Subjective and Objective Measures of Adaptation and Readaptation to Night Work on an Oil Rig in the North Sea

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**Study objectives:** To study the adaptation and readaptation processes to 1 week of night work (6:30 AM to 6:30 PM) followed by 1 week of day work (6:30 AM to 6:30 PM).

**Design:** Part of a randomized, placebo-controlled, crossover field study. Here, data from the placebo arm are presented.

**Setting:** Oil rig in the North Sea. Work schedule: 2 weeks on a 12-hour shift, with the first week on the night shift and the second week on the day shift.

**Participants:** Subjects complaining about problems with adjusting to shift work. Seventeen workers completed the study.

**Interventions:** N/A.

**Measurements:** Subjective and objective measures of sleepiness (Karolinska Sleepiness Scale and simple serial reaction time test) and sleep (diary and actigraphy).

**Results:** Both subjective and objective measures improved gradually during night work. The return to day work after 1 week on the night shift led to a clear increase in subjective sleepiness and worsening of sleep parameters. During the week on the day shift, sleepiness and sleep gradually improved, similar to the improvement seen during night work. The workers indicated that the day shift was worse than the night shift on some of the measures, e.g., sleep length was significantly longer during the night-shift period.

**Conclusions:** This is one of few studies showing how shift workers in a real-life setting adjust to night work. Both subjective and objective sleepiness and subjective sleep improved across days. The effects were especially pronounced for the subjective data.

**Keywords:** Night work, field study, circadian rhythm, subjective ratings, objective ratings

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INTRODUCTION

SHIFT WORK THAT INCLUDES NIGHT WORK IS ASSOCIATED WITH SHORTENED SLEEP AND INCREASED SLEEPINESS,1 AS WELL AS IMPAIRED PERFORMANCE and increased accident risk.2 Sleep is reduced by approximately 2 hours in connection with night and morning shifts,3 and mainly stage 2 and REM are affected.4-6 Sleepiness is particularly increased toward the end of the night shift and is seen in subjective measures7-9 as well as in electroencephalogram and electrooculogram indicators of sleep intrusions during work.6,10-12

One would expect the increased sleepiness to lead to impaired performance, but there are relatively few studies available. In industry, a classic study is that of Bjerner et al, who showed that errors in meter readings over a period of 20 years in a gas works had a pronounced peak on the night shift.13 There was also a secondary peak during the afternoon. Similarly, Brown demonstrated that telephone operators connected calls considerably slower at night.14 Woyczak-Jaroszova found that the speed of spinning threads in a textile mill went down during the night.15 Most other studies of performance have used laboratory-type tests and demonstrated, for example, reduced reaction time or poorer mental arithmetic on the night shift.9,16

Whether there is an adaptation to successive night shifts has often been discussed. On the whole, this does not seem to be the case, other than in very small amounts. Thus, sleep duration and subjective sleepiness do not adjust,17-19 and permanent night workers do not seem to have markedly longer sleep than do rotating shift workers.17,18 Performance has not been studied much with respect to adjustment, but accidents seem to increase across 4 night shifts.2 However, simulated shift work (in the laboratory) usually shows an improvement of performance across night shifts.20 Part of the reason for the lack of adjustment in field studies is very likely the morning exposure to light that prevents a secondary peak during the afternoon.21,22 The lack of interference from light and noise in the bedroom and social demands in the simulated night work also very likely may help to improve sleep.

In a previous study, we had the opportunity to carry out a field study with what might be seen as “laboratory-quality” sleep conditions, that is, without the interference indicated above.23 This may be an ideal situation for studying the adjustment process to night work in a real work situation but under conditions optimally conducive to adjustment. The study was carried out in 7 workers...
on a North Sea oil rig, working a 14-day 12-hour night shift. The rig is a self-contained living and working space in which most work is carried out indoors, with minimal daylight interference, with good sleeping conditions, and with indoor lighting adjusted to the work pattern. Thus, the biologic night is turned into day. The results showed a strong increase in sleepiness the first and second days but then a rapid adjustment of the sleepiness pattern, which was rather complete after 4 to 6 days. It also showed a similar rapid adjustment of the sleep pattern. After 14 days offshore, the workers returned home to daytime life and exhibited large increases in sleepiness and sleep difficulties.

