Published online: 10-1-2000

Sleep Patterns, Shiftwork, and Individual Differences: A Comparison of Onshore and Offshore Control-room Operators

Katharine R. Parkes
University of Oxford

Follow this and additional works at: <https://docs.lib.purdue.edu/jhpee>

Recommended Citation

Parkes, Katharine R. (2000) "Sleep Patterns, Shiftwork, and Individual Differences: A Comparison of Onshore and Offshore Control-room Operators," *Journal of Human Performance in Extreme Environments*: Vol. 5 : Iss. 1 , Article 8.

DOI: 10.7771/2327-2937.1009

Available at: <https://docs.lib.purdue.edu/jhpee/vol5/iss1/8>

This document has been made available through Purdue e-Pubs, a service of the Purdue University Libraries. Please contact epubs@purdue.edu for additional information.

This is an Open Access journal. This means that it uses a funding model that does not charge readers or their institutions for access. Readers may freely read, download, copy, distribute, print, search, or link to the full texts of articles. This journal is covered under the [CC BY-NC-ND license](#).

SLEEP PATTERNS, SHIFTWORK, AND INDIVIDUAL DIFFERENCES: A COMPARISON OF ONSHORE AND OFFSHORE CONTROL-ROOM OPERATORS

KATHARINE R. PARKES, *DEPARTMENT OF EXPERIMENTAL PSYCHOLOGY, UNIVERSITY OF OXFORD, SOUTH PARKS ROAD, OXFORD OXI 3UD, ENGLAND*

The sleep patterns of offshore control-room operators were compared with those of personnel carrying out similar work onshore, taking into account individual differences in age, number of years of shiftwork, and neuroticism. The dependent variables were self-reported sleep quality and duration for day-shift (D-S) and night-shift (N-S) work, and during leave periods (L-P). Offshore workers reported longer N-S sleep duration, and lower D-S sleep quality than those onshore, but the two groups did not differ in L-P measures. The effects of environmental differences (onshore versus offshore) on sleep patterns were more marked than those of the two different shift systems (weekly rotation and fast rotation) in operation onshore. Age was negatively related to both duration and quality of sleep; over and above age, number of years of shiftwork was negatively related to sleep duration. Neuroticism was also negatively related to sleep duration and, more strongly, to sleep quality. These findings are discussed in relation to the literature on shiftwork and sleep in general, and the characteristics of the offshore environment in particular.

1. INTRODUCTION

Continuous production processes, and other industrial and commercial activities operating round-the-clock, have become increasingly widespread in recent years. Consequently, the design of shift schedules, and their implications for the well-being and performance of the personnel concerned, has received considerable research attention. Significant effects of shift duration and of shift

rotation patterns have been reported for a variety of outcomes, including sleep duration and quality, circadian adjustment, health complaints, job satisfaction, alertness, cognitive performance, and accidents. Moreover, it is clear from the research literature that responses to shiftwork do not depend solely on shift schedules: personal and environmental factors also play important roles. In the present study of sleep patterns among shiftworkers in the oil industry, environmental effects associated with onshore versus offshore work, and individual differences (age, previous exposure to shiftwork, and neuroticism) are the main focus of interest. Relevant findings from shiftwork research are outlined below, with particular reference to the outcome variables, sleep duration and quality, used in the present study.

1.1. Shift duration and shift rotation patterns:

The duration of work shifts designed to cover round-the-clock operations is usually either 8 h or 12 h. Shift duration has direct implications for shift schedules and work/leave patterns, longer duration shifts being compensated by extended or more frequent rest periods. The most widely studied shift system associated with the 8 h work period involves weekly or fortnightly rotation from early shift to afternoon shift to night shift, or vice versa. For instance, Vaernes et al. (1988) studied Norwegian process-control operators who worked 8 h shifts rotating every 2 weeks; they found that sleep problems were among the most frequent complaints reported. This finding is consistent with other studies which draw attention to the problems of circadian adaptation, sleep disturbance, and performance decrement associated with weekly shift rotation (e.g., Knauth et al. 1978, Knauth and Kiesswetter 1987, Tilley et al. 1982).

In recent years, there has been a trend away from weekly rota-

tion in favour of 'fast rotation' patterns of work; these shift schedules take a variety of forms but, in general, no more than two or three night shifts are worked consecutively, and periods of night work are interspersed with similar periods of day shifts and with rest days. Fast-rotating 8 h shift schedules appear to be more favourable (in terms of total amount of night sleep) than weekly rotation patterns (Knauth et al. 1983), although Monk (1986) emphasizes that the job situation as a whole, including type of work, should be considered before making decisions about shift systems. In parallel with the move towards fast-rotating shifts, there has been a tendency for shift duration to be increased from 8 h to 12 h. However, evidence suggests that 12 h shifts result in greater subjective fatigue and performance decrement than 8 h shifts (for a review, see Hurrell and Colligan 1985). More recent studies tend to confirm these findings (Rosa et al. 1989, Rosa 1991); none the less, both employees and management were found to favour the longer shift duration. Other organizations changing to 12 h shifts have also found that this arrangement is perceived favourably by employees (Peacock et al. 1983).

Within a framework of either 8 h or 12 h shifts, most onshore organizations have considerable flexibility in the planning of shift changes and work/rest schedules. However, in some areas of work (e.g., deep-sea fishing, air and sea transport operations), environmental constraints may significantly limit the types of shift systems that can be implemented. Some situations of this kind, particularly duty schedules on ships at sea (e.g., Rutenfranz et al. 1988, Torsvall and Akerstedt 1988), have been widely studied. Much less research attention, however, has been directed towards North Sea oil and gas installations, on which shift schedules are also severely constrained by environmental factors.

