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The effect on sleep of being on-call: an experimental field study

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SUMMARY

The aim of this study was to: (i) gain more insight into the relationship between being on-call and sleep and (ii) investigate the role of stress in this relationship. Data were collected by means of an experimental field study with a within-subject design (two conditions, random order). Ninety-six students participated during two consecutive nights: a reference night and a simulated on-call night without an actual call. Participants were told they could be called at any time during the on-call night. In the case of a call, participants had to perform online tasks for approximately 30 min. Self-reported sleep quality and the extent to which participants experienced stress during the on-call period were assessed by means of short questionnaires. Actigraphy was used to obtain objective sleep measures. Results for actigraphy data revealed no significant within-person differences between conditions. However, participants reported longer sleep onset latencies, more awakenings and more wake after sleep onset during the on-call night than during the reference night. They also reported more sleep problems and a lower overall sleep quality, and felt less recuperated after the on-call night. Perceived stress moderated the relationship between being on-call, on one hand, and the number of awakenings, wake after sleep onset, sleep problems and overall sleep quality, on the other hand. Results show that, even in the absence of an actual call, sleep during on-call nights is of lower quality and has less restorative value – especially when being on-call is experienced as stressful.

INTRODUCTION

On-call work means that employees have to be available at certain times to be called into work if required by the employer. Offsite on-call work, the type of on-call work where employees do not have to remain at the workplace, is legally considered rest time, which means that it can be scheduled in between regular working periods at times which are meant for recovery, e.g. during weekends, evenings and at night (Ministry of Social Affairs and Employment, 2010). Research has shown unambiguously that sufficient recovery is important for wellbeing and health (e.g. Geurts and Sonnentag, 2006). Being called to work during an offsite on-call period implies extra effort expenditure and less recovery time.

However, even without an actual call, recovery during on-call periods may be impaired due to (i) continued psychophysiological activation (Åkerstedt *et al.*, 2009), (ii) lower cognitive detachment, and (iii) less control over free time

activities (see e.g. Dettmers *et al.*, 2016). The adverse effect of on-call work on recovery may be especially pronounced when the apprehension of a call induces stress, as stress is related negatively to recovery (e.g. Geurts and Sonnentag, 2006). Indeed, previous research has suggested that being on-call can be stressful, and that the mere possibility of being called can interfere with recovery (Bamberg *et al.*, 2012; Dettmers *et al.*, 2016; Van de Ven *et al.*, 2015; Ziebertz *et al.*, 2015).

The most important recovery opportunity is sleep (Åkerstedt *et al.*, 2009; Rook and Zijlstra, 2006). Poor sleep quality is characterized by one or more of the following symptoms: (i) difficulties falling asleep and (ii) staying asleep, (iii) waking up too early, and (iv) not feeling recuperated upon awakening (Edinger *et al.*, 2004). Poor sleep has been shown to be related to a range of physical and mental health problems such as cardiovascular disease (Schwartz *et al.*, 1999; Wolk *et al.*, 2005), obesity (Patel and Hu, 2008), diabetes (Barone

and Menna-Barreto, 2011), and depression (Lustberg and Reynolds, 2000; Taylor *et al.*, 2005). Furthermore, poor sleep is considered a risk factor for mortality (Cappuccio *et al.*, 2010; Kripke *et al.*, 2002, 2011).

So far, research has paid little attention to the effect of offsite on-call periods on sleep.