The present study was an extension of the previous one but with inclusion of objective sleep measurement (actigraphy) and reaction time performance during work. To the best of our knowledge, this has not been done before. In addition, the shift schedule was changed to a so-called “rotating shift,” with the first week on the night shift and the second week on the day shift. This offered the opportunity to study reentrainment to day work with control for work activity. In addition, the sample size was greatly increased.

METHODS

Subjects and Design

All subjects (n = 109) working nights at an oil rig in the North Sea completed a questionnaire about possible sleep complaints in relation to shift work (data submitted elsewhere). They were asked questions about the number of days they needed for adaptation to night work and readaptation back to day work and an overall rating of their sleep problems in relation to shift work (1 = no problem, 2 = some, 3 = moderate, 4 = severe, 5 = very severe problems). Based on an evaluation of the questionnaires, 38 subjects were included in the present study. The criteria for inclusion were problems adjusting to shift work, as indicated by needing more than 3 days for adaptation/readaptation, or an overall rating of their sleep problem as more than moderate (≥3).

The subjects were evaluated on 3 consecutive working schedules of 14 days in a randomized crossover design: placebo capsules, melatonin capsules (3 mg), and bright-light treatment. Here we present data from the placebo condition, in order to focus on the adaptation/readaptation process. Data from the treatment study will be presented elsewhere. Of the 38 included subjects, 17 completed the study. The others did not participate or complete for different reasons: did not want to participate (8 subjects), on sick leave (3), stopped working this shift schedule (5), and quit or on leave (3), whereas 2 subjects were dropouts during the study. Mean age of the 17 subjects completing the study was 42 years (range 29-55 years). One was a woman, the others men. They were in good health, as indicated by their biannual compulsory medical check-up. They enrolled in the study voluntarily and were not paid or otherwise compensated for participation. Data were collected from April 2002 to April 2003. Light levels inside the oil rig were not recorded in this study. We have previously measured this on a similar rig, where light levels varied from 20 to 700 lux, with an estimated average intensity in most areas of 200 to 300 lux.

The subjects had a work schedule of 2 weeks on a 12-hour shift, with the first week on the night shift (6:30 PM to 6:30 AM) and the second week on the day shift (6:30 AM to 6:30 PM). On the “rotating” day, the workers ended their night shift at 4:00 AM and started day work at 10:00 AM. After 3 to 4 weeks off work, this working schedule was repeated. There were small variations in the work hours between the subjects and from day to day, due to unplanned overtime and individually adjusted work schedules. This unplanned overtime was not systematically recorded.

Written informed consent was obtained from all subjects. The study was approved by The Regional National Committee for Research Ethics, and the Norwegian Medicines Agency.

Subjective Measures

Subjective ratings of sleepiness were obtained using the Karolinska Sleepiness Scale (KSS) and a shortened version of the Accumulated Time with Sleepiness scale (ATS). The KSS is a 9-point verbally anchored scale with the following steps: 1 = very alert, 3 = alert, 5 = neither alert nor sleepy, 7 = sleepy, but no problem staying awake, and 9 = very sleepy, fighting sleep, effort to stay awake. The intermediate steps are not anchored verbally. The subjects rated sleepiness on the KSS every other hour while at work (at 8:00 PM, 10:00 PM, and so on). The ATS scale is designed to give an integrated rating representing sleepiness over longer periods, i.e., accumulated sleepiness (in percentage of time) during the 12-hour shift. The subjects were asked: “Did you experience any of the following symptoms: heavy eyelids, feeling gravel eyed, difficulties in focusing your eyes, irresistible sleepiness, reduced performance, and periods when you were fighting sleep?” ATS ratings were recorded every day before going to bed during the 14-day work period. The subjects also gave an overall rating of the day (1 = very good, 3 = good, 5 = neither good nor bad, 7 = bad, 9 = very bad). In addition, they recorded their intake of coffee and tea on a daily basis.

Subjective sleep was obtained with a modified version of the sleep diary presented by Morin. The diary consisted of the subject’s estimates of the prior sleep episode and was recorded daily for the 14-day work period. The following measures were derived from the diary: bedtime, light out time, sleep-onset latency, wake after sleep onset, number of awakenings, early morning awakening (time spent in bed after final wake-up), final wake-up time, get-up time, total wake time (sleep-onset latency + wake after sleep onset + early morning awakening), total sleep time, time in bed, sleep efficiency (total sleep time as a percentage of time in bed), and an overall rating of the sleep episode (1 = very restless, 5 = very sound).