Shift patterns widely adopted in onshore organizations (fast-rotation schedules, in particular) are not practicable offshore. In the offshore environment, living and sleeping accommodation usually limits personnel on board the installation at any one time to twice the number actually required to be on-duty. Consequently, fast-rotating shifts would necessitate frequent travel to and from the shore; remote locations, and the expense and time involved in helicopter transport, preclude such an arrangement. Thus, the normal offshore work period is 2 weeks, although other work patterns have been examined. For instance, Alekperov et al (1988) compared 7-day work periods on oil rigs in the Caspian Sea with 15-day periods; on the basis of physiological data, the authors considered the shorter 7-day schedule to be more satisfactory than the longer cycle.

None the less, a 2-week duty cycle, in which 12 h work periods alternate with 12 h rest periods, continues to be the norm for many offshore employees in the UK sector of the North Sea. Furthermore, although working either night shifts or day shifts for the entire duration of the 2-week period would maximize the opportunity for circadian adaptation during night work, this arrangement does not appear to be widely adopted. Rather, the more usual sequence is for seven 12 h night shifts to be followed immediately by seven 12 h day shifts. Thus, when changing shift, at the end of the first week, operators have little or no sleep over a 24 h period with potentially adverse effects on sleepiness, negative mood, and cognitive task performance (Babkoff et al. 1988, Englund et al. 1985, Mikulincer et al. 1989, Wilkinson and Houghton 1982).

In spite of the problems associated with rapid shift changes, the pattern of seven night shifts followed by seven day shifts tends

to be preferred by offshore employees because it allows circadian adjustment to a normal sleep-wake cycle prior to returning to the shore (a 2-week offshore period is usually followed by 2-3 weeks leave); this pattern is also favoured by management as it enables all operators to work the same pattern during every offshore period, thus simplifying personnel schedules. However, a little research into the impact of this 2-week work cycle on the sleep and well-being of North Sea personnel has been reported, although a recent review (Sutherland and Cooper 1989) draws attention to some of the problems of shiftwork offshore. More specifically, Lauridsen et al. (1991) found that substantial proportions of offshore personnel reported one or more of the four sleep complaints assessed, and that rotating shifts were associated with more sleep problems than non-rotating shifts. Sleep problems may also be indicative of the health strains of offshore work. Thus, Hellesoy (1985) found that endorsing the item 'waking up tired' was significantly predictive of sick-bay visits among offshore workers. Although these surveys provide some general information about sleep problems associated with offshore work, there appear to be no published studies in which the duration and quality of sleep during different phases of the work cycle have been systematically compared in offshore and onshore personnel carrying out similar jobs.

1.2 *Individual differences in responses to shiftwork:*

Whilst shift duration and work-rest schedules have important effects on sleep, well-being, and performance, these effects are not the same for all employees: for instance, age, gender, personality and coping style, circadian type, rigidity of sleep patterns, and family responsibilities, may influence responses to shiftwork. Individual differences are therefore of inherent interest in understanding the processes by which shiftwork influences sleep patterns and other aspects of well-being. Furthermore, in studies which involve comparisons between different groups of shiftworkers, it may be necessary to include individual difference variables as covariates to control for possible group differences in mean levels of age, personality variables, and other individual characteristics. In the present comparison of sleep patterns in onshore and offshore workers, three individual difference variables (age, number of years previous experience of shiftwork, and neuroticism) were particularly relevant. Evidence demonstrating the roles of these factors in shiftwork adjustment is outlined below.

1.2.1. *Age:*

Adjustment to shiftwork tends to become more difficult with increasing age (Akerstedt 1990, Akerstedt and Torsvall 1981, Lavie et al. 1989, Monk and Tepas 1985); in particular, evidence suggests that at ages of about 50 years and above shiftwork may impose very severe strains (Monk 1989, Reinberg et al. 1980). In the present study, the role of age as a predictor of the duration and quality of sleep among shiftworkers merited attention for two reasons. First, offshore workers tend to be younger than those onshore; therefore, as noted above, it is important to take age into account prior to evaluating differences associated with onshore/offshore location. Second, it is possible that the demanding conditions of offshore shiftwork may give rise to particularly marked sleep problems among older employees. This is an issue of current concern because the average age of the offshore population is increasing as the offshore industry itself (which largely dates from the late 1960s) becomes more mature. It is appropriate therefore, to examine whether older shiftworkers show disproportionately impaired

sleep when employed in the offshore environment.

1.2.2. *Shiftwork experience:*

Some evidence suggests that prolonged experience of shiftwork may have harmful effects over and above the problems associated with increasing age. Foret et al. (1981) found that older shiftworkers reported poorer sleep and greater use of sleeping pills than their younger coworkers; more importantly, however, the results also showed that within a particular age group, those with longer prior experience of shiftwork reported less favourable sleep patterns. The inference that cumulative exposure to shiftwork has adverse effects on health is supported by more recent work in which it was found that the relative risk of heart disease among shiftworkers increased progressively as shiftwork exposure increased from 11 years to more than 20 years (Knutsson et al. 1986). These results suggest that, in studies of the health-related effects of shiftwork, not only age but also the total number of years a worker has been exposed to shiftwork is of interest as a potential predictor of outcomes.

1.2.3. *Neuroticism:*

Several studies have related neuroticism, and other measures of anxiety, to sleep problems, psychological symptoms, and adaptational difficulties among shiftworkers (e.g., Akerstedt 1980, Bohle and Tilley 1989, Costa et al. 1989, Harma et al. 1988, Suvanto et al. 1990). Evidence from laboratory research demonstrates links between sleep disorders, physiological activity, and neuroticism (e.g., Freedman and Sattler 1982, Monroe 1967). However, in field studies, sleep disturbance among shiftworkers has also been found to relate to general dissatisfaction about work conditions, and the quality of domestic life (Lavie et al. 1989). These results suggest that the 'negative affectivity' characteristic of neurotic individuals (Watson and Clark 1984) may be a contributory factor underlying a variety of subjective complaints, including sleep problems, reported by shiftworkers, and that individual differences in neuroticism should be taken into account in self-report studies of sleep patterns and shiftwork.

