Ergonomics

ISSN: 0014-0139 (Print) 1366-5847 (Online) Journal homepage: https://www.tandfonline.com/loi/terg20

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To cite this article: Christin Gerhardt, Maria Undine Kottwitz, Tarsia Jana Lüdin, Dominique Gabriel & Achim Elfering (2020) Work and sleep quality in railway employees: an actigraphy study, Ergonomics, 63:1, 13-30, DOI: 10.1080/00140139.2019.1677945

To link to this article: https://doi.org/10.1080/00140139.2019.1677945

Published online: 22 Oct 2019.

ERGONOMICS
2020, VOL. 63, NO. 1, 13–30
https://doi.org/10.1080/00140139.2019.1677945

ARTICLE

Work and sleep quality in railway employees: an actigraphy study

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ABSTRACT

This actigraphy study tests whether daily work stressors (time pressure, social stressors), work resources (control, social support) and mental detachment from work predict sleep quality, when controlling for demands and control after work. Fifty-two railway employees participated during five consecutive workdays by completing diary questionnaires and wearing an actigraphy device. The results confirmed that social stressors from supervisors predicted more frequent sleep fragmentation and lower sleep efficiency the following night. Higher levels of daily time control at work predicted shorter sleep-onset latency and better self-reported sleep quality. Leisure time control as a covariate turned out to be a private resource, followed by fewer awakenings the following night. Detachment after work related negatively to social stressors and time pressure at work but was unrelated to indicators of sleep quality; detachment after work neither mediated nor moderated the relationship between social stressors from supervisors and sleep quality. Work redesign to increase time control and reduce social stressors is recommended to preserve daily recovery in railway employees.

Practitioner summary: Sleep is important to renew health- and safety-related resources in railway employees. This diary and actigraphy study shows that higher daily work stressors were antecedents of lower sleep quality the following night, while more time control was followed by better sleep quality. Work redesign could promote health and safety by improving sleep quality.

Abbreviations: ISTA: Instrument for stress-oriented task analysis; EEG: electroencephalography; FTE: full time equivalent

ARTICLE HISTORY
Received 30 October 2018
Accepted 25 September 2019

KEYWORDS
Sleep; actigraphy; occupational health; time pressure; social stressors at work

Introduction

Operations in the railway service require precision, often under time pressure (Elfering, Grebner, and Haller 2012). Hence, work in the railway service is challenging with respect to the degree of responsibility, mental demands, and stress levels (Myrtek et al. 1994). Conductors, engine drivers, and traffic controllers have to maintain alertness and respond immediately to irregular events and critical signals. In the aftermath of demanding work, recovery is required (Semmer, Grebner, and Elfering 2010). Increasingly, evidence suggests that work conditions often impair recovery processes (Sonnentag, Casper, and Pinck 2016), including sleep as the most important such process (Åkerstedt, Nilsson, and Kecklund 2009; Sonnentag, Casper, and Pinck 2016). The current actigraphy study tests work stressors and work resources as antecedents of individual variation in sleep quality.

Work stressors and sleep

Adverse work conditions called *work stressors* increase the likelihood of employees to experience stress (Zapf and Semmer 2004). This may affect recovery mechanisms, such as sleep. Sleep is typically measured by two types of variables: sleep quality and sleep quantity (i.e. sleep duration). Whereas sleep quantity describes the amount of time someone spends asleep, the quality of sleep is a multifaceted construct (Barnes 2012; Crain et al. 2019). Following Buysse et al. (1989), sleep quality 'includes quantitative aspects of sleep, such as sleep duration, sleep latency or number of arousals, as well as more purely subjective aspects, such as depth or restfulness of sleep' (p. 194). It can be recorded both by means of a self-report and objective indicators (e.g. Kottwitz et al. 2019; Pereira and Elfering 2014a, 2014b). Although self-reported and objective indicators of sleep quality often do not coincide, both measures are important and

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informative (e.g. Matthews et al. 2018; Sadeh 2011). Because sleep quantity is a necessary part of and influences sleep quality, it is recommended to measure both categories together (e.g. Crain et al. 2019; Pereira, Meier, and Elfering 2013). Task-related work stressors, including time pressure, may impede sleep quality when sustained work-related activation is present long after work (Berset et al. 2011; Stuck and Maurer 2009). The experience of work stress is linked to biophysiological reactions, including activation of the sympathetic nervous system and hypothalamic-pituitary-adrenal axis activity (Kirschbaum 2010). Persisting high levels of catecholamines and cortisol cause psychophysical activation that maintains alertness (Steiger 2002) and decreases readiness for sleep onset (Porkka-Heiskanen, Zitting, and Wigren 2013). The neurotransmitters and hormones involved in the stress response are also involved in sleep regulation, and the relationship between stress and sleep is entangled in different disease processes and psychiatric disorders (Sanford, Suchecki, and Meerlo 2015). Evidence for time pressure (Kazemi et al. 2016; Mizuno et al. 2016) as a risk factor for sleep problems is increasing (Litwiller et al. 2017). Reduction of working time has been shown to increase sleep quality (Schiller et al. 2017) and recovery-eliciting activities at home after work (Schiller et al. 2018). According to Meijman and Mulder's (1998) effort–recovery theory, time pressure may lead to psychophysiological load reactions that persist after work. Persistent psychophysiological activation is in conflict with the deactivation that is a main characteristic of sleep (Åkerstedt, Nilsson, and Kecklund 2009; McEwen 1998; Meijman and Mulder 1998). We expect high daily time pressure to cause persistent activation that delays sleep-onset latency and shortens sleep duration while the risk of awakenings increases (Zijlstra, Cropley, and Rydstedt 2014). We hypothesise that experienced daily time pressure predicts more impairment in sleep quality the following night (H1). Daily work stressors of railway employees, like time pressure, are often task related, but employees also often experience social stressors at work. Those are among the most detrimental work stressors, inducing experiences of considerable stress both during and after work (Kivimäki et al. 2012; Nixon et al. 2011; Semmer, Mcgrath, and Beehr 2005; Semmer, Meier, and Beehr 2016). Beyond time pressure, social stressors at work have a strong potential to disturb sleep when individuals do not detach from work issues after work but mentally stick to work problems with supervisors and colleagues (Elfering et al. 2016; Pereira et al. 2016). Social stressors at work are often unpredictable and uncontrollable and are among the strongest cortisol-eliciting stressors (Dickerson and Kemeny 2004). Meanwhile, they also seem to cause the most severe sleep dysregulation (Sanford, Suchecki, and Meerlo 2015). We expect a given day's social stressors to predict more impairment in sleep quality the following night (H2). A recent large-scale study (Elfering et al. 2016) supported a mediation model with strain and restricted sleep quality to mediate the association between unfairness at work and health complaints. In diary research (Pereira and Elfering 2014a, 2014b), social stressors were shown to be linked to more frequent awakening in the subsequent night via lack of detachment; detachment is defined as an individual's feeling of being away from the work situation (Etzion, Eden, and Lapidot 1998). The basic stressor-detachment model, as proposed by Sonnentag and Fritz (2015), showed evidence for two proposed mechanisms involved in the recovery process: detachment to mediate the stressor–strain link, and detachment to attenuate the stressor–strain link. Hence, the current ambulatory assessment study tested the hypotheses, that detachment in the evening after work mediates between daily social stressors from supervisors and subsequent sleep quality impairments (H3, H4) and/or attenuates the association between daily social stressors from supervisors and subsequent sleep quality impairments (H5).

