Brit. J. industr. Med., 1969, **26**, 54-58

Sleep and wakefulness in a group of shift workers

G. S. TUNE
Medical Research Council, Unit for Research on Occupational Aspects of Ageing, University of Liverpool

Tune, G. S. (1969). *Brit. J. industr. Med.*, **26**, 54-58. **Sleep and wakefulness in a group of shift workers.** Fifty-two shift workers recorded their hours of sleep and wakefulness for a period of 10 weeks. Compared with matched non-shift-working control subjects it was found that they took a higher average duration of sleep per 24 hours and more and longer naps outside the major sleep period. A comparison of the on and off duty records from the shift workers showed that a sleep debt was incurred during the former which was largely paid off by taking long naps in the latter. It is suggested that the longer sleep taken by shift workers may be necessary in order to pay off specific kinds of sleep debt.

In his studies of several occupational groups, Masterton (1965a, 1965b) found a general tendency for more sleep to be taken during holiday periods rather than during the time spent at work. He described this process in terms of the accumulation of and repaying of a sleep debt. The process was most obvious among groups of hospital physicians and surgeons whose daily routine was essentially fairly irregular, and to a lesser extent among medical students (both male and female) and schoolboys. In view of the substantial evidence (Kleitman, 1963) that shift workers get less sleep than non shift workers and suffer generally more bodily discomfort (Dirken, 1966), it might be expected that this group of people might accumulate but not repay their sleep debt sufficiently. However, a previous study by the present author (Tune, 1968a), using a small (n = 14) and heterogeneous group of shift workers, was unable to find any significant differences between these men and a closely matched group of non-shift-working control subjects. There were only tendencies for the shift workers to take more sleep and longer naps, and for the experience of disturbed sleep to be more prevalent among the shift workers.

The present study was undertaken in an attempt to use a larger and more homogeneous group of shift workers, all working similar routines, in the hope of throwing more light on the subject.

Method

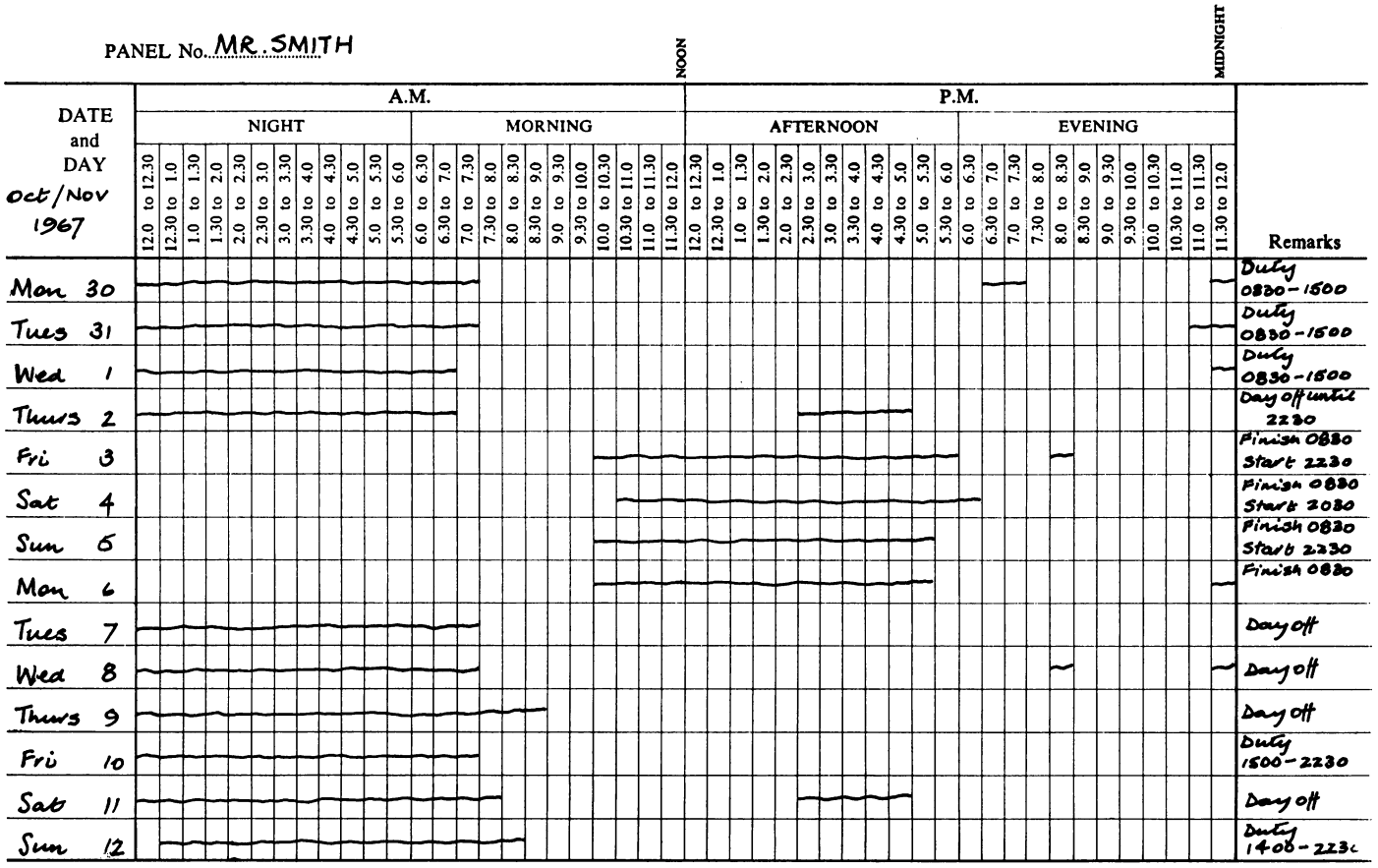
Sixty-eight male, professionally qualified engineers, all resident in the north-west of England and employed at a number of sites by a large nationalized industry, initially agreed to co-operate in the study. All the men worked a three-shift system. A preliminary letter outlined the procedure involved. The age and occupational status (Registrar General's Classification) were ascertained and, on the basis of these two factors, each shift worker was matched with a non-shift-working control subject. Each participant was sent, by post, a sleep chart (Figure) along with printed instructions for its use. The instructions asked for honesty and accuracy (since no external check could be made) to the nearest 30 minutes. A partially completed specimen chart was included with the instructions. It was emphasized that only the time actually spent *asleep* (whether in bed or elsewhere) was to be recorded and not time spent awake in bed. It was also explained that if any difficulty was experienced in recalling times, then the day in question was to be left blank.

