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Original Article

Subjective and objective sleep and sleepiness among tunnel workers in an extreme and isolated environment: 10-h shifts, 21-day working period, at 78 degrees north

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ABSTRACT

Objectives: The aim of this study was to examine the effects of extended work hours (10 h on, 14 h off for 21 days) on sleep and sleepiness in an extreme and isolated environment in the far north (Spitsbergen, 78 degrees north). We wanted to examine whether sleep duration, sleepiness and other parameters changed over the 3-week working period and whether the parameters differed between day and night shifts.
Methods: The work consisted of tunnel construction in Svea, Spitsbergen. The participants worked alternate fixed day shift (06:00–16:00) or fixed night shift (18:00–04:00) for a 21-day work period in a counterbalanced, crossover design. The participants were 25 male workers (age 24–60 years). We used subjective and objective measures of sleep (diary and actigraphy) and a subjective daytime sleepiness and function questionnaire.
Results: The workers had a high sleep efficiency measured both subjectively and objectively. This did not change across days or between day and night shifts. Total sleep time was significantly shorter (about ½ to 1 h) during the day shift period than during the night shift period, as measured both subjectively and objectively, but did not differ across days. Subjective ratings of sleepiness did not differ between shifts.
Conclusions: There were few differences between the day and night shift periods and across the 21-day working period, as measured both subjectively and objectively. The subjects experienced few problems and seemed to adapt easily to their work schedule. This contrasts with what is usually the case in more conventional shift work situations, where workers do not adapt well, as measured by sleepiness and various sleep parameters.

1. Introduction

The number of shift workers is increasing; 18.8% of the European workforce is engaged in shift work that includes night work [1]. Society has changed towards a 24-h society where time no longer sets limits for human activity. There is a change in lifestyle and social structure, and new economic and productive strategies require shift work to increase production and lower costs [1].

Shift work, and especially night work, disrupts the relationship between the body's internal clock and the environment and is associated with shortened sleep, increased sleepiness [2], impaired performance and increased accident risk [3,4]. Sleep is reduced by approximately 2 h in connection with night and morning shifts [5]; sleep stage 2 and REM sleep are mainly affected [6–8]. Sleepiness is particularly increased toward the end of the night shift and is seen in subjective [9–11] and objective measures [7,12–14].

Whether one can adapt to successive night shifts has often been discussed since studies are not always in agreement. This may be due to different working and living conditions in the different study populations and the different methods and approaches used [15]. In addition, the factors contributing to shift and night work tolerance are complex, including family, social and working conditions, and individuals' personality and coping strategies. The combined effects are difficult to interpret because their relations depend not only on the specific weight of each factor, but also on the timing and duration in a worker's life [15].

When looking at shift workers as a group, sleep duration and subjective sleepiness do not adjust [16–18] during consecutive night shifts, and there is no evidence that permanent night workers have markedly longer sleep than rotating shift workers [16,17]. Several studies indicate that workers may not adapt their circadian rhythm even following weeks of consecutive night work [19,20]; however, subjects usually show an improvement of performance across night

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shifts in simulated shift work (in the laboratory) [21]. Part of the reason for the lack of adjustment in field studies is likely the morning exposure to light that prevents a phase delay [22,23]. Also, in simulated night work, the lack of interference from light and noise in the bedroom and social demands may help to improve sleep. But field studies have been conducted under what might be seen as "laboratory-quality" sleep conditions, which are without the interference indicated above [24,25]. These studies were carried out on a North Sea oil rig, a self-contained living and working space in which most work is carried out indoors, with minimal daylight interference. The sleeping conditions are good with indoor lighting adjusted to the work pattern, and the biological night turns into day. Night workers show a strong increase in sleepiness the first and second days but then a rapid adjustment of the sleepiness pattern, which is rather complete after 4–6 days. The sleep pattern shows a similar rapid adjustment [24,25]. These studies are among the few showing that subjective and objective sleepiness and sleep of shift workers in a real-life setting may improve during consecutive night shifts. The effects were especially pronounced for the subjective data [25].

The aim of the present study was to examine the effects on sleep of extended work hours (10 h on, 14 h off for 21 days) in an extreme and isolated environment in the far north (Spitsbergen, 78 degrees North). We wanted to examine whether sleep duration, sleepiness and other sleep parameters changed over the course of the 3-week working period and whether there were differences between day and night shifts.