Work resources and sleep

Favourable work conditions such as time control and social support that decrease the likelihood of stress experience are called *work resources* (Zapf and Semmer 2004). Daily time-related resources should result in better sleep quality in the following night because stress levels and accompanying sustained activation are lower when employees have more degrees of freedom in time management. Evidence for time control as a sleep-protecting work characteristic is mixed. Large longitudinal studies (Salo et al. 2014; Takahashi et al. 2012; Tucker et al. 2015, 2016) did show a beneficial impact of time control on sleep quality. Kubo et al. (2016) showed an increase in time control across a 1-year follow-up; this was found to correspond with a decrease in fatigue and an increase in actigraphy-assessed sleep quality. A longitudinal study on new cases of sleep disturbance across 5 years (Åkerstedt et al. 2012) did show a beneficial impact of time control on sleep quality. In contrast, an intervention study that increased participation possibilities (Framke et al. 2016) did not show related changes in sleep quality. Another intervention study using actigraphy (Marino et al. 2016) failed to show that games designed to increase control of work processes were effective in improving sleep quality. It is noteworthy that a recent study even challenged the view that high decision latitude serves as a sleep- protective

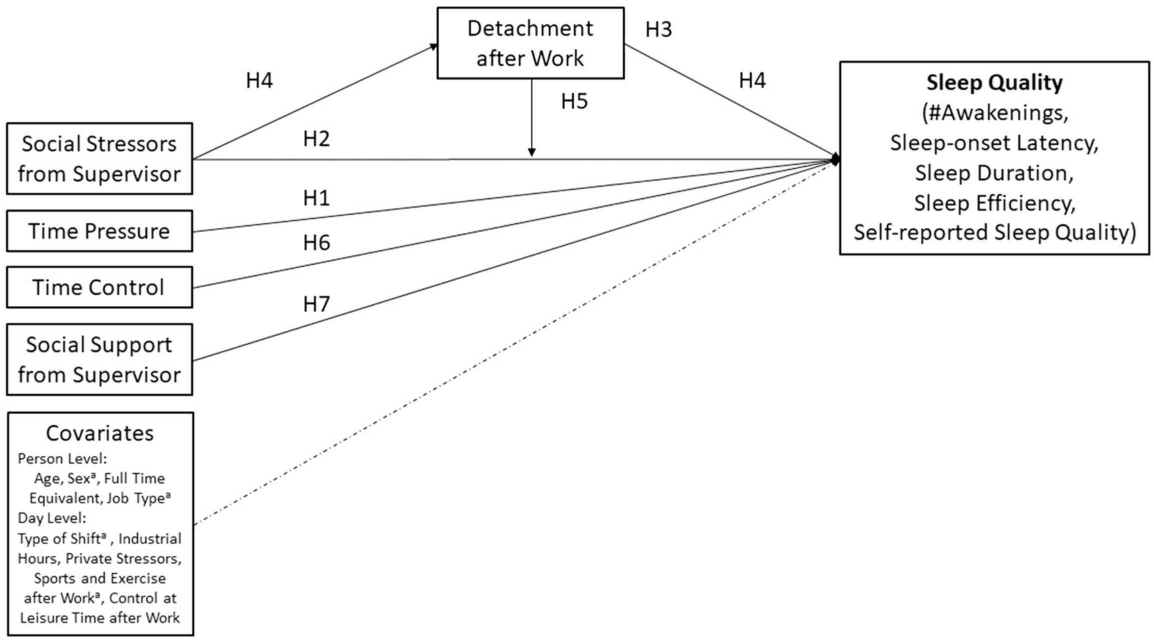

Figure 1. The theoretical model. H: hypothesis; [a]: Dummy coding.

factor (Dich et al. 2018). Contrary to expectations, it was *high* and not *low* decision latitude at work that amplified the negative association between stressful events and sleep quality (Dich et al. 2018). Following this, present-day work resources such as time control are expected to predict better sleep quality (H6).

In addition to time control, social support from supervisors is another work resource that is associated with better sleep quality and that prevents impairments of sleep quality due to daily job stressors (Pow et al. 2017). A longitudinal study across 8 years (Gosling et al. 2014) showed social support to be positively associated with the course of sleep quality. A large-scale Finnish study (Sinokki et al. 2010) showed lack of social support to predict lower sleep quality. Hence, present-day social support from supervisors is expected to predict better sleep quality (H7).

All hypotheses and the relationships between them are represented in Figure 1. Of note, the hypotheses are tested with control of daily private stressors after work and daily control during leisure time after work, in order to show the unique association of daily work-related stressors and resources with sleep (that go beyond other sources of stress and control). Within our study, leisure time describes all waking time someone spends apart from work and outside of working hours. Control during leisure time after work is known to be a recovery-promoting factor that should improve sleep quality (Cappelleri et al. 2009) and should therefore be especially taken into account as a control variable. By doing this, our research adds to further insight into unique work–sleep relationships by showing constraints of possible resources like leisure time control, since beyond them work-related stressors might still influence recovery mechanisms.

Methodology

Participants

Participants worked at a railway company in Switzerland. All 150 employees who worked as conductors (guiding in passenger areas), engine drivers (regulating machines), or traffic controllers of the company were contacted. Fifty-four employees agreed to participate (participation rate of 36%). Participants had to work a minimum of 60% of a 42-h full-time schedule. Most participants worked full time (72.2%). Mean tenure was 10.3 years ($SD = 7.45$ years). All participants worked a shift schedule. The final sample included 42 men and 12 women (22.2%). Most participants worked as engine drivers (61.1%). Other participants were train conductors (31.5%) or traffic controllers (7.4%). Age ranged between 24 and 63 years ($M = 46$; $SD = 9.7$). Participants all gave their informed consent to the study, and all 54 participants finished the study. The study was conducted in accordance with the Declaration of Helsinki and the code of the Swiss Association of Psychology. The ethical committee of the responsible university faculty approved the study proposal (proposal 2010-08-00003).

Study design

All questionnaire data were assessed electronically across five working days and nights (Qualtrics Survey, Woznyj 2017). One week before the daily assessments started, participants answered a general questionnaire. Participants received a portable data collection device (Sensewear armband, see Actigraphy section) and instructions. In the following week, daily questionnaires were filled out in the morning of each working day, immediately after the end of work, and immediately before participants went to sleep. All participants worked in a rotating schedule of early shifts (51.3%, of observation days, begun before 6 a.m.), day shifts (17.1%, begun between 6 a.m. and 2 p.m., ending between noon and 8 p.m.), or the late shift (31.6%, ending later than 8 p.m.). The duration of shifts ranged between 5.4 and 12.2 h. Mean duration was 8.8 h (*SD* = 1.1 h). According to their shift work schedule, participants received reminding emails 2 h in advance to fill out all questionnaires. The Sensewear armband was worn continuously so that participants could get used to it before the study started and to cover the whole week (7 days, including five working days). The Sensewear armband was worn during the whole day on the left forearm and taken off only for showering.