After the 2-week work period, the subjects were asked in a short questionnaire how many days they felt it took to adapt to night work and how many days they felt it took to readapt back to day work. They were also asked how they rated these 2 weeks of shift work compared with “regular” shift-work periods (1 = much better than usual, 3 = better than usual, 5 = as usual, 7 = worse than usual, 9 = much worse than usual).

Objective Measures

Objective ratings of sleepiness were obtained using a 5-minute simple serial reaction time test on a Palm handheld computer. This was a modified version of similar tests developed by others. This 5-minute reaction time test has been validated and compared with longer tests. Fifty black squares were displayed on the screen at squarely distributed intervals (4.75-7.25 seconds) over 5 minutes. The subject’s task was to respond to the stimuli by pressing a key to turn off the square. If no response was given within 1750 milliseconds, a new interval was started. Pressing the key before the square was displayed, or within 120 millisecond-
Comforts, caused the response to be discarded and a warning to be displayed. The software that controlled the internal clock yielded data with at least a 0.5-millisecond resolution. Another part of the program calculated the mean and median reaction times, the number of lapses (> 500 milliseconds), and the mean of the 10% best and slowest reaction times during the 5-minute task. The reaction time test was performed at 3 timepoints (midnight, 3:00 AM, 6:00 AM) during night 1, 3, and 6 of the night-shift period (week 1) and, similarly, at 3 timepoints (midday, 3:00 PM, 6:00 PM) during day 1, 3, and 6 of the day-shift period (week 2).

Objective sleep-wake activity was recorded with an Actiwatch recorder (Cambridge Neurotechnology Ltd, England), which is a small wrist-worn device, sized 1 × 3 × 3 cm, containing an accelerometer that is optimized for highly effective sleep-wake inference from wrist activity. The Actiwatch has been validated for documenting longitudinal changes in sleep patterns. The sensitivity of the Actiwatch was set to medium. Data were collected in 1-minute epochs and transferred, via an interface, to a computer and then analyzed (Actigraphy Sleep Analysis 2001, Cambridge Neurotechnology Ltd). The subjects wore the Actiwatch during the whole 2-week work period, except when taking a bath or shower. They were instructed to register the time they went to bed and the time they got out of bed by pressing a button on the actigraph. In case the subjects had forgotten to do so, bedtime or get-up time was obtained from the sleep diary. The following measures were derived from the actigraph: sleep-onset latency, wake after sleep onset, early morning awakening, total wake time, total sleep time, time in bed, and sleep efficiency.

Table 1—Subjective and Objective Sleepiness and Sleep

<table>
<thead>
<tr>
<th>Condition*</th>
<th>Day*</th>
<th>Condition × Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleepiness questionnaire</td>
<td>F₁,₁₆</td>
<td>F₆,₉₆</td>
</tr>
<tr>
<td>(n = 17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KSS mean</td>
<td>0.02</td>
<td>22.7***</td>
</tr>
<tr>
<td>Quality of day</td>
<td>5.3*</td>
<td>6.9***</td>
</tr>
<tr>
<td>Heavy eyelids</td>
<td>2.3</td>
<td>7.9***</td>
</tr>
<tr>
<td>Irresistible sleepiness</td>
<td>1.5</td>
<td>7.8***</td>
</tr>
<tr>
<td>Reduced performance</td>
<td>1.4</td>
<td>5.0**</td>
</tr>
<tr>
<td>Fighting sleep</td>
<td>0.4</td>
<td>9.1***</td>
</tr>
<tr>
<td>Coffee or tea intake</td>
<td>8.4*</td>
<td>0.4</td>
</tr>
<tr>
<td>Sleep diary (n = 16)</td>
<td>F₁,₁₅</td>
<td>F₅,₅₅</td>
</tr>
<tr>
<td>Total sleep time</td>
<td>8.7</td>
<td>3.9**</td>
</tr>
<tr>
<td>Total wake time</td>
<td>0.01</td>
<td>6.9***</td>
</tr>
<tr>
<td>Sleep efficiency</td>
<td>0.4</td>
<td>7.2***</td>
</tr>
<tr>
<td>Sleep-onset latency</td>
<td>1.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Sleep quality</td>
<td>2.3</td>
<td>2.4 p &lt; .10</td>
</tr>
<tr>
<td>Reaction time (n = 12)</td>
<td>F₁,₁</td>
<td>F₂,₂₂</td>
</tr>
<tr>
<td>Mean</td>
<td>0.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Median</td>
<td>0.2</td>
<td>3.5</td>
</tr>
<tr>
<td>Actigraphy (n = 14)</td>
<td>F₁,₁₁</td>
<td>F₅,₅₆</td>
</tr>
<tr>
<td>Total sleep time</td>
<td>23.7***</td>
<td>1.6</td>
</tr>
<tr>
<td>Total wake time</td>
<td>0.2</td>
<td>1.7</td>
</tr>
<tr>
<td>Sleep efficiency</td>
<td>0.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Sleep-onset latency</td>
<td>0.1</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Results from 2-way analysis of variance, F values, and p values. KSS refers to Karolinska Sleepiness Scale.
*Condition refers to night vs day work; day is the day of the week
*p < .05
**p < .01
***p < .001

