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Sleep in a live-in mining operation: The influence of start times and restricted non-work activities

Sally A. Ferguson [a,*], Angela A. Baker [a], Nicole Lamond [a], David J. Kennaway [b], Drew Dawson [a]

[a] Centre for Sleep Research, University of South Australia, City East Campus, Adelaide, SA, Australia
[b] Discipline of Obstetrics and Gynaecology, Research Centre for Reproductive Health, University of Adelaide, Australia

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ABSTRACT

The amount of sleep obtained between shifts is influenced by numerous factors including the length of work and rest periods, the timing of the rest period relative to the endogenous circadian cycle and personal choices about the use of non-work time. The current study utilised a real-world live-in mining environment to examine the amount of sleep obtained when access to normal domestic, family and social activities was restricted. Participants were 29 mining operators (26 male, average age 37.4 ± 6.8 years) who recorded sleep, work and fatigue information and wore an activity monitor for a cycle of seven day shifts and seven night shifts (both 12 h) followed by either seven or fourteen days off. During the two weeks of work participants lived on-site. Total sleep time was significantly less ($p < 0.01$) while on-site on both day (6.1 ± 1.0 h) and night shifts (5.7 ± 1.5 h) than days off (7.4 ± 1.4 h). Further, night shift sleep was significantly shorter than day-shift sleep ($p < 0.01$). Assessment of subjective fatigue ratings showed that the sleep associated with both days off and night shifts had a greater recovery value than sleep associated with day shifts ($p < 0.01$). While on-site, participants obtained only 6 h of sleep indicating that the absence of competing domestic, family and social activities did not convert to more sleep. Factors including shift start times and circadian influences appear to have been more important.

1. Introduction

The disruption to sleep and the circadian system caused by shiftwork is well documented. Inadequate recovery sleep between shifts, in combination with circadian influences on sleep and alertness result in increased fatigue-related risk for many shift-workers (Folkard and Tucker, 2003; Smith et al., 1994). Recent studies suggest that more than 6 h time in bed per night is required to maintain performance across consecutive nights (Belenky et al., 2003; Van Dongen et al., 2003). Further, sleep debt accumulated over a series of consecutive days can impact on cognitive and physical performance, and increase the risk of error and incident in the workplace and on the road (Belenky et al., 2003; Folkard and Tucker, 2003). Adequate sleep between work periods is thus critical, but remains a challenge for many.

Balancing work, non-work activities and sleep is increasingly difficult for workers in the western world. Long hours, family responsibilities, social commitments, leisure activities and personal time are in competition on a daily basis for limited hours. Individuals who work shiftwork and/or extended hours have a greater issue managing the challenges of work/life balance. For example, the family, social, and leisure opportunities of shift-workers rarely coincide with time away from work (Baker et al., 2003; Wedderburn, 1981). Thus, in addition to dealing with the well known physiological challenges of shiftwork such as sleep and circadian rhythm disruption imposed by the work schedules (Akerstedt, 1998; Dinges, 1995; Folkard and Tucker, 2003; Roach et al., 2003), shiftworkers also experience significant challenges balancing and prioritising all of life's activities (Pisarski et al., 2008; Yildirim and Aycan, 2008). This is highlighted in an analysis of time use in America that reported a strong negative relationship between work time and sleep time (Basner et al., 2008). As total work hours increased, the amount of sleep was reported to decrease. In addition, social, personal and leisure time were also reported as factors that influenced the amount of sleep people achieved on a daily basis (Basner et al., 2008). For most individuals, as work is generally the fixed variable in the 'equation', it follows that, where access to non-work activities is restricted, sleep should benefit. While there are few situations where that is actually the case, fly-in/fly-out operations are one example.

* Corresponding author. Centre for Sleep Research, University of South Australia, G.P.O. Box 2471, Adelaide, SA 5000, Australia. Tel.: +61 8 83026624; fax: +61 8 83026623.
E-mail address: sally.ferguson@unisa.edu.au (S.A. Ferguson).

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In live-in camps such as those used in remote mining operations, the normal social, domestic and leisure activities are absent. As a result, a common view is that employees in live-in camp environments "simply work and sleep" and therefore do not accumulate sleep debt in the same way as occurs in community-based operations (Folkard and Tucker, 2003; Tucker et al., 1999). While it seems logical that individuals need to partake in activities other than just work and sleep, there is some evidence that reduced domestic activities are associated with increases in total sleep time. Parkes and colleagues (Parkes, 1994) reported that workers in offshore installations obtained more sleep than workers performing the same job on the same roster (12-h shifts) in community-based settings and living at home. The authors suggested that the lack of non-work activities in the offshore environment, in particular domestic and family activities, contributed to more sleep. The current study examined the sleep patterns of employees working at a remote, fly-in/fly-out mining operation in Australia, both during time on-site and during days off away from the site, with the aim of assessing the amount of sleep obtained during non-work time compared to that reported in previous studies of 12-h shifts.