Questionnaires

General questionnaire

Before the daily measures started, participants completed a general questionnaire that included questions about demographic background; work situation, for example, sex, age, job type (traffic controllers, engine drivers, train conductors); and part-time work (% of a Full Time Equivalent [FTE]).

Morning diary

Self-reported reduced sleep quality during the prior night. A single item asked for an evaluation of the previous night's sleep quality ('How satisfied are you with the sleep quality of last night?') with four response options, ranging from 1 (very satisfied) to 4 (very unsatisfied). The single item on sleep quality was previously shown to have acceptable reliability and validity (Cappelleri et al. 2009; for a test of single items on sleep quality, see also Rosenzveig et al. 2014).

End-of-work diary

Daily time pressure at work was measured by four items of a shortened version of the Instrument for Stress-Oriented Task Analysis (ISTA, Semmer, Zapf, and Dunckel 1999; e.g. 'How often does it happen today that you cannot take your break, or that you cannot take your break on time, because of too much work?'). The answering format of the items ranged from 1 (very rarely/never) to 5 (very often/constantly). The Cronbach's alpha for these data was .66.

Daily social stressors from supervisors referred to negative interactions with supervisors and were measured with a scale by Frese and Zapf (1987). This contained five items, which were adapted to the day level (e.g. 'Today at work, I had a conflict with my supervisor'), using a 5-point Likert scale that ranged from 1 (strongly disagree) to 5 (strongly agree). The Cronbach's alpha for these data was .74.

Daily time control at work (e.g. influence on work, pace, and schedule) was assessed with five items from the ISTA (Semmer, Zapf, and Dunckel 1999; e.g. 'Today, could you decide yourself how much time you spend on a task?'). The response format of the items ranged from 1 (very rarely/never) to 5 (very often/constantly). The Cronbach's alpha was .71.

Social support from supervisor was assessed with five items using the scale by Caplan, Cobb, and French (1975; German translation by Frese [1989]). Questions asked how much supervisors helped the respondent to feel better, were willing to listen to work-related problems, showed empathy and understanding for problems at work, spent time to help solve problems, and helped in difficult situations at work. Response options ranged from 1 (not at all) to 5 (always). The Cronbach's alpha was .96.

Bedtime diary

We suggested above that social stressors might impair sleep quality through prolonged reactions in terms of arousal and/or cognition. We therefore included lack of psychological detachment from work on the day level as a potential mediator. Psychological detachment was measured with a four-item scale developed by Sonnentag and Fritz (2007), adapted for use in a diary study. The items used were: 'Today I forgot about work', 'Today I didn't think about work at all', 'Today I distanced myself from work', and 'Today I got a break from the demands of work'. The items were scored on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). The Cronbach's alpha varied from day to day and ranged from .87 to .94 ($M = 3.81$; $SD = 1.12$). Psychological detachment was assessed immediately before going to bed.

A single item examined private stressors after work. The question asked whether participants experienced an argument or conflict with partners, children, relatives, friends or others after the end of work.

Agreements were summed into an index that ranged from 0 to 5. To assess *control* of leisure time after work, one item from the German version of the Recovery Experiences Questionnaire by Sonnentag and Fritz (2007) was used ('Today, I determined the course of the evening myself'). The item used a 5-point scale ranging from 1 (I do not agree at all) to 5 (I fully agree).

A single item assessed sports and exercise after work: 'Did you participate in sports or carry out any sporting activities/exercise after work or in the evening (e.g. cycling, swimming, hiking, etc.)?' The response format was binary (0 = no, 1 = yes).

Actigraphy

The term actigraphy refers to miniaturised computerised methods to monitor movements. Sleep parameters are estimated through integrated algorithms that process movement data. Compared to polysomnygraphy that directly monitors the EEG during sleep (Åkerstedt et al. 2018), actigraphy can be seen as an effective way to estimate sleep behaviour that does not allow studying sleep stages (Morgenthaler et al. 2007; Sadeh 2011).

In the current study, we used a BodyMedia Sensewear Armband, including a multi-accelerometer device. Every minute, 2-axis oscillometric sensors assessed body movements. Data were analysed with BodyMedia software (Littner et al. 2003). We measured different sleep indicators, since sleep quality is a combination of both quantitative aspects and subjective impressions (Buysse et al. 1989; Harvey et al. 2008). The time participants needed to fall asleep after going to bed was coded as sleep onset latency. Sleep fragmentation was coded as the number of awakenings that lasted 5 min or longer and were preceded and followed by at least 15 min of uninterrupted sleep (Sadeh, Keinan, and Daon 2004). Sleep duration represented the time in minutes of sleep until final waking up in the morning. The percentage of time of sleep duration versus time being in bed was defined as sleep efficiency. Those objective measures were supplemented by the morning diary ('How satisfied are you with the sleep quality of last night?'). Inaccurate measurements (e.g. malfunction of the actigraphs) were identified by visual inspection of raw data. These were coded as missing data. Data losses were small and resulted from loss of dermal contact (2.5%) or participants forgetting to wear the armband again after taking a shower (1.8%). Naps during the day were not included in the analyses.

Data analysis

The data include repeated measurements across seven consecutive days including five working days. Thus, the data have a multi-level structure, with participant demographics and information from the general questionnaire at the person level (Level 2) and day- or night-related outcome variables at the day level (Level 1) (Eid, Gollwitzer, and Schmitt 2010; Woltman et al. 2012).

With respect to the person-level variable, we controlled for sex, age, job type, and FTE in multi-level regression analyses. The prevalence of sleep problems increases with age and is higher in women compared to men (Kudielka et al. 2004; Ribet and Derriennic 1999). We used a 0/1 dummy-coding procedure with two dummy variables for job type (representing traffic controllers and engine drivers compared to the remaining job types) to look at whether being on a specific job has an influence on the study variables. At the day level, we controlled for the type of shift (early and late shift, dummy coded), the industrial hours (time worked today), private stressors, doing sports and exercise after work, and control of leisure time after work. Finally, we also controlled for the autoregression, which is the correlation between the different values of one variable across different measurement points. Predictors at the person level were centred using a grand mean and day-level predictors at the participant's mean ('person mean centring') due to the interpretation of within-person effects (Ohly et al. 2010). This procedure removes the information about differences between persons (Enders and Tofighi 2007). Using multi-level regression modelling, four regression models were calculated for each indicator of sleep quality. The first model included all work-related predictor variables. In the second model, private stressors, doing sports and exercise after work, and control of leisure time after work were added. In the third model we included detachment, while in the fourth model the interaction of detachment and social stressors at work was added.

