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Evaluation of sleep strategies between night shifts in actual shift workers

Heidi M. Lammers-van der Holst[a], **Salim Qadri**[b], **Audra Murphy**[b], **Joseph M Ronda**[b,c], **Yuan Zhang**[d], **Laura K. Barger**[b,c], **Jeanne F. Duffy**[b,c]

[a]Department of Public Health, Erasmus University Medical Center, Rotterdam, the Netherlands.

[b]Division of Sleep and Circadian Disorders, Brigham and Women's Hospital, Boston, MA 02115, USA.

[c]Division of Sleep Medicine, Harvard Medical School, Boston MA, USA.

[d]Solomont School of Nursing, Zuckerberg College of Health Sciences, University of Massachusetts Lowell, Lowell, MA 01886, USA

Abstract

Objectives.—The aim of this observational study was to examine sleep obtained between consecutive night shifts from shift workers in their natural environment. The goal was to identify the various sleep strategies and the timing, duration, regularity, and quality of sleep associated with the strategies.

Methods.—Participants (N = 33, 23 women, aged 40 ± 15 y) reported their sleep information in daily diaries over 2 weeks while working at least one series of consecutive night shifts. Sleep timing, duration, quality, and regularity were calculated for each sleep episode between consecutive night shifts.

Results.—Based on the reported sleep behavior, shift workers were categorized as either morning, delayed, split- or mixed sleepers. We found significant differences between the groups

Corresponding author: Heidi M. Lammers-van der Holst, Department of Public Health, Erasmus University Medical Center, Dr. Molewaterplein 40, 3015 GD Rotterdam. h.lammers-vanderholst@erasmusmc.nl.

Dr. Czeisler's contributions to this work:

As former trainees of Dr. Czeisler (HML, LKB, JFD), our shift work studies cannot help but be influenced by his work. From showing that both worker satisfaction and industrial productivity could be improved by changing the frequency and direction of shift rotations [20] to demonstrating that bright light during work and darkness during bedrest could improve adaptation in simulated shift workers [21, 22], Dr. Czeisler has inspired us to look at a how shift work impacts a variety of safety-sensitive occupational groups and to transition laboratorytested countermeasures to field studies with the ultimate goal to improve the health and safety of shift workers.

CRediT statement

Heidi Lammers-van der Holst: Conceptualization, Investigation, Formal analysis, Writing – Original Draft preparation, Review & Editing. **Salim Qadri:** Software, Formal analysis. **Audra Murphy:** Resources, Investigation. **Joseph Ronda:** Software, Data curation. **Yuan Zhang**: Conceptualization, Writing-Review & Editing. **Laura Barger:** Conceptualization, Writing - Review & Editing. **Jeanne Duffy:** Conceptualization, Writing - Review & Editing, Supervision.

Declaration of conflict of interest

The authors have no conflicts of interest to disclose. All authors have approved the final article.

in timing of sleep, feeling refreshed, and regularity of sleep between consecutive night shifts, whereas duration and subjective soundness of sleep did not show significant differences.

Conclusions.—In this sample, four sleep strategies were observed between consecutive night shifts in actual shift workers. These observations may help design future interventions to improve sleep that are individualized to the worker.

Keywords

sleep strategy; night shift; delayed sleep; split-sleep; shift work

Introduction

Working during the night leads to misalignment between the endogenous circadian timing system and timing of sleep and wake, disturbing multiple physiological processes in the human body [1]. This misalignment typically results in a shorter, less consolidated, and highly disrupted sleep during the daytime, and increased sleepiness and performance decrements during night shifts [2, 3]. Indeed, night workers typically report shorter sleep durations than their day worker counterparts, resulting in greater levels of sleepiness on the following night shift, with accumulating sleep loss across multiple night shifts [4]. Sleep insufficiency is the most widespread problem affecting shift workers [5, 6]. When sleep insufficiency is severe and associated with excessive sleepiness during wake, it can even lead to Shift Work Disorder [7]. Shift workers report various sleep patterns, showing stable inter-individual differences [8], and are related to time of day and number of night shifts [9, 10]. Observational research on sleep strategies in shift workers' natural setting are still limited [10], with most prior reports being either laboratory-based [11–13] or retrospective [14]. The aim of this study was to observe different sleep strategies used by actual night shift workers between consecutive night shifts to gain a deeper understanding of the strategies in terms of duration, quality, timing, and regularity of their sleep.