Notable exceptions are the studies by Pilcher and Copen (2000), Torsvall *et al.* (1987), Torsvall and Åkerstedt (1988) and the laboratory study by Wuyts *et al.* (2012), which showed that being on-call is related negatively to sleep quality and quantity, and that sleep can be affected negatively even when no actual call occurs. The latter finding was interpreted as a potential effect of stress due to apprehension of a call. These previous studies included several limitations. The study by Torsvall *et al.* (1987) relied upon self-reports only, and the studies by Wuyts *et al.* (2012) and Torsvall and Åkerstedt (1988) included very small sample sizes ($n = 5$ and $n = 16$, respectively). In addition, the study by Wuyts *et al.* (2012) was conducted at the sleep laboratory, an environment unknown to the participants. As previous research has shown that individuals tend to sleep better at home (e.g. Bruyneel *et al.*, 2011; Van De Water *et al.*, 2011), it remains unclear whether the results can be generalized to everyday life. Furthermore, the on-call stimulus in that study (a sound lasting 5 s) and the requested action (pressing a button three times) were meaningless, and requested marginal physical or cognitive activation. In a real on-call situation, employees know that they will have to get up and perform work tasks when called. Therefore, the question remains as to whether similar results can be found when participants anticipate that they actually have to get up and perform tasks when called. Furthermore, previous research has shown that employees differ in the extent to which they find being on-call stressful (Ziebertz *et al.*, 2015), but whether or not this actually affects the relationship between being on-call and sleep (as suggested by Torsvall *et al.*, 1987; Torsvall and Åkerstedt, 1988; Wuyts *et al.*, 2012) has not been tested so far. A moderating role for stress in the on-call-sleep association can be expected, however, as stress is related to rumination and sleep problems (e.g. Åkerstedt *et al.*, 2009; Van Laethem *et al.*, 2016). Anticipation stress may thus aggravate the adverse effects of being on-call on sleep.

Summing up, offsite on-call work is legally considered rest time, and recovery during rest time is important to prevent negative effects on wellbeing and health. As sleep is considered the most important recovery opportunity, it is important to know whether sleep is affected by being on-call. Previous research suggests that this is the case, but has its limitations with regard to sample sizes and design. While trying to overcome these limitations, the aim of the present study was to: (i) gain more insight into the relationship between being on-call and sleep and (ii) examine whether the experience of stress due to being on-call acts as a moderator in this relationship. We expected that being on-call has a negative effect on sleep quality (hypothesis 1), especially when being on-call is perceived as stressful (hypothesis 2).

METHOD

Participants

The final sample consisted of 96 participants (89 female). All participants were first-year students from the Faculty of Social Sciences of a Dutch University participating in the study for credit points. Participants' age ranged from 18 to 26 years [mean = 20.85, standard deviation (SD) = 1.75].

Procedure

The study consisted of two parts: an online screening (part 1) and an experimental field study (part 2). Data collection took place between April and November 2015. The study was approved by the Ethical Committee of the Social Sciences of Radboud University.

Part 1 (screening)

The screening (online questionnaire) was used to identify students who met the following inclusion criteria: (i) being free on either Monday and Tuesday or Tuesday and Wednesday evening, (ii) not having severe sleep disturbances, and (iii) not using sleep medication on a regular basis. Of the 594 respondents, 352 students (59%) met these inclusion criteria and were invited to sign up for part 2. They had to select a period (either Monday–Tuesday or Tuesday–Wednesday) during which they (i) were free between 22:00 and 8:00 hours, (ii) had internet access, (iii) had no examinations or other predictable stressful events and (iv) had no events which would cause them to go to bed later than normal (e.g. a party). A total of 104 students (30%) signed up for part 2.

Part 2 (experimental field study)

Part 2 was an experimental field study with a within-subject design (Fig. 1) conducted on two consecutive nights. One night was the on-call condition (a simulated on-call night without an actual call) and the other night was the reference condition (a regular night without on-call). Whether the first (order 1) or the second (order 2) night was the on-call night was determined randomly. Each night, participants had to complete short online questionnaires before going to bed and upon awakening, and during the nights they had to wear actigraphy devices. Before the start of the study, participants were provided with written and oral information about the study and signed an informed consent form. Participation was rewarded with participation points.