1.3. *The present study:*

The main purpose of the present study was to compare the sleep patterns (as reflected in self-reported duration and quality of sleep during night shiftwork, day shiftwork, and when on leave) of onshore and offshore control-room operators. All participants worked 12 h shifts. The offshore personnel changed from night shift to day shiftwork after 1 week of the 2-week offshore duty period, which was followed by 2-3 weeks of leave. In contrast, most of the onshore personnel worked fast-rotating schedules with no more than two or three successive night shifts. However, one of the onshore sites concerned operated a weekly rotating shift system, based on a 5-week cycle; thus, the present data allowed some examination of the extent to which differences in sleep patterns between onshore and offshore workers were due to shift schedules rather than to environmental effects. In comparing sleep quality and duration in onshore and offshore personnel, age, years of shiftwork experience, and neuroticism, were included as predictor variables.

2. Method

2.1. *Subjects*

The participants in this study were oil industry personnel employed by a major UK oil exploration and production company. The offshore group consisted of 84 control-room operators working on three oil platforms in the UK sector of the North Sea, while the onshore participants ($n = 88$) were employed at six terminals in Scotland and the North of England. The total of 172 participants represented a response rate of more than 90% of the personnel concerned. Missing values for some sleep measures reduced the present data set from $n = 172$ to $n = 169$. All participants were male; they were responsible for monitoring and regulating production processes in the control room, and/or for similar tasks in the production areas. Further details of the sample are given by Parkes (1992).

2.2. *Procedure*

Prior to the start of data collection, potential respondents received personal letters detailing the nature and purpose of the planned work. The letters also explained that questionnaires would be identified only by numbers, and that all individual data would be confidential to the research team and not disclosed to company personnel. Questionnaires were administered at the place of work, whether onshore or offshore, and during working hours. In most cases, the experimenter was present while the questionnaire was completed, but a few participants returned their completed questionnaires by mail.

2.3. *Measures*

The questionnaire included items relating to demographic factors, employment history, and other background material, in addition to the measure of neuroticism and the ratings of sleep quality and duration. The measures reported in the present study are described in the following sections.

2.3.1. *Demographic and background information:*

The initial section of the questionnaire included items concerned with age, work location, shiftwork system, number of years of shiftwork employment, and other personal information. Demographic and background characteristics were similar in the onshore and offshore groups, except that offshore personnel were significantly younger than those onshore (see Results, section 3).

2.3.2. *Neuroticism:*

The Eysenck Personality Questionnaire was used to assess individual differences in neuroticism (Eysenck and Eysenck 1975); this measure has been widely used and extensively validated in UK samples. An abbreviated 12-item version of the original scale (Eysenck et al. 1985) was used here.

2.3.3. *Sleep quality and duration:*

To assess sleep quality, respondents were asked to rate how well they usually slept during off-duty hours when working night-shifts (N-S) and day-shifts (D-S), and during periods of leave (L-P). In each case, a seven-point (0-6) Likert response format was used, the scale ranging from 'very badly' to 'very well'. To assess sleep duration, respondents were asked to indicate how many hours they usually slept, again responding in terms of the N-S, D-S, and L-P work phases.

3. Results

3.1 Means of study variables for onshore and offshore groups:

The means and deviations of the variables used in the present study are shown in table 1, separately for the onshore and offshore groups. Offshore participants were significantly younger than those onshore, $t(167) = 3.28$, $p = 0.001$, but there was no significant difference in mean number of years exposure to shiftwork, or in mean neuroticism scores. Further analyses showed no significant differences in mean age, shiftwork years or neuroticism between the onshore employees working fast-rotating shifts and those working weekly rotation patterns.

In both the onshore and the offshore groups, L-P sleep quality was rated more favourably and, L-P sleep duration tended to be longer, than the corresponding N-S and D-S measures. Paired t -tests showed that, in the offshore group, N-S sleep quality was significantly higher than D-S sleep quality ($t = 2.78$, $df = 81$, $p < 0.01$) but, among onshore personnel, the opposite was true, D-S sleep quality being significantly higher than N-S sleep quality ($t = 5.70$, $df = 86$, $p < 0.001$). For sleep duration, there was no significant difference between N-S and D-S values for the offshore group but, for onshore employees, D-S sleep duration was significantly higher than the corresponding N-S value ($t = 8.81$, $df = 86$, $p < 0.001$).

	Offshore (n=82)		Onshore (n=87)	
	Mean	SD	Mean	SD
Age	40.91	6.67	44.57	7.75
Years of shiftwork	18.34	7.24	19.33	7.51
Neuroticism	3.29	2.71	3.17	2.84
Day shifts (D-S):				
Sleep quality	3.20	1.84	4.25	1.35
Sleep duration (hours)	6.99	1.18	7.07	0.82
Night shifts (N-S):				
Sleep quality	3.66	1.53	3.21	1.50
Sleep duration (hours)	7.20	1.34	5.86	1.26
Leave periods (L-P):				
Sleep quality	4.85	1.20	4.74	1.12
Sleep duration (hours)	7.74	0.81	7.59	0.74

Table 1. Means and standard deviation of study variables for onshore and offshore groups.

Intercorrelations between N-S sleep quality and N-S sleep duration, and between the corresponding D-S measures, were positive and highly significant in both the onshore and offshore groups, with values in the range 0.40 to 0.50. Correlations between N-S and D-S sleep duration were also highly significant and tended to be higher in the offshore group (0.65) than in the onshore group (0.31); a similar pattern was found for correlations between the N-

S and D-S sleep quality measures, the corresponding values being 0.61 (offshore) and 0.28 (onshore). Analysis of variance methods were used to examine the data relating to sleep duration and quality during the three work phases in more detail, with particular reference to the effects of offshore and onshore environments.