Methods

Participants and procedures

Shift workers were recruited from nationwide internet advertising and emails directed to nurses and other healthcare personnel across the U.S. Interested night shift workers completed an online ~5–10 min screening survey to determine eligibility. Inclusion criteria were full-time workers aged 18–70 years who work permanent (5 night shifts per week) or frequent night shifts, with at least 3 consecutive nights in a row. Participants were provided a study information sheet and completion of the screening survey indicated their implied consent.

After inclusion, each worker was contacted via telephone or email to explain the study and determine their preferred study dates. During their study, participants were sent a daily electronic survey to report their number of sleep episodes (sleep bouts, naps), sleep times, work hours, and sleep quality for 14 days in a row. The study was timed to include at least one series of three or more consecutive night shifts. These daily surveys were sent at a participant-selected time via email or text message and completed on the participant's

self-selected device (i.e. phone, laptop, desktop computer). Participants received a $25 gift card after completion. Data were collected from July 2020 to November 2022.

Measures & statistical analyses

For each sleep episode between consecutive night shifts, the timing of sleep, total sleep time (TST), and subjective sleep quality were calculated from the daily survey. Timing of sleep was extracted from the reported start and end times of each sleep bout. TST was calculated as time in bed minus subjective sleep latency. Subjective sleep quality was assessed using two questions: 1) 'How sound do you think your sleep was over the past 24 hours?' with responses on a 7-point Likert scale (1-extremely light to 7-extremely sound); and 2) 'How refreshed do you feel right now?' with similar responses (1-not refreshed at all to 7-extremely refreshed).

Means and standard deviations (SD) were calculated over all sleep episodes between night shifts for each participant. In addition, day-to-day regularity of sleep was calculated by each individual's variance score for the start time of the first sleep bout and for their TST. Based on their reported sleep behavior between consecutive night shifts, participants were grouped into four groups according to their consistent sleep strategy (i.e. reported on all days). First, morning sleepers, who started sleep immediately following their nights shifts, and slept in one sleep bout. Second, delayed sleepers, who started one sleep bout in the afternoon or more than four hours after their night shifts ended. Third, split sleepers, who consistently had two sleep episodes, regardless of sleep timing. Fourth, mixed sleepers, who did not show consistent sleep behavior but instead varied the timing and number of sleep bouts from day-to-day.

Depending on normal distribution and equal variance assumptions, univariate ANOVAs (F- and Welch tests) or Kruskal-Wallis non-parametric tests were performed using SPSS Statistics version 24 (IBM Corporation, Armonk, NY).

Results

Forty-three shift workers completed the two-week study; of these, four participants were excluded due to having not worked any night shifts during the two weeks, leaving N=39. Of these, four participants showed a major discrepancy in the number of consecutive night shifts they reported at screening versus what they did during their study (>5 night deviance) and therefore were excluded from further analysis (deemed unreliable). Finally, two participants reported only two consecutive night shifts (with one intervening sleep episode) during the 14 days and were therefore excluded.

The final participants included 23 women and 10 men, aged 40 ± 15 years (mean ± SD). On average, the participants worked five night shifts per week and had 11 years of shift work experience. Eighteen participants worked in healthcare, six in hospitality, three in public safety, two in office work, one in retail, and three in other sectors. Night shifts were identified when work started between 18:00–24:00 and lasted at least eight hours. Overall, a total of 206 sleep episodes recorded in the daily surveys were identified as occurring

between a series of at least two consecutive night shifts. Six sleep episodes between night shifts were analysed on average, with a range of 2–11 per participant.

The 33 shift workers were categorized into four groups based on their sleep strategy using their day-to day sleep starting times and number of sleep bouts between consecutive night shifts. We classified seven as morning sleepers, eight as delayed sleepers, eight as split sleepers, and ten as mixed sleepers. See Table 1 for a detailed description of participant demographic characteristics.