The sample sizes in multi-level regression analysis at the person level (level 2, $N = 54$ individuals) and day level (level 1, $n = 201$ days/nights) were sufficient (Maas and Hox 2005). The maximum number of recorded nights of working days was $54 \times 5 = 270$. However, because of autocorrelations included in the analyses (which were lacking in the first working day's night), the maximum number was reduced to $54 \times 4 = 216$. The sample size of level 2 fitted the recommended minimum size of 50 (Maas and Hox 2005).

Table 1. Descriptive statistics of study variables.

Variables	Number of items	*M*	SD	α
Day level:				
(1) Daily time pressure at work (end of work measure)	4	1.93	1.05	0.66
(2) Daily social stressors supervisor (end of work measure)	5	1.05	0.22	0.74
(3) Detachment after work (evening measure)	4	4.28	0.83	0.94
(4) Daily time control at work (end of work measure)	5	2.70	0.99	0.71
(5) Social support supervisor (end of work measure)	5	2.03	1.40	0.98
(6) Early shift this day (0 = no, 1 = yes; end of work measure)	1	0.50	0.50	n.a.
(7) Day shift this day (0 = no, 1 = yes; end of work measure)	1	0.33	0.47	n.a.
(8) Industrial hours (end of work measure)	1	8.85	1.4	n.a.
(9) Private stressors after work (evening measure, index)	5	0.18	0.39	n.a.
(10) Sports and exercise after work (0 = no, 1 = yes; evening measure)	1	0.11	0.32	n.a.
(11) Leisure time control (evening measure)	1	4.38	0.91	n.a.
(12) Awakenings during night sleep (number, actigraphy)	–	1.27	1.11	n.a.
(13) Sleep-onset latency (min., actigraphy)	–	12.06	12.02	n.a.
(14) Sleep duration (min., actigraphy)	–	363.94	99.70	n.a.
(15) Sleep efficiency (% sleeping while lying in bed, actigraphy)	–	85.19	8.64	n.a.
(16) Self-reported sleep quality next morning (morning measure)	–	2.99	0.64	n.a.
(17) Autoregression: Awakenings day before	–	1.28	1.23	n.a.
(18) Autoregression: Sleep-onset latency day before	–	12.30	12.01	n.a.
(19) Autoregression: Sleep duration day before	–	347.35	85.33	n.a.
(20) Autoregression: Sleep efficiency day before	–	84.47	9.11	n.a.
(21) Autoregression: Self-reported sleep quality day before Person Level:	–	2.95	0.67	n.a.
(22) Age (years)	1	46.09	9.68	n.a.
(23) Sex (0 = m, 1 = f)	1	0.21	0.41	n.a.
(24) Full Time Equivalent (FTE)	1	94.63	9.75	n.a.
(25) Traffic controller (0 = no, 1 = yes)	1	0.08	0.28	n.a.
(26) Engine driver (0 = no, 1 = yes)	1	0.59	0.49	n.a.

M: mean; SD: standard deviation; α: Cronbach's alpha; n.a.: not applicable.

Note that unstandardised coefficients were reported. The alpha level was set to $p < .05$, two-tailed.

Results

Descriptive results

Means and standard deviations are shown in Table 1. Average daily social stressors with supervisors were low. On average, participants experienced just over one awakening per night. Mean sleep efficiency was 85%. Mean sleep onset latency was 12 min and average sleep duration was 6 h. Pearson correlations between study variables are shown in Table 2.

Work stressors

Daily social stressors with supervisors and daily time pressure were negatively related to detachment after work. Daily social stressors with supervisors, but not time pressure, were related to more awakenings in the following night. Sleep efficiency was negatively related to daily social stressors with supervisors. Self-reported sleep quality was negatively related to time pressure but not to daily social stressors with supervisors. Detachment after work was unrelated to actigraphy-based indicators of sleep quality but was positively related to self-reported sleep quality.

Work resources

Time control and social support from supervisors at work were not related to actigraphy-based indicators of sleep quality or self-reported sleep quality in the following night, but both were positively related to sleep duration in the previous night.

Covariates

More control during leisure time after work was followed by fewer awakenings at night.

Test of hypotheses

> Today's time pressure, social stressors with supervisors, and after-work detachment as antecedents of lower sleep quality in the following night:

Table 3 shows results of the multi-level regression analysis of awakenings, sleep-onset latency, sleep duration, sleep efficiency and self-reported sleep quality in the next morning on our predictor variables.

Time pressure was not a significant predictor of any indicator of sleep quality in the four regression models (H1). Social stressors with supervisors (H2), however, significantly predicted more frequent awakenings and lower sleep efficiency (Table 3, model 1), and these effects of social stressors with supervisors were

Table 2. Pearson's correlations between study variables.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Time pressure	1																		
2. Social stressors	.100	1																	
3. Time control at work	−.136	−.032	1																
4. Leisure time control	−.265**	−.094	.232**	1															
5. Social support Sv	−.112	−.076	.101	.009	1														
6. Private stressors	−.115	.087	.102	.028	.000	1													
7. Detachment	−.382**	−.220**	.089	.368**	.091	−.143*	1												
8. Awakenings	−.057	.170*	.101	−.176*	−.047	.070	−.019	1											
9. Sleep-onset latency	.116	−.023	.008	.055	.006	.055	.053	.066	1										
10. Sleep duration	−.049	.049	−.060	−.044	.086	.118	.046	.064	.046	1									
11. Sleep efficiency	−.084	−.124	−.011	.056	.105	.087	−.045	−.462**	−.386**	.362**	1								
12. Self-reported sleep quality next morning	−.171*	−.022	−.100	−.016	.023	.091	.137	−.022	−.001	.266**	.078	1							
13. Awakenings day before	.019	.125	.010	−.043	−.021	−.005	.024	.267**	.084	−.054	−.293**	−.071	1						
14. Sleep-onset latency day before	.092	−.062	.174*	.043	−.013	.042	−.018	−.051	.306**	.139*	−.129	.096	−.010	1					
15. Sleep duration day before	−.014	−.068	.174*	.032	.191**	.052	−.034	−.140*	.082	.284**	.233**	.033	.112	.031	1				
16. Sleep efficiency day before	−.058	−.043	.031	.009	.125†	.079	−.097	−.348**	−.164*	.219**	.563**	.039	−.460**	−.262**	.450**	1			
17. Self-reported sleep quality day before	−.127	.005	.013	−.015	−.004	.059	.061	.006	−.101	.087	.004	.500**	−.165*	.035	.117	.051	1		
18. Industrial hours (time worked today)	−.171*	.003	.019	−.023	−.057	.002	−.168*	−.075	−.004	−.019	.074	−.004	−.135	.203**	.037	.030	.064	1	
19. Age	−.294**	−.074	−.230**	−.037	−.119	.138	−.011	.045	−.216**	−.152*	.067	−.027	−.002	−.143*	−.264**	−.025	−.049	.035	1
20. Full work schedule or part-time work (% of a Full Time Equivalent [FTE])	−.084	−.090	−.052	−.049	−.113	−.057	.211**	.037	.018	−.053	−.144*	.350**	.004	.087	−.211**	−.202**	.320**	.028	.203**

Note: **Correlation is significant at the 0.01 level; *Correlation is significant at the 0.05 level; Sv: supervisor; 1–18 are day level, 19–20 are person level.

observed even after we included leisure time control and private stressors after work (frequent awakenings: Table 3, model 2: $B = 1.077$, $p = .003$; lower sleep efficiency: Table 3, model 2: $B = -7.047$, $p = .003$). Detachment after work did not predict sleep quality in the following night (H3).