3.2. Repeated-measures analyses of variance:

Repeated measures analyses of variance (BMDP P2V, Jennirich et al. 1988) were used to evaluate the significance of the independent variables as predictors of sleep duration and sleep quality (the two outcomes being treated separately). In these analyses, there were three covariates (age, number of years of shiftwork, and neuroticism); one repeated-measure factor, work phase (representing N-S, D-S, and L-P sleep); and one between-groups factor, location. The location factor was coded to distinguish three groups; offshore employees ($n = 82$), all of whom worked the standard offshore weekly rotation system: onshore personnel employed at sites operating fast-rotation patterns ($n = 73$), and onshore personnel employed at a site operating a weekly rotation pattern ($n = 14$). Although the size of the third group was relatively small, differentiating the two sub-groups of onshore employees allowed not only overall comparisons between onshore and offshore personnel but also comparisons between the two onshore groups working different shift systems. Thus, it was possible to some extent to evaluate the separate contributions of environmental effects (onshore versus offshore) and of shift patterns (weekly rotation versus fast-rotation) to sleep outcomes.

The results of the analyses are shown in table 2. For sleep duration, all terms in the analysis were significant. The covariates (age, shiftwork years, and neuroticism) each predicted sleep duration negatively, while location and work phase also showed significant main effects. More importantly, however, there was a significant interaction between location and work phase; thus, the effects of location on sleep duration were different for the N-S, D-S and L-P phases. The adjusted sleep duration scores (controlling for neuroticism, age and shiftwork experience) are shown graphically in figure 1. It can be seen that the N-S and D-S sleep duration values for the weekly rotation onshore group are more similar to the fast-rotation onshore group than to the offshore group, while L-P sleep duration is closely similar for all three groups.

In the analysis of the sleep quality data (also shown in table 2), neuroticism and age were significant predictors, high neuroticism and older age being associated with poorer sleep quality. In this analysis, shiftwork experience was not significant ($F < 1$) after age had been taken into account, and it was therefore dropped from the model. Work phase was highly significant, but the main effect of location was nonsignificant. However, the interaction between

Source	Sleep duration				Sleep quality			
	MS	df	F	p	MS	df	F	p
Age	14.29	1	9.49	0.002	15.20	1	3.81	<0.05
Years of shift work	7.26	1	4.82	0.029	—	—	—	—
Neuroticism	11.29	1	7.50	0.007	41.75	1	11.53	<0.001
Onshore/offshore location	7.73	2	5.13	0.007	3.81	2	1.05	ns
Error	1.50	163			3.62	164		
Work phase (N-S, D-S, L-P)	43.85	2	61.05	<0.0001	41.68	2	35.32	<0.0001
Work phase x location	24.53	4	17.56	<0.0001	13.36	4	11.32	<0.0001
Error	0.72	332			1.18	332		

Note. N-S = Night shifts; D-S = Day shifts; L-P = Leave periods

Table 2. Analyses of variance predicting sleep duration and sleep quality over the three work phases.

location and work phase was highly significant. The adjusted sleep quality scores are shown in figure 2. The L-P sleep quality values were similar for each group; however, D-S sleep quality was lower among offshore personnel than among those onshore, while N-S sleep quality was lowest for the fast-rotation onshore group.

3.3. One way analyses of variance:

The interactions between work phase and location found in the analyses described above were further investigated by one-way covariance analyses (BMDP P1V. Engelman 1988). In these analyses, each of the six sleep measures was analysed separately, the independent variables were location (respondents being divided into three groups, as above), and the covariates were age, neuroticism, and (for sleep duration only) years of shiftwork. These analyses served two purposes. First, they allowed the equality of the slopes of the regression lines relating each of the dependent vari-

ables to the covariates in the three location groups to be tested (thereby providing, tests of the location X covariate interactions). Secondly, they allowed the significance of two a priori contrasts to be evaluated for each of the sleep measures. The first contrast represented the overall comparison between onshore and offshore personnel, while the second contrast compared the two subgroups of onshore workers (i.e., those working a weekly rotation system and those working a fast-rotation system).

3.3.1. Equality, of regression slopes:

There was no evidence to suggest that the regression slopes differed significantly across the three groups for any of the six dependent measures; none of the relevant significance tests reached the 0.05, probability level. These results applied to the three covariates used in the analyses of sleep duration, and to the two covariates used in the analysis of sleep quality, tested individually, as well as to the tests of all covariates jointly. Thus, these analyses provided no evidence that any of the covariates, including age, was more strongly associated with sleep problems among offshore employees than among those working onshore.

3.3.2. A priori contrasts:

The second purpose of the one-way analyses of variance (carried out separately for the three sleep duration measures and the corresponding sleep quality measures) was to evaluate the significance of the two specified contrasts. For N-S sleep duration, the onshore-offshore contrast was highly significant, $t(163) = 5.56$, $p < 0.0001$; offshore personnel reported significantly longer N-S sleep duration than those working onshore. For D-S sleep quality, the onshore/offshore contrast was also highly significant, $t = -3.82$, $df = 164$, $p < 0.001$; sleep quality was higher for onshore personnel than for offshore employees. There was also one marginally significant finding; for D-S sleep duration, among onshore personnel, the fast-rotation group tended to report longer D-S sleep duration than the weekly rotation group, $t(163) = 1.63$, $p = 0.01$. Other contrasts for the D-S and N-S sleep quality measures were non-significant. For L-P sleep quality and duration, all contrasts were non-significant.

4. Conclusions

The present study allowed systematic comparison of the sleep duration and quality reported by control-room operators carrying out similar jobs either at onshore sites or on offshore oil and gas installations. The analyses described above showed that the onshore and offshore personnel reported significantly different patterns of N-S and D-S sleep duration and quality, although the corresponding L-P measures for the two groups did not differ. Furthermore, age, years of shiftwork, and neuroticism also played a significant role in the prediction of sleep outcomes. In interpreting these findings, it is important to note that all participants in the study were employed by the same company and worked

Figure 1. Sleep duration during night shiftwork and day shiftwork, and during leave periods: offshore weekly rotation compared to onshore weekly rotation and onshore fast rotations.

Figure 2. Sleep quality during night shiftwork and day shiftwork, and during leave periods: offshore weekly rotation compared to onshore weekly rotation and onshore fast rotations.

shifts of the same duration (12 hours). The study also meets the point made by Bohle and Tilley (1989) in their discussion of methodological aspects of shiftwork research; they emphasize that, when evaluating shiftwork effects, it is important to compare similar jobs. Thus, in the present study, all participants were responsible for similar monitoring and control tasks involved in oil and gas production; thus, observed differences in sleep patterns in the onshore and offshore environments could not be attributed to specific differences in job demands associated with the onshore and offshore environments.