Participants had to complete the evening diary just before going to sleep and the morning diary upon awakening. They received the links to the online questionnaires via e-mail. At the start of the on-call period (22:00 hours), participants received an SMS (short message service) which reminded them that they were on-call until 08:00 hours and had to

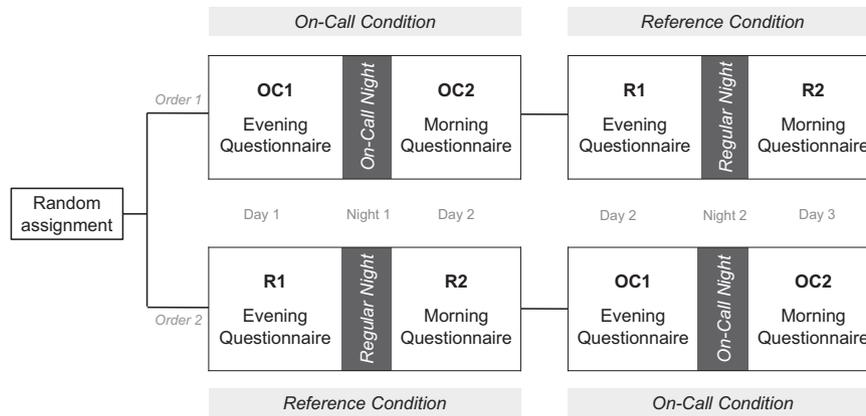


Figure 1. Research design of the experimental field study (part 2).

leave their phone switched on. Participants were told that during the on-call night, they could be called at any time between 22:00 and 8:00 hours. In case of a call, they had to get up, switch on their computer and complete several cognitive tasks online for approximately 30 min. After that, they could go back to sleep. Only six participants were actually called. This was conducted in order to prevent rumours spreading that no one was actually being called. Participants who were exposed to a call were not included in the final sample. Furthermore, two participants who indicated that they did not believe that they would be called were also excluded.

MATERIALS AND MEASURES

Screening

The Pittsburgh Sleep Quality Index (PSQI; Buysse *et al.*, 1989) was used for screening. Participants who reported having sleep disturbances and using sleep medication once a week or more often (score 2 or 3 on the respective items) were not invited to participate in part 2 of the study. Furthermore, participants were asked to indicate whether they had regular activities (e.g. training, work) on weekday evenings. Participants who were not free on at least two consecutive evenings in the period from Monday to Wednesday were not invited for part 2 either. Age and gender (0 = female, 1 = male) were also assessed in the screening questionnaire.

Day-level self-reports

Self-reported sleep quality and quantity were assessed in the morning questionnaire. Sleep problems were assessed with the Groningen Sleep Quality Scale (GSQS; Mulder-Hajonides Van der Meulen *et al.*, 1981; Meijman *et al.*, 1988). The GSQS consists of 14 items (i.e. 'Last night, I woke several times'; 0 = no, 1 = yes). Higher sum scores represent more sleep problems. The sleep consensus diary (Carney *et al.*, 2012) was used to measure (i) sleep duration: the amount of

time (min) spent asleep minus wake periods after sleep onset¹; (ii) sleep onset latency (SOL): how long it took participants to fall asleep (in min); (iii) number of awakenings after sleep onset; (iv) wake after sleep onset (WASO): total amount of time awake after sleep onset (in min); (v) recuperation upon awaking [on a scale from 1 (not rested at all) to 10 (very rested)]; and (vi) overall sleep quality [on a scale from 1 (very bad) to 10 (very well)]. Current sleepiness was assessed with a single item (Karolinska Sleepiness Scale; Åkerstedt and Gillberg, 1990). The morning questionnaire after the on-call night included two additional items to assess the experience of on-call stress ('I was stressed due to being on-call' and 'I was unable to relax due to being on-call'; $\alpha = 0.81$) and one item that served as manipulation check ('I expected to be called'). Answer categories ranged from 1 (I totally disagree) to 5 (I totally agree). In the evening questionnaire, participants had to indicate how many units of caffeinated and alcoholic drinks they had consumed during the day.