The timing and duration of sleep episodes between consecutive night shifts in the four sleep strategy groups are presented in Figure 1. As expected, the timing of the first sleep bout (i.e. start time) differed significantly between groups (H=18.70, $p<0.001$). Pairwise comparisons showed that the sleep start time of the morning group was significantly earlier than the delayed group ($p<0.001$), and earlier than the mixed sleepers ($p=0.043$). The start time of the delayed group was later than the split sleepers ($p<0.002$) and the mixed sleepers ($p=0.015$). No differences were found in the regularity of start time of the first sleep episode between groups (H)=6.24, $p=0.100$). TST between consecutive night shifts showed no significant differences between groups ($Welch_{(3,16)}$=2.18 $p=0.131$), although regularity of TST did differ significantly between the groups (H=12.38, $p=0.006$). Mixed sleepers showed more irregularity compared to delayed ($p=0.008$) or split sleepers ($p=0.001$). Subjective soundness of sleep was not different between groups (H=0.54, $p=0.910$), but feeling of being refreshed from sleep did differ between the groups ($F_{(3,29)}$=3.70, $p=0.023$). Delayed and mixed sleepers reported feeling more refreshed than split sleepers (delayed: $p=0.004$; mixed: $p=0.042$), and delayed sleepers felt more refreshed than morning sleepers ($p=0.046$).

Discussion

We studied a small sample of night shift workers in their natural setting, revealing a variety of sleep patterns between consecutive night shifts. We identified morning, delayed, and split-sleep strategies also reported in previous studies [5, 10, 11, 15]. In addition, we identified a subgroup who showed a mix of sleep strategies (or lack of a consistent strategy) between consecutive night shifts. We found that overall sleep duration was shorter than the recommended 7–9 hours daily, regardless of which strategy used between night shifts, congruent with previous studies [5, 9, 10].

We observed similar sleep durations between the various sleep strategies used in these shift workers, consistent with two laboratory-based studies performed on healthy men [11, 12]. Other simulated shift work studies reported that scheduling delayed sleep between night shifts could lengthen sleep duration and improve performance and adaptation on night shifts in both younger [16, 17] and older adults [18, 19]. Here, delayed sleepers reported feeling more refreshed than split sleepers. We found no differences in individual variability of sleep start times between groups, but individual variability in TST was greater for mixed-sleep shift workers than delayed- or split-sleep shift workers. This result raises the question of whether mixed sleepers have any strategy at all.

A strength of this study is that experienced shift workers were studied when following their usual sleep patterns, which enhances external validity of the results. However, recruitment took place during the COVID-19 pandemic, which could have both limited enrollment and created a selection-bias among those who did participate. Other limitations are the small sample size and imbalance in sex distribution, as well as lack of detail about second jobs or why each individual chose their particular sleep strategy. Also, we did not screen for use of medication, sleep disorders or medical conditions, which could have influenced our results. Even though actigraphy would be a better approach for real-time monitoring of sleep patterns, daily electronic surveys were used to limit wrong data entries by hand and were easy to use.

Future studies where workers are followed longer and queried at regular intervals, together with actigraphy, should be carried out to better understand factors contributing to individual sleep strategies. Although we did not explore sleep behavior during night shifts (such as napping during breaks) or while transitioning onto or off of a series of night shifts, limiting our investigation to sleep between consecutive night shifts gave us a way to compare sleep between shift workers, especially knowing that their schedules differed in terms of shift type, duration, time of day, rotation, occupation and workload on any given shift. Further studies of strategies used by different shift workers when rotating onto and off of night shifts would be useful to understand the prevalence of different strategies and whether those result in differences in sleep duration and quality during such transitions. Lastly, given the findings from laboratory studies [18, 19], it would be interesting to investigate how different self-selected sleep strategies relate to sleepiness during the night shifts [11, 14].

To conclude, our results provide insight into the various sleep patterns adopted by shift workers when working consecutive night shifts, and these findings may help design new sleep interventions that can be individualized to improve shift workers' sleep, safety, and health.

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Public Health Relevance

In our modern 24/7 society, about one third of the workforce are engaged in night and rotating shifts or other irregular work schedules. Shift workers have shorter and more disrupted sleep than day workers, resulting in increased risk for errors, accidents, and long-term adverse health outcomes. Understanding naturally adopted sleep patterns of actual shift workers in real-life settings could help us design effective individualized sleep interventions, and thereby improve shift workers' health and safety.