Table 2—Subjective and Objective Sleepiness using Separate Analyses for the Night and Day Shift

<table>
<thead>
<tr>
<th>Condition*</th>
<th>Day*</th>
<th>Time*</th>
<th>Day × time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karolinska Sleepiness Scale score (n = 17)</td>
<td>F₅,₈₀</td>
<td>F₅,₈₀</td>
<td>F₅,₈₀,₈₀</td>
</tr>
<tr>
<td>Subjective sleepiness</td>
<td>F₂,₂,₂</td>
<td>F₂,₂,₂</td>
<td>F₄,₄,₄</td>
</tr>
<tr>
<td>During night work</td>
<td>16.3***</td>
<td>36.4**</td>
<td>3.9**</td>
</tr>
<tr>
<td>During day work</td>
<td>6.8***</td>
<td>5.5*</td>
<td>2.6**</td>
</tr>
<tr>
<td>Reaction time</td>
<td>F₂,₂,₂</td>
<td>F₂,₂,₂</td>
<td>F₄,₄,₄</td>
</tr>
<tr>
<td>Night work (n = 14)</td>
<td>Mean</td>
<td>4.7*</td>
<td>2.7</td>
</tr>
<tr>
<td>Median</td>
<td>5.3*</td>
<td>2.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Day work (n = 12)</td>
<td>Mean</td>
<td>2.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Median</td>
<td>0.7</td>
<td>0.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Results from 2-way analysis of variance, F values, and p values. *Condition refers to night vs day work; day is the day of the week
**p < .05
***p < .01
****p < .001

Statistical Analysis

Data were analyzed using SPSS version 11.5 (SPSS, Inc., Chicago, IL). For a straightforward analysis of overall adaptation to the shifts, variables with more than 1 measurement per shift were averaged to yield 1 value per shift. Thus, sleepiness and sleep were analyzed in a 2-way analysis of variance (ANOVA) with condition (night work or day work) and day as factors, in order to compare and follow the adjustment process to night work and the readaptation back to day work. Lights out and wake-up time were analyzed separately for the night and day shift using a 1-way ANOVA with day as factor. Since the work schedule imposed restrictions on sleep opportunity on the rotating day, subjective and objective sleep data were analyzed during the first 6 days of both conditions (day 7 excluded). In order to study the within-shift pattern in detail for KSS and reaction time, another 2-factor repeated-measures ANOVA was carried out, retaining the individual measurements during the shift and employing day and time of day as factors, separately for the night week and day week. For the KSS tests, the rotating day was excluded in the ANOVA analysis due to fewer timepoints. P values were corrected for lack of compound symmetry using the epsilon correction according to the Huynh-Feldt procedure. The α level was set at .05. In order to retain as many subjects as possible in the analysis, missing data were replaced by careful estimates. If data from, for example, night 3 were missing, an average of night 2 and 4 was inserted. If night 7 or day 7 was missing, night or day 6 was inserted instead. If night or day 1 was missing, night or day 2 was inserted. The total number of missing data that were corrected varied between 1.1% and 3.6%, except for recorded intake of coffee and tea, in which 8.0% of the data were missing.

