0.2)		1.02	0.70-1.50		0.98	0.65-1.47
Concussions and internal injuries	112 (0.7)	534 (0.5)		**1.33**	**1.08-1.63**		1.22	0.97-1.53
Multiple injuries and other injuries	51 (0.3)	237 (0.2)		**1.38**	**1.01-1.88**		1.16	0.83-1.62
Injury causes								
Slipping, stumbling and falling, stepping on an object	137 (0.8)	593 (0.5)		**1.34**	**1.11-1.62**		**1.31**	**1.07-1.61**
Sudden body movement	104 (0.6)	536 (0.5)		**1.27**	**1.02-1.58**		1.07	0.84-1.35
Loss of control of machine, handling equipment, handling tool, animal	158 (0.9)	788 (0.7)		**1.28**	**1.07-1.53**		1.08	0.89-1.31
Violence, other	68 (0.4)	347 (0.3)		**1.32**	**1.02-1.72**		1.20	0.90-1.59
	mis 153 (0.9)	mis 877 (0.8)						

Notes: N=number of all injuries of specific injury type or causes (%). Reference group for sleep duration is 7-8.5 h, for sleep difficulties “no sleep difficulties” and for short sleep duration and/or sleep difficulties sleep duration 7-8.5 h and “no sleep difficulties”.

Model 1 is adjusted for age and gender

Model 2 is adjusted for age, gender, occupational status, job demands, shift work, smoking, heavy alcohol use, physical activity, depression, diabetes and cardiovascular diseases

Table 5. The association between sleep duration and sleep difficulties and commuting injury types and causes.

	Short	**Normal**						
Short ≤ 6.5 h	**N=41.405**	**N=132.114**		**Model 1**			**Model 2**	
Type of injury	**Injuries (1.7 %)**	**Injuries (1.4 %)**		**OR**	**95 % CI**		**OR**	**95 % CI**
Wounds and superficial injuries	123 (0.3)	268 (0.2)		**1.34**	**1.08-1.67**		**1.35**	**1.07-1.72**
Dislocations, sprains and strains	307 (0.7)	752 (0.6)		**1.22**	**1.07-1.40**		**1.20**	**1.04-1.39**
Bone fractures	79 (0.2)	186 (0.1)		1.16	0.89-1.51		0.97	0.72-1.30
Concussions and internal injuries	169 (0.4)	459 (0.4)		1.11	0.93-1.33		1.03	0.84-1.26
Multiple injuries and other injuries	52 (0.1)	138 (0.1)		1.10	0.79-1.53		1.01	0.71-1.45
Injury causes								
Slipping, stumbling and falling, stepping on an object	573 (1.3)	1.384 (1.1)		**1.21**	**1.09-1.33**		**1.15**	**1.04-1.29**
Driving off the road and collision	122 (0.3)	312 (0.2)		1.21	0.97-1.50		1.16	0.92-1.48
Violence, other	35 (0.1)	107 (0.1)		0.99	0.67-1.46		0.91	0.59-1.39
Any sleep difficulty								
Type of injury	Sleep difficulties, N=42.964, Injuries (1.7 %)	No sleep difficulties, N=135.439, injuries (1.4 %)						
Wounds and superficial injuries	105 (0.2)	300 (0.2)		1.03	0.82-1.29		1.03	0.80-1.31
Dislocations, sprains and strains	323 (0.8)	768 (0.6)		**1.29**	**1.13-1.48**		**1.21**	**1.05-1.40**
Bone fractures	80 (0.2)	197 (0.2)		1.15	0.88-1.50		1.05	0.78-1.42
Concussions and internal injuries	182 (0.4)	470 (0.4)		1.18	0.99-1.40		1.14	0.94-1.38
Multiple injuries and other injuries	54 (0.1)	138 (0.1)		1.17	0.85-1.61		0.99	0.69-1.42
Injury causes								
Slipping, stumbling and falling and stepping on an object	596 (1.4)	1.428 (1.1)		**1.24**	**1.13-1.37**		**1.16**	**1.04-1.30**
Driving off the road and collision	110 (0.3)	339 (0.3)		1.02	0.82-1.26		1.03	0.81-1.30
Violence, other	38 (0.1)	106 (0.1)		1.10	0.76-1.60		0.95	0.63-1.44
Both short sleep duration and sleep difficulties vs. none	Both	No sleep difficulties or no short sleep duration						

Type of injury	N= 17.289	107.964						
Wounds and superficial injuries	54 (0.3)	231 (0.2)		**1.36**	**1.00-1.86**		1.36	0.97-1.91
Dislocations, sprains and strains	136 (0.8)	597 (0.6)		**1.41**	**1.16-1.70**		**1.30**	**1.06-1.61**
Bone fractures	39 (0.2)	157 (0.1)		1.33	0.94-1.89		1.07	071-1.62
Concussions and internal injuries	68 (0.4)	369 (0.3)		1.14	0.88-1.48		1.02	0.76-1.37
Multiple injuries and other injuries	23 (0.1)	109 (0.1)		1.25	0.77-2.01		0.98	0.57-1.69
Injury causes								
Slipping, stumbling and falling and stepping on an object	263 (1.5)	1.118 (1.0)		**1.39**	**1.21-1.59**		**1.26**	**1.09-1.47**
Driving off the road and collision	42 (0.2)	259 (0.2)		1.04	0.75-1.45		0.94	0.64-1.37
Violence, other	15 (0.1)	86 (0.1)		1.09	0.63-1.90		0.90	0.48-1.67

Notes: N=number of all injuries of specific injury type or causes (%). Reference group for sleep duration is 7-8.5 h and for sleep difficulties “no sleep difficulties”.

Model 1 is adjusted for age and gender

Model 2 is adjusted for age, gender, occupational status, job demands, shift work, smoking, heavy alcohol use, physical activity, depression, diabetes and cardiovascular diseases