2. Material and methods

Recruitment to the study was facilitated by information sessions at the shift-start meetings for each crew. Interested individuals then met with the researchers and were provided with participant information sheets and gave informed consent. The protocol was approved by the University of South Australia's Human Research Ethics Committee.

Forty-seven individuals working in the mining operation volunteered for the study and from that group, 42 participated in data collection. The final dataset for analysis consisted of 29 volunteers (26 males) who completed all aspects of the data collection – i.e. completed sleep/work diaries on and off site, wore the activity monitor for the entire data collection period and completed performance testing while on-site (reported elsewhere). Employees travelled to the work site from various parts of Australia and stayed in the employer-provided accommodation facilities throughout their 2-week work cycle. Average age of participants was 37.4 ± 6.8 years (mean $\pm$ SEM) with an average BMI of 27.7 ± 3.6 kg/m^2. Participants had an average of 12.6 ± 7.1 years of experience working shiftwork.

2.1. Work and living environment

All participants worked seven day shifts followed by seven night shifts followed by either seven or 14 days off site (a 24-h change-over period separated day and night shift blocks). Individuals participated for the length of one complete cycle (i.e. 21 or 28 days – 7D, 7N 7 or 14 off). Day shifts started between 0500 h and 0600 h and night shifts between 1700 h and 1800 h. Shifts were 12.2 h in length (note that there were no differences in demographic characteristics between the employees who had seven days off site and those who had 14 days off site). Two meal breaks were provided during each shift.

The accommodation areas were located a short distance from the mine and the majority of employees used the bus service. The majority of rooms had ensuites while some had shared bathroom facilities.

2.2. Measurements

Participants wore an activity monitor (Actiwatch®, Philips Respironics, Bend, OR) for one complete roster cycle, including their days off. The monitor was removed briefly when bathing. Participants also completed a daily work diary while on-site which recorded shift start and end times, and a daily sleep diary for the entire study period.

2.2.1. Determination of sleep parameters

During days on-site and days off, subjects recorded the time they went to bed, the time they believed they fell asleep and the time they woke. Diary information, in conjunction with the record from the activity monitor were combined to calculate sleep duration (total amount of sleep obtained during each sleep period), total time in bed and timing of bedtime and sleep period (Darwent et al., 2008).

In addition, subjective fatigue ratings pre-sleep and post-sleep were recorded using the Samn–Perelli Fatigue Scale (Samn and Perelli, 1982).

Each main sleep period was classified according to the following: day-shift sleeps ($n = 148$) followed a day shift, night shift sleeps ($n = 162$) followed a night shift, and days off sleeps (n = 169) were defined as those with days off prior to and after.

Subjective fatigue ratings were used to calculate the 'recovery value' of a sleep period, defined as the difference between the pre-sleep fatigue rating and the post-sleep fatigue rating.

2.3. Data analysis

Data were analysed using a mixed model ANOVA with shift type (Day, Night or RDO) entered as the fixed effect and subject ID entered as a random effect in the model. Where significant effects were found, pairwise post-hoc comparisons were used to identify differences between shift type (with Bonferroni corrections for multiple comparisons). No differences were found between roster schedules for sleep time.

3. Results

3.1. Time in bed

Time in bed was significantly higher for days off (8.6 ± 1.5 h) than both day shifts (7.1 ± 1.0 h) and night shifts (6.7 ± 1.6 h) ($F_{2,516.47} = 112.18$, $p < 0.0001$) (Fig. 1).

3.2. Sleep

Total sleep time was significantly less while on-site, for both day (6.1 ± 1.0 h) and night (5.7 ± 1.5 h) shifts, compared to days off

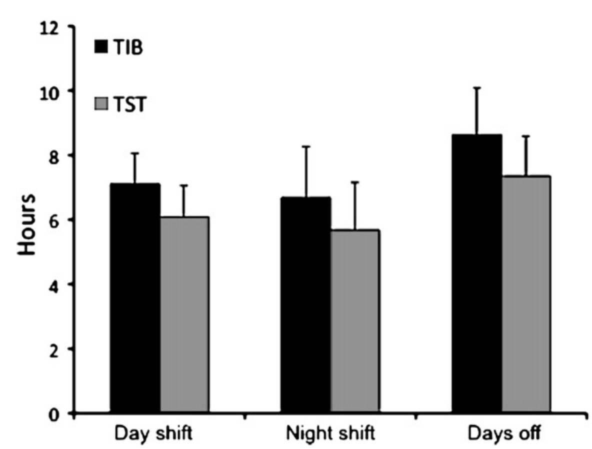

Fig. 1. Time in bed (TIB) represented by the black bars and total sleep time (TST) represented by grey bars, recorded for day shifts, night shifts and days off. The data represents the mean and standard deviation for time in bed and total sleep time of 29 individuals. TIB and TST are significantly different in each group.