In the more detailed discussion of the present findings given below, the effects of onshore versus offshore location on the N-S and D-S sleep measures are considered first, with reference to the shift schedules worked in the two environments; in a subsequent section, the roles of age, shiftwork experience, and neuroticism are considered.

4.1. *Night-shift sleep duration and quality:*

The analysis of the sleep duration data showed that onshore/offshore differences were most marked for N-S sleep duration. Among onshore personnel (irrespective of the particular shift pattern worked), N-S sleep was significantly shorter than among offshore personnel. Literature findings indicate that sleep loss among night workers is a potentially serious problem: in particular, successive night-shifts have been found to give rise to a cumulative sleep deficit (e.g., Rosa 1991). Furthermore, sleep loss during night shifts may reach a point where reasonable wakefulness cannot be maintained during work periods; for instance, Torsvall et al. (1989) found that 20% of participants in their study had sleep episodes (as identified by EEG recordings) during night work. For control-room operators, such as those who participated in the present study, impaired alertness is a potential hazard; as Akerstedt (1988) points out, sleepiness during night shiftwork may endanger lives and have serious economic consequences.

The present results showed that sleep deficits during night shiftwork as compared with day shiftwork were apparent only among onshore personnel. Thus, for the fast-rotation onshore group, N-S sleep duration averaged 1.25 hours less in a 24 h period than D-S sleep duration. The mean values of 5.95 h N-S sleep duration, and 7.20 h D-S sleep duration for this group are closely similar to mean values reported by Anderson and Bremer (1987) for comparable fast-rotation shiftwork. Similarly, in the weekly rotation onshore group, mean N-S sleep duration was 5.83 hours as compared with 6.74 h for D-S sleep duration, corresponding to a deficit of 0.91 h. In contrast to these findings, offshore personnel (who also worked a weekly rotation pattern in which seven successive night shifts followed a period of normal sleep/wake adaptation) reported marginally longer average sleep duration when working night shifts (7.13 h) than when working day shifts (6.92 h). The difference between onshore and offshore employees in N-S sleep quality, was not significant, although the trend was in the same direction (offshore personnel tending to report better N-S sleep quality than onshore personnel). Furthermore, the correlational data showed no evidence of a trade-off between sleep duration and quality, on the contrary, longer sleep duration was strongly associated with higher sleep quality.

As discussed below, several contrasting features of onshore and offshore environments may contribute to the observed differences in sleep during night shiftwork.

(a) During, the 2-week duty period, offshore personnel live and work in an environment which operates on a 24 h basis. Not only does work continue round-the-clock, but meals and recreational activities also provide a similar routine for day and night shiftworkers. Thus, adaptation to night work is less difficult for offshore personnel than for those working onshore, whose off-duty hours are out-of-phase with normal family and social life. Wedderburn (1967) suggested that adjustment to shiftwork was easier for employees living in towns in which shiftwork was the norm because these 'company towns' provided appropriate facilities and support for shiftworkers. The particular features of offshore installations not only mirror the 'company town' effect, but go some way beyond it in facilitating adjustment to night shiftwork. The importance of social factors and domestic factors in coping, with shiftwork has also been noted by Monk (1988).

(b) In the offshore environment, the day-time sleep of night shiftworkers is not subject to the competing social and family demands experienced by those onshore. Thus, onshore employees are involved in many social and domestic activities during their off-duty time: these activities may reduce sleep duration, particularly in households with children (Anderson and Bremer 1987). More generally, as Monk and Tepas (1985) point out, night workers lack the protection of social conventions that serve to protect dayworkers' sleep hours. Thus, in the onshore environment, family responsibilities and social activities may have to take precedence over day-time sleep, whereas this is not true of offshore employees.

(c) Whilst it is difficult for onshore employees working night-shifts to sleep in complete darkness during the day-time, offshore accommodation rarely has windows, and hence absence of natural light is the norm for offshore employees during sleep hours whether during the day or the night. In this respect, offshore accommodation may serve to facilitate day-time sleep to a greater degree than normal domestic conditions onshore. Thus, recent experimental studies suggest that complete darkness during day-time sleep, coupled with exposure to bright artificial light at night, helps people to adjust to night work (Czeisler et al. 1990). No definite conclusions about the particular methods advocated by Czeisler et al. can be drawn from the present study but, in the longer-term, the offshore environment might provide a particularly suitable setting for further evaluation of these methods.

4.2. *Day-shift sleep duration and quality:*

Whereas N-S sleep differences between onshore and offshore personnel favoured offshore personnel, and were most marked for sleep duration, differences in D-S sleep favoured onshore personnel and were most marked for sleep quality. One important factor underlying this finding is that the shift patterns of onshore workers generally allowed them to adapt to normal sleep-wake cycles before starting day shifts, whereas this was not true of offshore workers (who switched directly from night work to day work). However, the favourable D-S sleep quality of onshore workers is also consistent with the fact that, in onshore settings, day-shiftwork accords with the normal wake-sleep cycle and therefore does not pose any unusual environmental problems. In contrast, in the offshore environment, night-time sleeping conditions compare unfavourably (in terms of possible external sources of disturbance such as noise, vibration, and weather conditions) with those normally experienced onshore. The findings of Sunde (1983) suggest

that noise is a particular problem offshore. Although sound-proofing does not appear significantly to facilitate the sleep of night shiftworkers onshore (Monk and Tepas 1985), noise reduction is an important issue in offshore engineering. In particular, recent design standards for offshore accommodation particularly emphasize the importance of providing quiet and comfortable sleeping areas for operating personnel (Santa Fe Drilling Company 1990).