RESULTS

Subjective Measures

Sleepiness

Table 1 and 2 present the results from the ANOVAs. Table 1 shows that there were significant changes in sleepiness across
days on all measured parameters. During the first week of night work, sleepiness was gradually reduced. Then, when the workers shifted back to day work, sleepiness was again increased to high levels. During the second week (day work), and similar to the night-work week, sleepiness was gradually reduced toward the end of the working period (Figure 1).

In addition, KSS ratings at different timepoints were analyzed, separately for the night shift and day shift (Table 2, Figure 2). During night work, sleepiness was significantly reduced from day to day, whereas the time-of-day analysis showed that sleepiness steadily increased from 8 PM to 6 AM (Table 2, Figure 2). In addition, there was a significant interaction between day and time,
indicating that the rate of increase in sleepiness across the night fell during the work period (Figure 2).

During day work, significant changes across days and between individual timepoints were seen, as was a significant interaction between day and time (Table 2, Figure 2). Similar to findings from the night work, sleepiness decreased from day to day (Figure 2). The first day after shifting back to day work, sleepiness was highest early in the day (at 10 AM), whereas, during the following days, sleepiness showed an increasing trend with highest sleepiness in the late afternoon (Figure 2).

On most sleepiness measures (Table 1), no significant difference was seen between the conditions (night or day work). Sleep-onset latency did not differ across days or between conditions (Table 1).

There was no significant change across days in when the workers turned off the lights to go to sleep during the night shift (F = 1.1) or during the day shift (F = 2.2, p = .07). Wake-up time during the night shift did not change either (F = 1.5), but, during the day shift, a significant delay was seen (F = 3.8, p < .01). Figure 4 shows lights-out and wake-up times during both the night and day shifts.

**Short Questionnaire**

The subjects reported significantly fewer days for adaptation to night work than for adaptation back to day work (2.7 versus 4.4, p = .002, t-test). The subjects rated these 2 weeks of shift work compared with “regular” shift work periods. The score was 5.6 (SD 1.8), indicating that the shift-work period was rated “as usual.”

**Objective Measures**

**Sleepiness—Reaction Time Test**

Due to missing data and technical problems with the Palm computer, fewer subjects (n = 14 night shift, n = 12 day shift) completed the reaction time tests. Similar to the subjective sleepiness data, no consistent differences in reaction times were seen between the night-shift and day-shift conditions (Table 1, Figure 5). The second ANOVA that included separate analysis for the night and day shift showed a significant reduction in reaction time across days for the night shift but not for the day shift (Table 2, Figure 5). During the day shift, no significant changes were seen across days, time of day, or interaction between day and time (Table 2, Figure 5).

**Sleep—Actigraphy**

Objective sleep showed similar values as subjective sleep, but there were no significant differences across days on the measured parameters (Table 1, Figure 3). As for subjective sleep data, total sleep time was clearly longer during the night shift compared with during the day shift (Table 1, Figure 3). Total wake time, sleep efficiency, or sleep latency did not show any significant changes across condition (Table 1, Figure 3).
DISCUSSION

Both subjective and objective measures of sleepiness and subjective sleep gradually improved during the night-work week. The return to day work after 1 week on the night shift led to a clear increase in subjective sleepiness and worsening of sleep parameters. During the week on day shift, sleepiness and sleep gradually improved, similar to the improvement seen during night work.

The adjustment is similar to what was seen in our previous study, but contrasts with what is usually the case in more conventional shift-work situations in which sleepiness and sleep do not seem to improve much. Part of the reason for the lack of adjustment in traditional field studies is very likely the morning exposure to light that prevents a phase delay. In the laboratory studies, the lack of interference from...
light and noise in the bedroom and the absence of social demands also may help to improve sleep. Working offshore at an oil rig may provide similar and more optimal conditions for adjustment, since workers are not leaving the rigs between shifts. Our previous study also showed a gradual adjustment, but across 14 days. This study, however, was small (7 subjects) and only investigated subjective measures. Thus, the present study extends the previous findings that improvement in sleep and sleepiness is possible in real-life night-work settings. Other studies have looked at adaptation to night work using circadian markers. Barnes et al showed that oil rig workers on a 2-week night shift adapted to night work within a week, as measured by the circadian phase marker melatonin. In a similar shift schedule, as in the present study, Gibbs et al showed that oil rig workers adapted to the night shift during the first week, whereas there were large individual variations seen during the day shift, using a urinary melatonin metabolite as circadian marker. They concluded that subjects did adapt to the night shift but not back to day shift.