Detachment after work as a mediator and/or a moderator of the link between daily social stressors from supervisors and lower sleep quality:

In multi-level regression analyses, less detachment from work during leisure time was not predicted by daily social stressors from supervisors ($B = 0.051$, $p = .413$). Moreover, detachment from work during leisure time was not found to be a significant predictor of sleep quality indicators (Table 3, model 3). Hence, detachment did not function as a mediator between social stressors from supervisors and indicators of sleep quality (H4). In addition, no interaction term between social stressors from supervisors and detachment was found to be a significant predictor (H5, Table 3, model 4).

Daily time control and daily social support from supervisors as antecedents of better sleep quality:

Daily time control (H6) significantly predicted better self-reported sleep quality (Table 3, model 2, $B = -0.186$, $p = .008$) and shorter sleep-onset latency (Table 3, model 2, $B = -3.669$, $p = .023$). In the case of shorter sleep-onset latency, daily time control reached significance only after leisure time variables were added to the analysis but failed to be significant when only work-related predictors were included (Table 3, model 1). Social support from supervisors was not a significant predictor of any indicator of sleep quality (H7). In addition to work-related resources, we found our covariate control during leisure time after work to predict less frequent awakenings (Table 3, model 2, $B = -0.242$, $p = .009$).

Discussion

The current ambulatory diary study on railway employees addressed occupational factors that are potentially related to sleep quality while controlling for nonoccupational factors. It is noteworthy that the study included social processes at work, by asking about both daily social stressors and social support from supervisors.

A recent cross-sectional longitudinal questionnaire study on a large Norwegian sample (Vleeshouwers, Knardahl, and Christensen 2016) identified quantitative job demands, decision control, role conflict, and

Table 3. Multi-level regression analysis of awakenings, sleep-onset latency, sleep duration, sleep efficiency, and self-reported sleep quality in the next morning.

Variable	Awakenings							
Model	1		2		3		4	
	B	SE	*B*	SE	*B*	SE	*B*	SE
Constant	1.280	0.261	1.386	0.254	1.387	0.254	1.372	0.253
Person level								
Sex[a]	0.469	0.305	0.438	0.292	0.438	0.292	0.451	0.290
Age	0.010	0.010	0.012	0.009	0.012	0.009	0.013	0.009
Full work schedule or part-time work (% of a FTE)	0.026*	0.012	0.026*	0.012	0.026	0.012	0.026	0.012
Traffic controller[b]	−0.899**	0.360	−0.896**	0.345	−0.898**	0.345	−0.939**	0.345
Engine driver[b]	−0.575*	0.239	−0.626**	0.229	−0.625**	0.229	−0.630**	0.228
Day level								
Autoregression	−0.076	0.068	−0.075	0.066	−0.076	0.067	−0.083	0.067
Social stressors Sv	1.135**	0.392	1.077**	0.386	1.078**	0.386	1.136**	0.388
Time pressure	0.222	0.169	0.104	0.170	0.106	0.171	0.088	0.171
Early shift[b]	0.302	0.202	0.277	0.197	0.427	0.197	0.304	0.198
Day shift[b]	0.355	0.225	0.307	0.219	0.308	0.220	0.327	0.220
Time worked today (industrial hours)	−0.037	0.057	−0.040	0.056	−0.039	0.056	−0.033	0.056
Social support Sv	−0.117	0.095	−0.131	0.094	−0.131	0.094	−0.126	0.093
Time control at work	−0.071	0.164	−0.141	0.162	−0.139	0.164	−0.123	0.164
Leisure time control			−0.242*	0.102	−0.245*	0.105	−0.254*	0.105
Private stressors after work			0.426	0.262	0.425	0.262	0.415	0.262
Doing sports after work[b]			−0.335	0.227	−0.337	0.228	−0.351	0.227
Detachment					0.016	0.133	0.021	0.132
Social stressors X detachment							1.438	1.258
IGLS	569.078		557.980		557.966		556.665	
VAR level 2 (Person)	0.178	0.083	0.153	0.076	0.152	0.076	0.150	0.075
VAR level 1 (Day)	0.854	0.099	0.818	0.094	0.818	0.094	0.814	0.094

Variable	Sleep onset latency							
Model	1		2		3		4	
	B	SE	*B*	SE	*B*	SE	*B*	SE
Constant	12.946	2.764	12.417	2.808	12.390	2.812	12.410	2.812
Person level								
Sex[a]	1.950	3.224	1.885	3.282	1.873	3.289	1.842	3.290
Age	−0.270**	0.102	−0.279**	0.104	−0.280**	0.104	−0.281**	0.104
Full work schedule or part-time work (% of a FTE)	0.129	0.130	0.102	0.132	0.102	0.133	0.101	0.133
Traffic controller[b]	2.625	3.807	2.771	3.876	2.831	3.888	2.945	3.906
Engine driver[b]	−0.642	2.492	−0.707	2.541	−0.719	2.546	−0.716	2.546
Day level								
Autoregression	0.011	0.082	0.010	0.081	0.009	0.081	0.010	0.081
Social stressors Sv	0.641	4.316	−0.623	4.379	−0.645	4.376	−0.870	4.442
Time pressure	−0.027	2.245	−0.233	1.960	−0.316	1.975	−0.238	1.993
Early shift[b]	−0.939	2.226	−1.113	2.226	−1.120	2.225	−1.181	2.234
Day shift[b]	−2.222	2.496	−1.606	2.495	−1.639	2.499	−1.664	2.500
Time worked today (industrial hours)	0.443	0.672	0.435	0.661	0.401	0.668	0.385	0.670
Social support Sv	0.462	1.095	0.314	1.080	0.310	1.080	0.301	1.080
Time control at work	−3.134	1.792	−3.669*	1.834	−3.760*	1.851	−3.828*	1.865
Leisure time control			−0.387	1.159	−0.293	1.192	−0.251	1.200
Private stressors after work			2.555	2.631	2.589	2.630	2.505	2.645
Doing sports after work[b]			4.238	2.576	4.309	2.583	4.358	2.588
Detachment					−0.508	1.528	−0.520	1.529
Social stressors X detachment							−4.129	13.998
IGLS	1575.378		1571.353		1571.243		1571.156	
VAR Level 2 (Person)	15.808	9.558	18.161	9.558	18.395	9.588	18.379	9.610
VAR Level 1 (Day)	114.168	12.534	110.148	12.534	109.928	12.511	109.887	12.494