More significantly, the reported D-S sleep quality of offshore workers was not only worse than that of onshore workers, it also compared unfavourably with their N-S sleep quality. This finding cannot readily be attributed to external causes, or to circadian effects (both the N-S and the D-S weeks offshore followed a 12h shift in wake-sleep patterns). One possibility is that sleep quality during day shiftwork offshore was impaired by cumulative fatigue and strain associated with the second week of the offshore work cycle. However, fear of sudden emergencies, which are a source of particular anxiety to offshore workers during hours of darkness, may also be relevant; thus, many offshore employees experienced difficulty in sleeping soundly at night because they tended to be alerted by any unusual changes in background noise or vibration.

4.3. *Sleep during leave periods:*

There was close similarity in the L-P sleep duration measures for the onshore and offshore groups, and in the L-P sleep quality measures. This finding is important in that it suggests that there are no long-term differences in sleep patterns between the onshore and offshore employees, and that the differential effects of the two work environments on reported sleep quality and duration do not carry-over into periods of leave.

4.4. *Shift patterns:*

Taken together, the present results suggested that environmental differences between the onshore and offshore locations were stronger determinants of sleep patterns than differences between shift schedules. Thus, in both N-S sleep duration and D-S sleep quality, the weekly rotation onshore group resembled onshore personnel working fast-rotation schedules rather than offshore personnel working on a weekly rotation basis within the two-week offshore duty period. However, this finding should be qualified by the proviso that the small size of the weekly rotation group would tend to reduce the likelihood of demonstrating significant differences between the two onshore shift patterns. One finding of interest apparent in comparing the onshore shift patterns should be noted; the fast-rotation shift system tended to be associated with longer average D-S sleep duration (7.20 h) than the weekly rotation system (6.74 h). This trend is similar to that found in other studies which have compared weekly and fast-rotating systems (e.g., Knauth and Rutenfranz 1982).

4.5. *Age, prior experience of shiftwork, and neuroticism as predictors of sleep outcomes:*

The results of the present study were consistent with previous findings which indicate that older workers experience greater difficulty in adjusting to shiftwork than their younger coworkers. Thus, age was found to be negatively related to both sleep duration and quality in the present sample, although the relationship with sleep duration was stronger than that with sleep quality. In spite of concerns about the capacity of older employees to adapt to the demands of offshore work, the available evidence does not suggest that age is associated with particularly negative perceptions of the

offshore work environment (Hellesoy 1985, Lauridsen et al. 1991). Similarly, there was no evidence in the present data to suggest that older offshore workers experienced disproportionately more impaired sleep than older onshore workers; as discussed above, the offshore environment appeared to facilitate adjustment to night shiftwork, and this finding applied to the present sample irrespective of age.

Whilst the effects of age on the sleep patterns of shiftworkers are well established in the literature, the extent to which prior experience of shiftwork predicts health-related outcomes has been less widely explored. In research of this kind it is necessary to separate the effects of age per se from those of years of shiftwork; in the present study, after control for age, number of years of shiftwork was found to be a significant predictor of sleep duration, although it did not predict sleep quality. In particular, operators with longer shiftwork experience reported shorter N-S and L-P sleep hours. The present findings thus add to the literature which suggests that shiftwork has a cumulative and adverse effect on sleep (Foret et al. 1981) and on health (Knutsson et al. 1986, Knutsson 1989), which are not accounted for by age alone. Consistent with these findings, Frese and Okonek (1984) found that employees who left shiftwork solely for health reasons had longer experience of working shifts than those who left for other reasons. However, it is not clear from the present results why sleep duration and not sleep quality was affected by length of previous exposure to shiftwork. Indeed, the mechanisms by which shiftwork may have cumulative adverse effects on health are not well understood, although Knutsson (1989) discusses some possible pathways in relation to disease outcomes. In relation to sleep measures, repeated disruption of circadian rhythms and the psychosocial implications of a lifestyle that is out-of-phase with normal sleep/wake patterns may be relevant factors, but further research is clearly needed to establish the specific causal mechanisms and to determine whether these long-term effects can be mitigated.

The present findings also demonstrated that neuroticism played a significant role as a predictor of sleep outcomes. As expected, individuals high in neuroticism reported shorter sleep duration and poorer sleep quality than those low in neuroticism. It is not possible to determine from the present data to what extent the observed association between neuroticism and reports of impaired sleep reflected objective differences in the sleep of high and low neurotic individuals. While neuroticism may result in restlessness and reduced sleep hours, particularly among shiftworkers, it is also possible that the correlational findings are to some extent inflated by generalized negative perceptions associated with high neuroticism. Further research would be required to resolve this question; however, the present data are consistent with other studies of shiftworkers which have demonstrated significant sleep impairment associated with neuroticism and anxiety (e.g., Bohle and Tilley 1989, Costa et al. 1989).

4.6. *General issues:*

Adverse features of the offshore work environment (for instance, confined living and working areas, lack of privacy; adverse physical environment; procedural constraints, and the continuous emphasis on safety; and isolation from family) tend to attract particular attention in the research literature, and in the media more widely. However, as Sunde (1983) notes, some features of offshore work (such as relatively long periods of leave and favourable pay rates, careful monitoring of health, restrictions on

smoking and alcohol, the availability of offshore health services, and a lower retirement age) have more positive implications for well-being. The present findings suggest that, as compared with onshore settings, the offshore environment may also be more favourable in facilitating adjustment to night shiftwork, although at the cost of poorer sleep quality during day shiftwork.

In spite of the large number of personnel currently employed on oil and gas installations in the North Sea, the present study is apparently the first to examine sleep patterns in groups of onshore and offshore employees carrying out similar work. However, the present research makes only an initial contribution to understanding the role of the offshore environment in relation to shiftwork and sleep. Many issues remain to be clarified; in particular, although questionnaire methods have been widely used in studies of sleep and shiftwork (e.g., Lavie et al. 1989, Knauth and Kiesswetter 1987, Rahman 1988, Rosa et al. 1989), other methods of data collection (for instance the use of sleep diaries and EEG monitoring) would allow a more detailed examination of internal and external factors influencing circadian adjustment and sleep among offshore employees as compared with those working onshore. In addition, longitudinal research, which would allow some clarification of the causal processes involved in adjustment to shiftwork in general, and shiftwork in the offshore environment in particular would be desirable. The present work also indicates that individual differences, including age and years of exposure to shiftwork, are important predictors of outcomes, and would merit longitudinal investigation in an offshore environment. Furthermore, in the present study, all the offshore personnel worked the same shift pattern; comparisons with other pattern, of offshore work (for instance, fixed day-shift or night-shift for the entire two-week offshore period), perhaps introduced on an experimental basis, would not only contribute to the understanding of the effects of the offshore environment on sleep but would also provide information of value in making recommendations about optimal shift systems for offshore employees.