Actigraphy

Wrist actigraphy (Actiwatch 2; Phillips Respironics, Murrysville, PA, USA) was used to collect data objectively on (i) sleep duration, (ii) SOL, (iii) the number of awakenings, (iv) WASO, and (v) sleep efficiency: the percentage of actual sleep time as a function of time in bed. Participants wore the Actiwatch on their non-dominant wrist during both nights. The epoch length was 1 min and data were analysed with the Actiware Software (Phillips Respironics). Due to technical problems ($n = 4$) and one participant forgetting to wear the Actiwatch the second night, actigraphy data were available for 91 of the 96 participants.

¹One subject entered 00:05 hours as self-reported sleep duration during the regular night and 00:00 hours during the on-call night. These values were considered invalid and replaced by the calculated sleep duration: subtraction of self-reported SOL and WASO from the total sleep time (time between the moment the participant decided to go to sleep and the moment he woke up).

RESULTS

Descriptive statistics

The manipulation of the on-call night was successful: only two participants did not expect to be called (and were therefore excluded from the final sample). The scores on on-call stress ranged from 1 to 5, with a mean score of 3.26 (SD = 1.00). Nearly one-third (32%) of the participants scored lower than 3, whereas 53% scored higher than 3, indicating that the majority of the participants experienced moderate to high stress during the on-call period.

The means and SDs of the self-reported sleep parameters can be found in Table 1. Those of the actigraphy data are shown in Table 2.

Hypotheses testing

In order to test hypotheses 1 and 2, two repeated-measures multivariate analyses of covariance (MANCOVAs) were conducted, with condition (on-call/reference) as within-subject factor. In the first analysis, the self-report sleep measures (i.e. sleepiness, recuperation, sleep problems, sleep quality,

sleep duration, SOL, number of awakenings and WASO) were the dependent variables, whereas actigraphy measures (i.e. sleep duration, SOL, number of awakenings, WASO, and sleep efficiency) were included in the second analysis. On-call stress (standardized) was entered as covariate in both analyses in order to test whether it moderates the relationship between being on-call and sleep. The standardized difference scores of caffeine and alcohol consumption in both conditions were entered into the analyses as control variables. Finally, it was also controlled for gender.

Self-reports

The results of the first analysis revealed a large, significant main effect of condition ($F_{\text{cond}(8,84)} = 4.90$, $P < 0.001$, $\eta_p^2 = 0.32$), indicating that there was a significant difference between the on-call night and the regular night on self-reported sleep (H1). As can be seen in Table 1, participants felt significantly less recuperated after the on-call night than after the regular night, reporting a significantly lower sleep quality and significantly more sleep problems. Furthermore, it took participants significantly longer to fall asleep in the on-call condition, and they woke more often during the night and

Table 1 Means, standard deviations (SD) and univariate tests of self-report data ($n = 96$)

	On-call condition		Reference condition		Univariate tests* Main effect of condition			Univariate tests* Condition \times on-call stress		
	Mean	SD	Mean	SD	F	P	η_p^2	F	P	η_p^2
Sleepiness (1–9)	5.66	1.66	5.54	1.93	0.01	0.937	0.000	0.13	0.720	0.001
Recuperation (1–10)	5.48	1.51	6.08	1.73	5.48	0.021	0.057	3.02	0.086	0.032
Sleep problems (0–14)	5.34	3.52	3.22	2.73	22.22	0.000	0.196	16.83	0.000	0.156
Sleep quality (1–10)	5.95	1.57	7.15	1.44	26.91	0.000	0.228	11.35	0.001	0.111
Sleep duration (h)	7:45	1:16	7:57	1:15	1.90	0.171	0.020	0.32	0.575	0.003
SOL (h)	0:29	0:28	0:21	0:21	7.46	0.008	0.076	0.70	0.405	0.008
Number of awakenings	3.05	2.26	1.58	1.83	26.46	0.000	0.225	10.30	0.002	0.102
WASO (h)	0:22	0:22	0:10	0:16	21.26	0.000	0.189	9.72	0.002	0.096

SOL: sleep onset latency; WASO: wake after sleep onset.