Variable	Sleep duration							
Model	1		2		3		4	
	B	SE	*B*	SE	*B*	SE	*B*	SE
Constant	356.321	24.936	356.818	25.083	356.113	25.007	356.539	24.836
Person level								
Sex[a]	18.643	30.646	18.567	30.636	18.253	30.525	17.263	30.241
Age	−1.830	0.968	−1.766	0.969	−1.800	0.966	−1.853	0.958
Full work schedule or part-time work (% of a FTE)	−0.383	1.221	−0.432	1.225	−0.431	1.221	−0.462	1.210
Traffic controller[b]	17.705	36.274	16.770	36.270	18.501	36.173	22.260	36.004
Engine driver[b]	16.861	23.676	15.725	23.723	15.290	23.640	15.123	23.417
Day level								
Autoregression	−0.358**	0.110	−0.358**	0.111	−0.366**	0.111	−0.377**	0.112
Social stressors Sv	2.752	34.439	0.871	35.473	0.025	35.395	−6.531	35.992

(*continued*)

Table 3. Continued.

Variable	Sleep duration							
Model	1		2		3		4	
	B	SE	*B*	SE	*B*	SE	*B*	SE
Time pressure	−12.796	15.357	−15.608	15.625	−17.682	15.711	−15.604	15.839
Early shift[b]	−3.747	18.594	−3.103	18.658	−3.661	18.618	−5.805	18.727
Day shift[b]	−35.533	20.775	−35.547	20.861	−36.318	20.819	−36.471	20.768
Time worked today (industrial hours)	1.860	5.132	1.818	5.121	0.923	5.178	0.504	5.191
Social support Sv	−0.038	8.704	−0.047	8.707	−0.147	8.686	−0.357	8.685
Time control at work	−13.683	14.124	−14.783	14.668	−17.058	14.790	−18.890	14.896
Leisure time control			−8.499	9.378	−6.102	9.626	−4.972	9.685
Private stressors after work			−1.348	21.263	−0.546	21.224	−2.638	21.322
Doing sports after work[b]			−3.720	21.362	−1.640	21.399	−0.139	21.426
Detachment					−13.000	12.323	−13.421	12.323
Social stressors X detachment							−111.661	113.331
IGLS	2439.396		2438.497		2437.388		2436.425	
VAR Level 2 (Person)	2205.395	817.715	2199.239	814.835	2478.693	808.967	2103.167	794.189
VAR Level 1 (Day)	7051.927	803.398	7019.286	799.646	6985.798	795.823	6986.575	795.831

Variable	Sleep efficiency							
Model	1		2		3		4	
	B	SE	*B*	SE	*B*	SE	*B*	SE
Constant	82.978	2.413	82.789	2.423	82.849	2.432	82.851	2.434
Person level								
Sex[a]	2.013	3.193	2.096	3.186	2.100	3.201	2.097	3.202
Age	0.072	0.101	0.073	0.101	0.075	0.101	0.075	0.102
Full work schedule or part-time work (% of a FTE)	−0.161	0.126	−0.167	0.126	−0.167	0.126	−0.167	0.126
Traffic controller[b]	2.462	3.753	2.314	3.747	2.230	3.766	2.236	3.775
Engine driver[b]	3.347	2.448	3.396	2.444	3.403	2.455	3.403	2.455
Day level								
Autoregression	−0.049	0.077	−0.050	0.077	−0.052	0.077	−0.052	0.078
Social stressors Sv	−7.225**	2.544	−7.047**	2.555	−7.037**	2.547	−7.045**	2.573
Time pressure	−1.533	1.087	−1.571	1.114	−1.485	1.119	−1.481	1.1.19
Early shift[b]	0.234	1.344	0.259	1.346	0.263	1.343	0.259	1.356
Day shift[b]	−0.758	1.615	−0.756	1.621	−0.734	1.619	−0.736	1.623
Time worked today (industrial hours)	0.368	0.363	0.367	0.362	0.408	0.366	0.407	0.368
Social support Sv	−0.273	0.620	−0.254	0.622	−0.248	0.620	−0.249	0.621
Time control at work	0.784	1.061	0.898	1.074	1.004	1.082	1.002	1.087
Leisure time control			−0.348	0.686	−0.461	0.703	−0.460	0.705
Private stressors after work			−1.243	1.776	−1.288	1.773	−1.287	1.773
Doing sports after work[b]			0.888	1.596	0.773	1.600	0.776	1.605
Detachment					0.602	0.877	0.602	0.877
Social stressors X detachment							−0.185	9.392
IGLS	1361.918		1361.024		1360.557		1360.557	
VAR Level 2 (Person)	33.992	8.588	33.793	8.534	34.248	8.602	34.244	8.621
VAR Level 1 (Day)	34.405	3.982	34.265	3.967	34.049	3.944	34.050	3.941

Variable	Sleep quality							
Model	1		2		3		4	
	B	SE	*B*	SE	*B*	SE	*B*	SE
Constant	3.021	0.167	3.007	0.170	3.005	0.170	3.005	0.170
Person level								
Sex[a]	0.157	0.216	0.161	0.219	0.161	0.219	0.161	0.219
Age	−0.007	0.007	−0.007	0.007	−0.007	0.007	−0.007	0.007
Full work schedule or part-time work (% of a FTE)	0.029**	0.009	0.029**	0.009	0.029**	0.009	0.029**	0.009
Traffic controller[b]	−0.071	0.252	−0.066	0.255	−0.064	0.255	−0.063	0.256
Engine driver[b]	0.042	0.165	−0.048	0.167	0.048	0.167	0.048	0.167
Day level								
Autoregression	−0.100	0.072	−0.108	0.072	−0.111	0.072	−0.111	0.072
Social stressors Sv	−0.020	0.190	−0.036	0.188	−0.035	0.188	−0.036	0.191
Time pressure	−0.047	0.079	−0.045	0.081	−0.049	0.081	−0.048	0.082
Early shift[b]	−0.127	0.102	−0.137	0.101	−0.138	0.101	−0.138	0.102
Day shift[b]	−0.117	0.118	−0.102	0.118	−0.104	0.118	−0.104	0.118
Time worked today (industrial hours)	0.008	0.027	0.007	0.027	0.006	0.027	0.005	0.027
Social support Sv	0.051	0.045	0.044	0.045	0.044	0.045	0.044	0.045
Time control at work	−0.182*	0.077	−0.186*	0.077	−0.189*	0.078	−0.189*	0.078
Leisure time control			0.022	0.050	0.026	0.051	0.026	0.051
Private stressors after work			0.117	0.128	0.117	0.128	0.117	0.128
Doing sports after work[b]			0.115	0.118	0.118	0.119	0.118	0.119

(*continued*)

Table 3. Continued.