Acknowledgments

The research described in this paper was funded by the Health and Safety Executive, and carried out with the cooperation of BP Exploration, Aberdeen; the author gratefully acknowledges the support of these organizations, and the contributions of the research assistants involved in the study.

References

- AKERSTEDT, T. 1980, Interindividual differences in adjustment to shiftwork, in W. P. Colquhoun and J. Rutenfranz (eds), *Studies of Shiftwork* (Taylor & Francis, London), 121-130.
- AKERSTEDT, T. 1988, Sleepiness as a consequence of shiftwork, *Sleep*, 11, 17-34.
- AKERSTEDT, T. 1990, Psychological and psychophysiological effects of shift work, *Scandinavian Journal of Work, Environment, and Health*, 16 (Suppl. 1), 67-73.
- AKERSTEDT, T. and TORSVALL, L. L. 1981, Shift-dependent well-being and individual differences, *Ergonomics*, 24, 265-273.
- ALEKPEROV, I. I., MELKUMYAN, A. N. and ZAMCHALOV, A. J. 1988, Some peculiarities of the physiological validity of shift work schedules for the crews of floating oil drilling platforms, *Journal of Hygiene, Epidemiology, Microbiology and Immunology*, 32, 385-396.
- ANDERSON, R. M. and BREMER, D. A. 1987, Sleep duration at home and sleepiness on the job in rotating 12-hour shift workers, *Human Factors*, 29, 477-482.
- BABKOFF, H., MIKULINCER, M., CASPY, T., KEMPINSKY, D. and SING, H. 1988, The topology of performance curves during 72 hours of sleep loss: a memory and search task, *The Quarterly Journal of Experimental Psychology*, 40A, 737-756.
- BOHLE, P. and TILLEY, A. J. 1989, The impact of night work on psychological well-being, *Ergonomics*, 32, 1089-1099.
- COSTA, G., LIEVORE, F., CASALETTI, G., GAFFLURI, E. and FOLKARD, S. 1989, Circadian characteristics influencing interindividual differences in tolerance and adjustment to shiftwork, *Ergonomics*, 32, 373-385.
- CZEISLER, C. A., JOHNSON, M. P., DUFFY, J. F., BROWN, E. N., RONDA, J. M. and KRONAUER, R. E. 1990, Exposure to bright light and darkness to treat physiologic maladaptation to night work, *New England Journal of Medicine*, 322, 1253-1259.
- ENGELMAN, L. 1988, One way analysis of covariance, in W. J. Dixon (ed.), *BMDP Statistical Software Manual, Volume 2* (University of California Press, Berkeley, CA), 1013-1024.
- ENGLUND, C. E., RYMAN, D. H., NAITOH, P. and HODGDON, J. A. 1985, Cognitive performance during successive sustained physical work episodes, *Behavior Research Methods, Instruments, and Computers*, 17, 75-85.
- EYSENCK, H. J. and EYSENCK, S. B. O. 1975, *Manual of the Eysenck Personality Questionnaire* (Hodder & Stoughton, London).
- EYSENCK, H. J., EYSENCK, S. B. G. and BARRETT, P. 1985, A revised version of the psychoticism scale, *Personality and Individual Differences*, 6, 21-29.
- FORET, J., BENSIMON, G., BENOIT, O. and VIEUX, N. 1981, Quality of sleep as a function of age and shiftwork, in A. Reinberg, N. Vieux and P. Andlauer (eds.), *Night and Shift Work: Biological and Social Aspects* (Pergamon Press, Oxford), 149-160.
- FREEDMAN, R. R. and SATTLER, H. L. 1982, Physiological and psychological factors in sleep-onset insomnia, *Journal of Abnormal Psychology*, 91, 380-389.
- FRESE, M. and OKONEK, K. 1984, Reasons to leave shiftwork and psychological and psychosomatic complaints of former shiftworkers, *Journal of Applied Psychology*, 69, 509-514.
- HARMA, M., ILMARINEN, J., and KNAUTH, P. 1988, Physical fitness and other individual factors relating to the shiftwork tolerance of women, *Chronobiological International*, 5, 417-414.
- HELLESOY, O. H. (ed.). 1985, *Work Environment*: Stanford Field (Universitetsforlaget, Oslo).
- HURRELL, J. J. and COLLIGAN, M. J. 1985, Alternative work schedules: Flextime and the compressed work week, in C. L. Cooper and M. J. Smith (eds) *Job Stress and Blue Collar Work* (Wiley, Chichester), 131-147.
- JENNRICH, R., SAMPSON, P. and FRANE, J. 1988, Analysis of variance and covariance with repeated measures, in W. J. Dixon (ed.), *BMDP Statistical Software Manual, Volume I* (University of California Press, Berkeley, CA), 483-519.
- KNAUTH, P., RUTENFRANZ, J., HERMANN, G. and POPPEL, S. J. 1978, Re-entrainment of body temperature in experimental shiftwork studies, *Ergonomics*, 21, 775-783.
- KNAUTH, P. and RUTENFRANZ, J. 1982, Development of criteria for the design of shiftwork systems, *Journal of Human Ergology*, 11 (Suppl.), 337-367.
- KNAUTH, P., KIESSWETTER, E., OTTMAN, W., KARVO-