*Repeated-measures multivariate analysis of covariance (MANCOVA); controlled for gender, alcohol consumption and caffeine consumption.

Table 2 Means, standard deviations (SD) and univariate tests of actigraphy data ($n = 91$)

	On-call condition		Reference condition		Univariate tests* Main effect of condition			Univariate tests* Condition \times on-call stress		
	Mean	SD	Mean	SD	F	P	η_p^2	F	P	η_p^2
Sleep duration (h)	7:27	0:52	7:23	1:04	0.18	0.674	0.002	0.29	0.591	0.003
SOL (h)	0:10	0:10	0:10	0:12	0.01	0.910	0.000	0.48	0.491	0.006
Number of awakenings	34.68	10.44	34.08	10.15	0.08	0.775	0.001	0.06	0.806	0.001
WASO (h)	0:57	0:23	0:53	0:24	0.58	0.448	0.007	0.34	0.563	0.004
Efficiency (%)	84.98	4.81	85.29	5.52	0.22	0.644	0.002	0.88	0.351	0.010

SOL: sleep onset latency; WASO: wake after sleep onset.

*Repeated-measures multivariate analysis of covariance (MANCOVA); controlled for gender, alcohol consumption, and caffeine consumption.

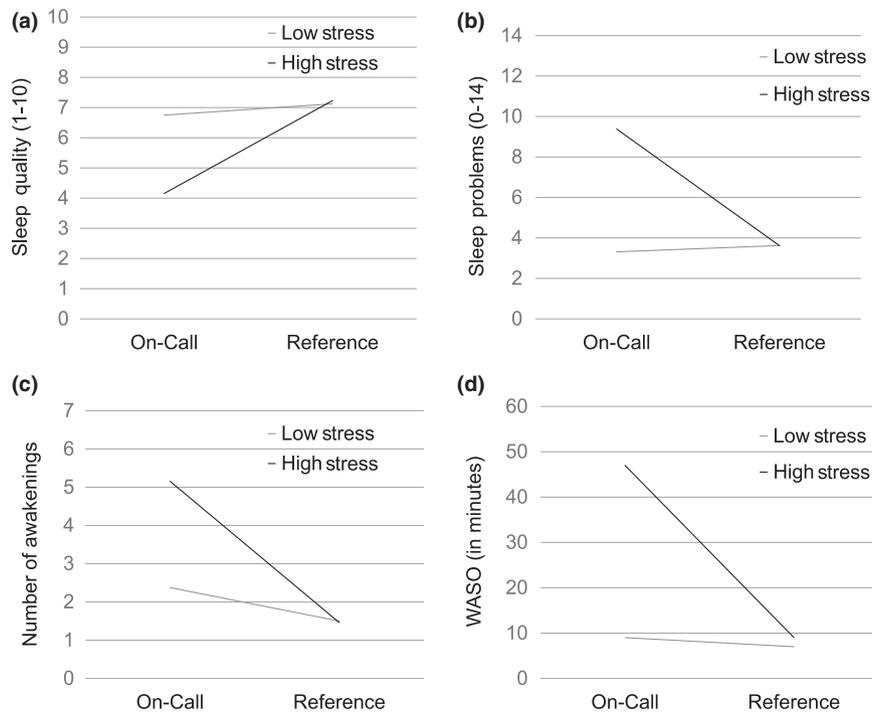


Figure 2. Plots of the significant simulated interactions between condition and on-call stress for (a) sleep quality, (b) sleep problems, (c) the number of awakenings and (d) wake after sleep onset (WASO).

were awake for a longer time during the on-call night (large effect sizes). The duration of sleep did not differ significantly between conditions, nor did sleepiness in the morning. Table 1 shows that the significant effects were medium to large.

The interaction effect between condition and on-call stress was also significant ($F_{\text{cond} \times \text{stress}(8,84)} = 2.93$, $P = 0.006$, $\eta_p^2 = 0.22$), indicating that on-call stress acts as a moderator in the relationship between being on-call and sleep (H2). Univariate tests (see Table 1) showed that the interaction effect was significant for self-reported sleep problems, sleep quality, the number of awakenings and WASO, but not for sleepiness, recuperation, sleep duration and SOL. Effect sizes were medium to large.