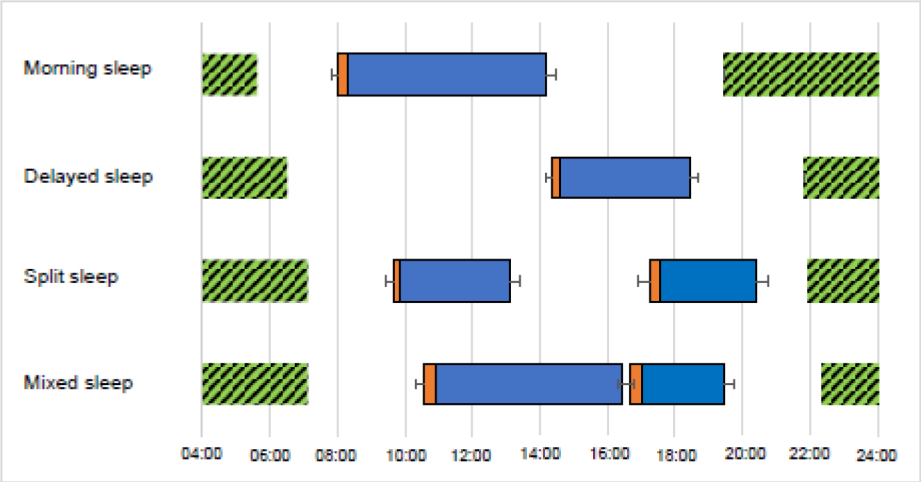

Figure 1:
Sleep strategies between consecutive night shifts. Start and end times of night shifts are shown in green dashed boxes; self-reported bed times are shown in blue with self-reported sleep latency in orange. Standard errors are included for sleep bouts.

Table 1.

Demographics of participants in each sleep strategy group, and timing, duration, quality, and regularity of sleep between consecutive night shifts.

Demographics	**Morning** ***N=7***	**Delayed** ***N=8***	**Split** ***N=8***	**Mixed** ***N=10***	**Total** ***N=33***
Women/men [n]	5/2	4/4	7/1	7/3	23/10
Age [mean (sd)]	34 (11)	40 (15)	38 (16)	47 (15)	40 (15)
Evening types[a] [n]	5	6	3	6	20
Presence of 2nd job [n]	3	5	3	4	15
Participants with children [n]	3	2	4	1	10
Average number of children [mean (sd)]	3.7 (2.1)	2 (1.4)	1.8 (1.5)	1	2.3 (1.7
Start time of NS [mean (sd)]	19:27 (01:35)	21:49 (00:56)	21:55 (02:08)	22:22 (1:22)	21:30 (01:51)
End time of NS	05:37 (01:44)	06:30 (00:53)	07:07 (00:40)	07:07 (01:01)	06:39 (01:13)
NS duration in hours [mean (sd)]	10.1 (0.9)	8.7 (1)	9.2 (1.8)	8.8 (1.5)	9.1 (1.4)
Outcomes [mean (sd)]					
Start time 1st sleep	08:01 (01:26)	14:21 (01:14)	09:39 (01:55)	10:34 (02:31)	10:43 (02:55)
End time 1st sleep	14:12 (01:48)	18:26 (01:58)	13:05 (02:30)	16:27 (03:06)	15:38 (03:07)
Regularity of start time 1st sleep (min)	30 (23)	59 (22)	34 (27)	65 (48)	49 (35)
Start time 2nd sleep	-	-	17:17 (02:50)	16:39 (03:15)	16:58 (02:58)
End time 2nd sleep	-	-	20:24 (02:47)	19:27 (03:08)	19:55 (02:54)
TST (min)	353 (74)	233 (140)	363 (76)	387 (109)	337 (117)
Regularity of TST (min)	52 (21)	41 (24)	33 (20)	71 (28)	50 (27)
Soundness[b]	3.7 (0.9)	4 (1.7)	3.5 (1.2)	4.1 (1.2)	3.8 (1.3)
Refreshed[b]	2.9 (0.8)	4.1 (1.2)	2.3 (0.9)	3.4 (1.3)	3.2 (1.2)

NS, night shifts; TST, total sleep time; n, number of participants; min, minutes.

[a]Eveningness was measured with the question: 'One hears about "morning" and "evening" types of people. Which one of these types do you consider yourself to be?'

[b]Soundness of sleep and feeling refreshed after sleep were rated on a scale from 1–7.