2. Methods

2.1. Subjects and design

The background for this study was a request by a construction company in Norway to use a work schedule that was not in accordance with Norwegian law. The company was building a tunnel for a coal mine in Svea, Spitsbergen (78 degrees North), an isolated place where there are no or few other possible activities than work. The workers spent 21 days at Svea followed by a 21-day free period at home. During the work period, the workers completed 21 day shifts or 21 night shifts every other period in a counterbalanced, crossover design. The day shift was from 06.00 to 16.00, and the night shift was from 18.00 to 04.00. The workers were organized in teams of 10–12 workers for each shift. They performed blasting and drilling of rock, loading and transport of the blasted rock out of the work area, scaling, cleaning, rock bolting and cement spraying, as well as maintenance of the equipment and cars. The tunnel itself was dark, but the blasting and drilling areas were lit. Parts of the work were physically demanding, as they had to climb, crawl and work in different positions.

The Norwegian Labor Inspection Authority gave the company permission to use this shift schedule if the University of Bergen undertook an evaluation of the health consequences during the work period. This article covers the sleep portion of the study; other parameters and results are submitted elsewhere [unpublished observations]. Only workers who had valid sleep diary data for both the day- and night-shift periods were included in this study ($n = 25$). All 25 subjects were men, and mean age was 44 years (SD = 9.2, range 24–60 years). Only 12 had valid data from actigraphy due to missing data. Twenty-three workers had valid data from the Daytime Sleepiness and Function Questionnaire.

Data concerning the sleep portion of the study were collected two times: September/October 2003 and November/December 2003 (counterbalanced, crossover design). Food was freely available in a dining room, but dinner was served only once a day at about 5 p.m. There are 14 h of sunlight in mid-September and the sun is below the horizon from October 27th.

2.1.1. Overall questionnaire

The sleep questions included in the main health study questionnaire assessed sleep parameters during the workers time off and included an overall rating of their sleep the past three months (1 = very good, 2 = good, 3 = neither good nor bad, 4 = bad, 5 = very bad), their average sleep duration per day both during the work periods, their periods off work, and their subjective sleep need. They were also asked a question about the overall rating of their sleep problem in relation to shift work (1 = no problem, 2 = some, 3 = moderate, 4 = severe, 5 = very severe problems). In addition, the subjects completed a modified version of Karolinska sleep/wake questionnaire assessing sleep problems during the last three months. This questionnaire included questions like whether or not they felt they were getting an insufficient amount of sleep (at least 1 h less than subjective sleep need), tired/sleepy during work hours/leisure time and the need to fight off sleep. These last questions had a five-point verbally anchored scale where 1 = never, 2 = seldom, 3 = sometimes, 4 = often and 5 = always. They were also asked about their use of sleep medication, melatonin and bright light treatment.

2.1.2. Daytime sleepiness and function

Subjective ratings of sleepiness were obtained using a shortened version of the Accumulated Time with Sleepiness (ATS) scale [26]. 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 10-h 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 (subjectively scored as the percentage of time at work with the complaint) during the 21-day work period. In addition, the subjects gave an overall rating of the day (1 = very good, 3 = good, 5 = neither good nor bad, 7 = bad, 9 = very bad). They also recorded their intake of coffee, tea and cola on a daily basis.

2.1.3. Sleep diary

Subjective sleep was obtained with a modified version of the sleep diary presented by Morin [27]. The subjects' recorded estimates of prior sleep episodes daily in the diary for the 21-day work period. The following measures were derived from the diary: bedtime, lights out, 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), time in bed, total sleep time, 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). In addition, any use of sleep medication was recorded.

2.1.4. Actigraphy

Objective sleep–wake activity was recorded with an Actiwatch recorder (Cambridge Neurotechnology Ltd, England), which is a small wrist-worn device, sized $1 \times 3 \times 3$ 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 [28]. The sensitivity of the Actiwatch was set to medium. Data were collected in 1-min epochs and transferred via an interface to a computer and then analyzed (Actigraphy Sleep Analysis 2001, Cambridge Neurotechnology Ltd). The subjects were instructed to put on the Actiwatch when they went to bed and take it off when they got out of bed. They could not wear the Actiwatch continuously as they were often exposed to water during work, possibly destroying the Actiwatch. They were instructed to register the time they went