- NEN, M. J. and RUTENFRANZ, J. 1983, Time-budget studies of policemen in weekly or swiftly rotating shift systems. *Applied Ergonomics*, 14, 247-252.
- KNAUTH, P. and KIESSWETTER, E. 1987, A change from weekly to quicker shift rotations: a field study of discontinuous three-shift workers. *Ergonomics*, 30, 1311-1322.
- KNUTSSON, A., 1989, Shift work and coronary heart disease, *Scandinavian Journal of Social Medicine, Supplement*, 44, 1-36.
- KNUTSSON, A., AKERSTEDT, T., JONSSON, B. G. and ORTH-GOMER, K. 1986, Increased risk of ischiemic heart disease in shift workers. *Lancet*, 2, 89-92.
- LAURIDSEN, O., TRONSMOEN, S., BERLAND, J., GITLESEN, J. P., RINGSTAD, A. J., PEDERSEN, T. H., ERIKSSON, L. and NOME, T. 1991, Shift work and health: shift work, sleeping difficulties, psychosocial work environment and psychosomatic complaints, *Phillips Petroleum/ Rogaland Research (RF. 127/91)*.
- LAVIE, P., CHILLAG, N., EPSTEIN, R., TZISCHINSKY, O., GIVON, R., FUCHS, S. and SHANAL, B. 1989, Sleep disturbances in shift workers: a marker for maladaptation syndrome, *Work and Stress*, 3, 33-40.
- MIKULINCER, M., BABKOFF, H., CASPY, T. and SING, H. 1989, The effects of 72 hours of sleep loss on psychological variables, *British Journal of Psychology*, 80, 145-162.
- MONK, T. H. 1986, Advantages and disadvantages of rapidly rotating shift schedules-a circadian viewpoint, *Human Factors*, 28, 553-557.
- MONK, T. H. 1988, Coping with the stress of shift work, *Work and Stress*, 2, 169-172.
- MONK, T. H. 1989, Shift work and safety. *Professional Safety*, 34, 26-30.
- MONK, T. H., and TEPAS, D. I., 1985, Shift work. in C. L. Cooper and M. J. Smith (eds), *Job Stress and Blue Collar Work* (Wiley, Chichester). 65-84.
- MONROE, L. 1967, Psychological and physiological differences between good and poor sleepers. *Journal of Abnormal Psychology* 72, 255-264.
- PARKES, K. R. 1992, Mental health in the oil industry: a comparative study of onshore and offshore employees, *Psychological Medicine*, 22, 997-1009.
- PEACOCK, B., GLUBE, R., MILLER, M. and CLUNE, P. 1983, Police officers' responses to 8 and 12 hour shift schedules, *Ergonomics*, 26, 479-493.
- RAHMAN, A. 1988, Workers' sleep quality as determined by shift system and demographic factors, *International Archives of Occupational and Environmental Health*, 6, 425-429.
- REINBERG, A., ANDLAUER, P., GUILLET, P., NICOLAI, A., VIEUX, N. and LAPORTE, A. 1980, Oral temperature, circadian rhythm amplitude, ageing and tolerance to shift work, *Ergonomics*, 23, 55-64.
- ROSA, R. R., COLLICAN, M. J. and LEWIS, P. 1989, Extended workdays: effects of 8-hour and 12-hour rotating shift schedules on performance, subjective alertness, sleep patterns, and psychosocial variables, *Work and Stress*, 3, 21-32.
- ROSA, R. R. 1991, Performance, alertness, and sleep after 3.5 years of 12 h shifts: a follow-up study, *Work and Stress*, 5, 107-116.
- RUTENFRANZ, J., PLETT, R., KNAUTH, P., CONDON, R., DE-VOL, D., FLETCHER, N., EICKHOFF, S., SCHMIDT, K. H., DONIS, R. and COLQUHOUN, W. P. 1988, Work at sea: a study of sleep, and of circadian rhythms in physiological and psychological functions, in watchkeepers on merchant vessels. II. Sleep duration and subjective ratings of sleep quality. *International Archives of Occupational and Environmental Health*, 60, 331-339.
- SANTA FE DRILLING COMPANY. 1990, North Sea rig quarters designed with hotel standards. *Oil and Gas Journal*, 89, 82-83.
- SUNDE, A. 1983, Psychosocial aspects of offshore work, in *Safety and Health in the Oil and Gas Extractive Industries* (Graham & Trotman, Ltd. for the Commission of European Communities, London).
- SUTHERLAND, V. J. and COOPER, C. L. 1989, Occupational stress in the offshore oil and gas industry, *International Review of Ergonomics*, 2, 183-215.
- SUVANTO, S., PARTINEN, M., HARMA, M. and ILMARINEN, J. 1990, Flight attendants' desynchronization after rapid time zone changes. *Aviation, Space and Environmental Medicine*, 61, 543-547.
- TILLEY, A. J., WILKINSON, R. T., WARREN, P. S. G., WATSON, B. and DRUD, M. 1982, The sleep and performance of shiftworkers, *Human Factors*, 24, 629-641.
- TORSVALL, L. and AKERSTEDT, T. 1988, Disturbed sleep while being on-call: an EEG study of ships' engineers, *Sleep*, 11, 35-38.
- TORSVALL, L., AKERSTEDT, T., GILLANDER, K. and KNUTSSON, A. 1989, Sleep on the night shift: 24-hour monitoring of spontaneous sleep/wake behavior, *Psychophysiology*, 26, 352-358.
- VAERNES, R. J., KNARDAHL, S., et al. 1988, Relations between environmental problems, psychology and health among shift-workers in the Norwegian process industry, *Work and Stress*, 2, 7-15.
- WATSON, D. and CLARK, L. A. 1984, Negative affectivity: the disposition to experience aversive emotional states, *Psychological Bulletin*, 96, 465-490.
- WEDDERBURN, A. A. I. 1967, Social satisfaction with swiftly rotating shifts, *Journal of Occupational Psychology*, 41, 85-107.
- WILKINSON, R. T. and HOUGHTON, D. 1982, Field test of arousal: a portable reaction timer with data storage, *Human Factors*, 24, 487-493.