Variable / Model	Sleep quality 1 B	1 SE	2 B	2 SE	3 B	3 SE	4 B	4 SE
Detachment					−0.023	0.064	−0.023	0.064
Social stressors X detachment							−0.015	0.611
IGLS	325.553		323.515		323.381		323.380	
VAR Level 2 (Person)	0.148	0.039	0.154	0.040	0.154	0.040	0.154	0.040
VAR Level 1 (Day)	0.198	0.022	0.194	0.022	0.194	0.022	0.194	0.022

Note: [a]0 = male/1 = female, [b]0 = no/1 = yes, Sv: supervisor. *Correlation is significant at the 0.05 level, **Correlation is significant at the 0.01 level, model 1 contains main effects for work-related variables only, model 2 contains main effects for all variables including leisure time, model 3 shows mediation test for detachment (H3, H4), model 4 includes test of moderation by detachment (H5).

support from superiors as the most robust predictors of difficulties in initiating sleep and disturbed sleep. In light of this outcome, these job characteristics were also suggested to be priority targeted in interventions (Vleeshouwers, Knardahl, and Christensen 2016). The current actigraphy study included these work factors in a daily field study covering a working week of railway workers, in order to have a deeper look at the potential mechanism involved (cf. Figure 1). In the current study, time pressure was not related to sleep quality, although there is some evidence that time pressure can be related to impairments of sleep quality in railway workers (Fan and Smith 2018; Härmä et al. 2002). However, time pressure was a significant predictor of less detachment, which is also involved in recovery from work demands (Elfering et al. 2016). Hence, time pressure was involved in the recovery from work process, but this process did not primarily include sleep but detachment after work.

Findings confirmed that daily social stressors with supervisors, as well as work-related time control and leisure time control (as a covariate), predicted sleep quality in the following night. Although Nielsen and Einarsen (2012) found the relationship between bullying (as a social stressor) and sleep quality to be unclear, a recent cross-sectional investigation (Rosario-Hernández et al. 2018) found social stressors to be negatively correlated with sleep quality. Moreover, these authors found affective rumination and detachment to mediate the relationship between workplace bullying and sleep quality. According to our data, the association between social stressors from supervisors and sleep quality was neither mediated nor moderated by psychological detachment.

The role that detachment was expected to play as a unique predictor, mediator, and/or moderator in sleep-related recovery was unmet. Pravettoni et al. (2007) conducted a field study in which they compared repetitive blue-collar and creative workers in terms of their rumination, which is defined as 'a manifestation of the people's tendency to persisting goal-directed thought until they have either attained their goal or given up the desire for it' (Martin and Tesser 1996, 11). They found that blue-collar workers ruminated significantly less than creative workers. As Cropley and Zijlstra (2011, 497) stated, 'Thinking about work is indeed not compatible with detachment, and therefore will hinder recovery from work'. Because blue-collar workers tend to ruminate less, this might affect the possible role of lack of detachment. If there is less rumination about work, detachment will be less likely hindered. Interestingly, time pressure and social stressors were negatively associated with detachment in the present study. However, this did not lead to impairments in sleep quality. While detachment has often been confirmed as a mediator in cross-sectional and longitudinal studies (Barber and Jenkins 2014; Rodriguez-Munoz, Notelaers, and Moreno-Jimenez 2011; Syrek and Antoni 2014; Van Laethem et al. 2015, 2018), diary studies have so far shown no clear confirmation of the mechanism (Cropley, Dijk, and Stanley 2006; Pereira, Meier, and Elfering 2013, Vahle-Hinz et al. 2014). According to the stressor–detachment model (Sonnentag and Fritz 2015), the content of job-related thoughts could be an important factor for the relationship between detachment and strain. Zijlstra, Cropley, and Rydstedt (2014) assumed that, after stressful work, individuals dream and think about job issues, and sleep grows more fragmented, as compared to after less stressful days. Thereby, mostly negative affective thoughts (Pravettoni et al. 2007) seem to predict increased chronic and acute work-related fatigue (Cropley and Zijlstra 2011; Querstret and Cropley 2012), while this is not found with thoughts concerning problem solving, that is, ongoing mental engagement with a particular problem or previous strategies in order to improve them (Cropley and Zijlstra 2011). This highlights the importance of the negative affective element (i.e. anxiety) in such work-related thoughts. Future research might consider affective reaction such as anxiety in this stressor–sleep relationship.

To the best of our knowledge, previous research in railway work and sleep widely neglected social aspects of work, such as social stressors and social support. One of the few exceptions is a study by Cotrim et al. (2017), which showed the influence of job satisfaction on sleepiness during afternoon and night shifts. Hence, our study fills a gap that was described by Gordon, Mendes, and Prather (2017): occupational sleep research often separates sleep (and the factors that affect it) from the social context in which sleep occurs. The daily experience of social stressors from supervisors was found to correspond to more awakenings and poorer sleep efficiency in the following night. Thus, although the level of social stressors from supervisors in this study was generally low, it seems to play a role in sleep quality of railway workers as well. This result confirms recent evidence from teachers underscoring the importance of social-related job characteristics for a good night's sleep (Kottwitz et al. 2018). In line with the present finding, fair treatment by management was found to be relevant to sleep patterns: within a prospective cohort study (Hayashi et al. 2017), low organisational justice was found to be a risk factor for sleep in the sense of insomnia onset, even after adjustment for lifestyle and work-related variables. In particular, interpersonal (in)justice was revealed as an associated factor for both insomnia onset and persistence. Thus, adverse social working conditions could impair a good night's sleep; further, this could influence people's health (e.g. in the sense of pain; Afolalu, Ramlee, and Tang 2018; Kottwitz et al. 2017) as well as cognitive and academic performance (Levy et al. 2016). The mechanism seems to be a change in sleep architecture. Future actigraphy studies in railway workers should also model the influence of sleep quality on cognitive performance, including cognitive failure (Elfering, Grebner, and Haller 2012).

The potential protective function of social support from supervisors at work was not found. In daily assessments, the level of reported (received) social support was low, reflecting a presumably greater absence of problems than a structural lack of support provision. In line with previous research (e.g. Linton et al. 2015), control at work turned out to be an important resource that protects sleep quality. Higher levels of time control were associated with more rapid sleep onset and better self-reported sleep quality in the following night. The correspondence with shorter sleep-onset latency reached significance only when leisure time variables were added to the model. Time control at work may carry over into leisure time (e.g. by increasing work–family conflict). In fact, the small suppression effect shows it is not that potential carry-over effect of time control but the task-related effect that was related to delayed sleep onset. In addition to time control at work, control of leisure time seemed also to be a valuable antecedent of higher sleep quality. Control of leisure time predicted fewer awakenings. Recent research (Merritt et al. 2017) found self-selected leisure activities to improve sleep quality. Moreover, the current study is the first to test not only work conditions but also private stressors and control during leisure time to predict sleep quality (as was continuously assessed by objective and subjective sleep indicators across a working week). Results confirm that both work-related and private conditions affect sleep quality.