In order to interpret the significant interaction effects, we used a procedure suggested by Cohen *et al.* (2003), which does not involve splitting the sample into two groups based on stress-level, but instead simulating the interaction effect by computing of the effect of condition and condition \times on-call stress separately for a typical person who experienced a great deal of stress (i.e. an individual 1 SD above the mean, computed by adding 1 to standardized on-call stress scores) and a typical person who experienced little stress (i.e. an individual 1 SD below the mean, computed by subtracting 1 from standardized on-call stress scores). Repeating the analysis for a typical person with high on-call stress (1 SD above the mean) showed that the effect of condition remained significant ($F_{\text{cond}(8,84)} = 0.73$, $P < 0.001$, $\eta_p^2 = 0.41$), whereas no significant main effect was found for a typical person with low on-call stress ($F_{\text{cond}(8,84)} = 0.79$, $P = 0.617$, $\eta_p^2 = 0.07$).

This means that the effect of condition (being on-call versus not being on-call) was stronger for participants who experienced being on-call as stressful. Fig. 2 provides a graphical presentation of the simulated interaction effects.

Actigraphy

The second repeated-measures MANCOVA revealed no significant within-subject differences between the on-call night and the regular night on actigraphy measures ($F_{\text{cond}(5,82)} = 0.21$, $P = 0.96$) and no significant interaction between condition and on-call stress ($F_{\text{cond} \times \text{stress}(5,82)} = 0.50$, $P > 0.78$). Table 2 shows the results of the univariate tests as well as means and SDs of the actigraphy sleep measures for both conditions.

DISCUSSION

So far, little is known about the effect of being on-call on sleep. The few existing studies show that being on-call is related to impaired sleep, even if no actual call occurs (Torsvall and Åkerstedt, 1988; Torsvall *et al.*, 1987; Wuyts *et al.*, 2012). Although stress has been suggested to play a role in this relationship (Torsvall and Åkerstedt, 1988; Torsvall *et al.*, 1987; Wuyts *et al.*, 2012), this has not been studied so far. Therefore, the aim of the present study was to not only (i) to gain more insight into the relationship between being on-call and sleep, but also (ii) to examine whether the experience of stress due to being on-call is a moderator in this relationship. In order to do so, an experimental study was conducted with a

within-subject design including a simulated on-call night and a reference night. It was expected that sleep quality would be worse during the on-call night (H1), especially when being on-call is experienced as stressful (H2).

The results partly confirm these hypotheses. Based on actigraphy measures, no differences between the on-call night and the reference night were found. Previous studies using electroencephalogram (Torsvall and Åkerstedt, 1988) and polysomnography (Torsvall *et al.*, 1987; Wuyts *et al.*, 2012) found several significant differences between the on-call night and the reference night. Actigraphy has been validated against polysomnography with mixed results, and it has been shown that actigraphic accuracy decreases with decreased subjective sleep quality (Van De Water *et al.*, 2011), which might explain why we did not find significant differences. Further research is needed to gain more insight into the relationship between being on-call and objective indicators of sleep quality.

Even though actigraphy revealed no significant differences between the two nights, participants reported having more trouble falling asleep (i.e. longer SOL), waking up more often during the night and spending more time awake (i.e. more WASO) during the on-call night than during the regular night. They also reported more sleep problems and lower overall sleep quality, and felt less recuperated after the on-call night. These results are largely in line with previous research, in which negative effects of being on-call on several sleep parameters were found (Torsvall and Åkerstedt, 1988; Torsvall *et al.*, 1987; Wuyts *et al.*, 2012). Unlike previous research, we additionally examined the often-assumed role of stress in the on-call–sleep association. The results show that the experience of stress due to being on-call moderated the relationship between being on-call, on one hand, and the number of awakenings, WASO, sleep problems and overall sleep quality on the other hand. This means that the effect of being on-call on these sleep parameters was worse for those individuals who perceived being on-call as stressful (the majority of participants in the present study).