One convincing piece of evidence of an adjustment to night work in the present study was the clear increase in sleepiness and worsening of sleep following return to day work. If adjustment to night work had not taken place, we would have expected a fairly easy return to day work. For most measures, there were no significant differences between the night- and day-work conditions, indicating that both shifts were problematic. Interestingly, for some measures such as quality of day and total sleep time, the day shift was considered worse. Sleep length was clearly shortened for several days following the shift back to day work. The workers also reported that they felt it took fewer days to adapt to night work than to readapt back to day work: 2.7 versus 4.4 days. This was also reflected in the disappearance of symptoms like “heavy eyelids” after 3 to 4 night shifts, whereas, during the day shift, such symptoms were maintained at higher levels throughout the week. This is consistent with the complaints of many offshore workers, who claim that the problem is mainly during the readaptation period (personal communication).

One reason why it may be easier to adapt to night work than to readapt back to day work is that it is easier to phase delay than to phase advance the circadian rhythm. This is in part due to the fact that most people have a biologic clock running at a period slightly longer than 24 hours. On the other hand, with 12-hour shifts, a shift from day to night work would seem to be as much of a delay as a shift to day work. But, inspection of the pattern of adjustment of KSS indicates that the pattern on the last night still was one of a rise during the shift (from 8 PM to 6 AM). A full reversal was clearly not seen, since normal day work usually shows a U shape with low values in the middle of the waking span. Thus, one might suspect that full adjustment had not occurred, at least not in terms of pattern. On the day shift, however, the fall during the first day gradually became more of a U shape toward the last day, suggesting a return to a normal daytime pattern. In the present case, external light exposure was virtually nonexistent during daytime, and, thus, readaptation was not facilitated by morning light exposure. Direct comparisons between the night and day shifts are complicated, since the day shift follows a week of 7 consecutive night shifts, likely to induce cumulative sleep deprivation. Also, the workers suffer from acute sleep deprivation during the rotating day preceding the day shift. These factors influence how the workers adjust to the day shift.

However, we would like to point out that, even though the day-shift period may be worse, both sleepiness and sleep were compromised during the first days and nights on the night shift. That is, the present study clearly shows that night work is problematic for these offshore workers. It is important to note that the present study only examined shift workers complaining about night work. Many shift workers claim that they do not suffer from sleepiness or disturbed sleep. Few studies have examined these workers in detail, in order to look for possible discordance between subjective and objective measures. One recent study showed that satisfaction with the shift schedule reflected how well the shift workers coped with the schedule, suggesting that the increase in sleep-wake problems for the dissatisfied workers may be related to increased sensitivity to curtailed and displaced sleep.

The subjective and objective measures of sleepiness and sleep did not show complete agreement. The results were clearer and more significant for the subjective data. There are many possible reasons for this. Actigraphy is considered a valid form of objective sleep recording, and, even though it may overestimate sleep, it has been shown to correspond well with sleep diaries and poly-
The performance measure chosen was a simple serial reaction time task, which has been identified as being sensitive to sleepiness-inducing situations. Even though the workers reported increased sleepiness in the present study, they performed relatively well on the performance test. In fact, during day work, no significant changes were seen across days or time of day. One may argue that a 5-minute reaction time test is too short, as most other researchers have used tests lasting 10 minutes. Recently, a direct comparison between a 10-minute and a 5-minute reaction time test showed comparable results following 28 hours of sustained wakefulness. A shorter test was used in the present study for logistic purposes but may have masked possible sleepiness-induced performance decrements. The reaction test was also used during the second half of the shift and only a few nights or days, making direct comparisons with subjective sleepiness difficult.

In conclusion, this is one of few studies showing that the sleepiness and sleep of shift workers in a real-life setting improve during consecutive night shifts. Both subjective and objective sleepiness and subjective sleep measures showed improvement. The effects were especially pronounced for the subjective data.

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