Taken together, with the exception of social support from supervisors, the pattern of results reported by Vleeshouwers, Knardahl, and Christensen (2016) was found in this in-depth study of railway workers. The current study also allowed the adequate estimation of reversed causation effects, that is, the previous night's sleep quality predicted the day's work and private stressors and resources. For instance, in the current data, sleep fragmentation at night significantly predicted more social stressors during the next workday ($p < .05$). Reversed causation included evidence for the previous night's sleep quality serving as a buffer against the link between customer mistreatment in the morning and negative mood in the evening (Liu et al. 2017). With respect to the buffering effects of time control and social support (e.g. Pow et al. 2017), that could be expected according to the job-demands control model (Karasek 1979). However, additional analyses in the current study could not confirm the buffering effect for interactions with social stressors from supervisors and time pressure.

Sufficient sleep contributes to longer, healthier, and happier life (Johnson and Acabchuk 2018). Although the relationship between working conditions and a good night's sleep might be complex, reducing exposure to adverse working conditions (such as a lack of social support) has been shown to decrease the risk of sleep problems (Johannessen and Sterud 2017). Moreover, this refers to both work and private domains, as reduced working was correlated with more restorative sleep on workdays and rest days (Barck-Holst et al. 2017). However, regarding train drivers, occupational health interventions must be able to account for work organisational, job design and self-regulatory barriers to healthier lifestyle behaviours (Naweed et al. 2017a, 2017b). One main barrier for health interventions in drivers might constitute the lack of control, consisting of following schedules while having less autonomy and significant responsibility (Bowles, McEwen, and Boutin-Foster 2017). Yet an additional starting point might be enabling leisure time recovery. Recovery experiences have been shown to buffer the incivility–rumination–sleep quality impairment link (Demsky et al. 2019). In line with previous studies (e.g. Merritt et al. 2017), our results highlight the importance of leisure time control.

Strengths and limitations

Inclusion of task-related and social stressors at work as well as private stressors and control over leisure time is an advantage in this study design. Nevertheless, the current study did not control for sleep-threatening environmental factors such as noise. The small sample size is an additional limitation. Meanwhile, as long as cross-level interaction is not a focus of the study, as in the current investigation, the power seems to be acceptable (Maas and Hox 2005).

Some considerations concerning the measurements using BodyMedia Sensewear should be respected. First, the fact of wearing an actigraph can disturb the sleep. By having participants wear it before the study started and during the whole day, we tried to adapt them to the device. Even though the validity of actigraphs has been shown under laboratory conditions (Lotjonen et al. 2003), further use in naturalistic settings and validation are needed. However, Kawada et al. (2011) used a comparison between Sensewear-detected rotational body movements at night and video recordings and showed congruence of 72% without systematic deviation, with equal percentages of undetected movements (15%) and false-positive detection of movements (14%). These results have been supported by Wouwe, Valk, and Veenstra (2011), who also showed the armbands to be sensitive, accurate, and specific. Anyway, using actigraphy has become an indispensable tool in sleep research and sleep medicine (Sadeh and Acebo 2002).

Practical implications

The importance of sleep for performance and safety in the workplace has been widely recognised (Czeisler 2015), including the cost-related benefits it provides (Rosekind et al. 2010). An important way to intervene in sleep habits is to improve sleep quality. Reduced working time was recently shown to have sustained beneficial effects on sleep, sleepiness, and perceived stress both during workdays and days off (Schiller et al. 2017).

The person-oriented approach to sleep in workers and employees thus far includes sleep extension on weekends, especially for those who sleep fewer than 6 h after workdays (Kubo et al. 2011). After work, online sleep training interventions (including mindfulness training) were confirmed to increase sleep quality (Ebert et al. 2015; Thiart et al. 2015). Moreover, cognitive-behavioural stress management was shown to improve sleep quality (e.g. Querstret et al. 2016). Meanwhile, a randomised controlled trial (Dalgaard et al. 2014) showed occupational stress management training to have only very small effects on sleep quality and the reduction of cognitive failure. Recently, a rather short education-based occupational sleep intervention (Nakada et al. 2018) was shown to improve actigraphy-based sleep indicators. Even if person-oriented approaches show good results in improving sleep, besides treating the symptom we can also work at the source. By applying organisational interventions, we can shape and adapt employees' working conditions, for example by decreasing time pressure and enhancing time control. Because our research shows that time control independently has an effect on sleep quality, it is an important factor to consider in job redesign. To increase control, self-rostering interventions seem to be a promising opportunity in railway employees. A self-rostering intervention applied among caregivers who had to work 24/7 improved sleep quality and decreased somatic symptoms and mental distress (Garde et al. 2012). Because increasing time control during the work shift is rather unlikely due to default schedules, at least participation in planning work shifts and days off can be an auspicious resource to foster time control in general. To decrease time pressure during shifts, a rescheduling of the railways' timetables could be auspicious by allowing more breaks to be taken, more time buffer, and more flexibility. Letting employees participate in restructuring by means of quality circles helps them shape their own working conditions and environment. The implementation of quality circles has been shown to significantly improve job satisfaction and the quality of work life (Hosseinabadi et al. 2013). The Participatory Ergonomics approach summarises the idea of involving employees in planning and controlling their own work activities as much as possible while having adequate knowledge and power to affect processes and outcomes for achieving desired goals (Wilson and Haines 1997). Especially within the scope of control, for an in-depth analysis, future studies should also consider both working conditions and conditions in private life.

Over and above the effects of specific work characteristics (such as shift, working hours, and job type) and specific characteristics of private life, social stressors at work and time control are important in railway employees. For decreasing social stress at work, communication and awareness interventions can lead to better handling of interpersonal issues. Also, as a side effect of organisational interventions like quality circles, working together for better work conditions can lead to an improvement of interpersonal relationships. Organisational climate and policy interventions can also help improve interpersonal relationships by reducing stressful situations, and psychosocial work environment interventions can help increase resources like co-worker support (Uchiyama et al. 2013).

In any case, it is important to consider the different obstacles that are faced within different job roles. While it is easier for train conductors to take a short break than for engine drivers or traffic controllers, they are more exposed to customers than are engine drivers and traffic controllers. Therefore, different jobs have different needs, and interventions should be adapted individually. To have a deeper look into the differences between the job types, future studies should consider the effects between employees in terms of different job characteristics, different percentages of FTE, and shift durations. Further, they should examine whole-day physical activity, exercises, and recovery prospects to analyse the relationships among working conditions, recovery aspects, and sleep quality.

Conclusion

The results of our actigraphy study showed that daily experiences of social stressors at work are likely to impede sleep quality in the following night and that daily time control at work is likely to function as a resource that fosters sleep quality. Private stressors did not relate to sleep quality impairment, while leisure time control turned out to be a unique private resource. Therefore, work redesign should focus on reducing social work stressors and increase time control in railway work. By using participatory approaches, employees can be involved while improving their working conditions. Further, employee resources can be fostered by person-oriented interventions like sleep training and cognitive-behavioural stress management.

Disclosure statement

No potential conflict of interest was reported by the authors.

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