Summing up, the results show that the mere possibility of being called leads to lower perceived sleep quality, especially when being on-call is perceived as stressful. Furthermore, being on-call also leads to impaired recovery during the night, manifesting itself in not feeling refreshed the morning after. This may be worrisome in the long term, as sleep is a crucial recovery opportunity and recovery is crucial for wellbeing and health (Meijman and Mulder, 1998).

Strengths, limitations and suggestions for future research

By investigating the role of stress in the relationship between being on-call and sleep, we believe that this study makes a valuable theoretical contribution. Even though it has been suggested that stress might explain why being on-call affects sleep negatively, this assumption has not been tested so far. The present study shows that stress moderates the relationship between being on-call and sleep.

Ecological validity constitutes a second strength. To the authors' knowledge, the present study was the first to investigate the effect of a 'simulated offsite on-call period without an actual call' outside the laboratory. The manipulation check showed that the on-call simulation was successful. Compared to previous laboratory studies, the on-call simulation in the present study was more realistic. First, resembling an actual offsite on-call duty, participants slept at home, in their own bed, and apprehended that they could be called on their mobile phone at any time during the night. Secondly, participants understood that, in case of a call, they had to get up and perform cognitive computer tasks for approximately 30 min. This is more comparable to an actual offsite on-call duty than tasks used in previous studies (e.g. Wuyts *et al.*, 2012).

A third asset of the present study is the multi-method approach. Research has shown that both objective and subjective measurements of sleep provide valuable insights and are related to physical and mental health (e.g. Barone and Menna-Barreto, 2011; Patel and Hu, 2008; Taylor *et al.*, 2005; Wolk *et al.*, 2005).

Another strength is the sample size. Whereas previous experimental studies were conducted among very small samples, our sample included 96 participants. In addition, the experimental design provides valuable insights into the actual effects on sleep, and the use of diary questionnaires reduces the risk of recall biases.

The present study also has limitations. The first limitation is the short study period. Because, in practice, on-call periods often last longer than 1 night, an experiment with multiple reference and on-call nights (of which some include a call) is recommended strongly for future research. Furthermore, the short study period might have limited the accuracy of actigraphy measurements and might play a role in why no effects have been found (Van De Water *et al.*, 2011). In future, studies with similar designs could be conducted with actigraphy measures over a longer period, or with home-based polysomnography measures at participants' homes (Bruyneel *et al.*, 2011).

Another limitation is that participants were obliged to leave their phone on during the on-call night, but not during the reference night. As such, their sleep during the on-call night may have been disturbed by their phone (e.g. due to notifications or incoming calls). However, this is also the case during real on-call periods. A third limitation is that participants in the present study were students, not actual on-call workers. In future research, employees should be studied during actual on-call periods and days/nights off.

CONCLUSION

The present study shows that being on-call has a negative effect on perceived sleep quality, especially when being on-call induces stress. This may be worrisome in the long term, as sleep is a crucial recovery opportunity and adequate recovery is important for wellbeing and health (Meijman and Mulder, 1998). As offsite on-call work counts legally as free

time, employees do not gain additional recovery opportunities (e.g. extra free time), which might be needed in order to compensate for the impaired recovery during on-call nights. Future research is needed to examine under what circumstances being on-call is perceived as stressful, and whether feelings of stress can be counteracted (e.g. by means of stress-management trainings).

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AUTHOR CONTRIBUTIONS

Conception or design of the work: CZ, DB, MvH, SG; data collection: CZ; data analysis and interpretation: CZ, DB, MvH, SG; drafting the paper: CZ; critical revision of the paper: CZ, DB, MvH, SG, MK. Final approval of the version to be published: CZ, DB, MvH, SG, MK.

CONFLICT OF INTEREST

None of the authors has declared any conflicts of interest.

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