The sleep charts were of a type previously used and described fully elsewhere (Tune, 1968b). Each chart lasted for 14 days. Five charts were sent to each participant at fortnightly intervals with stamped, addressed return envelopes, in an attempt to get a 10-week sample.

MEDICAL RESEARCH COUNCIL, UNIT FOR RESEARCH ON OCCUPATIONAL ASPECTS OF AGEING

SLEEP CHART

PANEL No. MR. SMITH



PLEASE PLACE A LINE IN EACH HALF-HOUR PERIOD DURING WHICH YOU SLEPT

FIGURE An example of the sleep chart used, giving details of the routine experienced by one of the shift workers in the study.

Additional instructions to the shift workers asked them to record their hours of work in the remarks column of the charts. All subjects were asked to declare any illness, medication or unusual occurrence which might have upset their daily routine.

Results

Fifty-two of the 68 shift workers finally returned all five charts complete and suitable for analysis. The remaining subjects (16) were discarded because of illness, failure to send complete data or, in a few cases, transfer to non-shift-work duties. The day on which the clocks were adjusted from British Summer Time to Greenwich Mean Time was omitted in order to avoid any confusion the subjects may have experienced in dealing with the 'extra' hour. Thus a 69-day sample of data was available from each person.

The following dependent measures were extracted from each participant's cards: (*a*) the mean duration of sleep per 24 hours; (*b*) the number of disturbances of the major sleep period; (*c*) the mean duration of these disturbances; (*d*) the number of naps taken outside the major sleep period; and (*e*) the mean duration of these naps. It should be noted that the disturbances of the major sleep period and the naps were only those lasting for the greater part of 30 min.; any such happenings of a briefer duration would not have been recorded.

The data were analysed in two ways; first, the shift workers and non-shift-working control subjects were compared by means of Mann-Whitney U tests (Siegel, 1956). The two groups were comparable in terms of age ($t = 0{\cdot}480$, $P > 0{\cdot}01$) and had been matched occupationally. However, Table 1 shows that there were significant differences between the two groups in terms of the dependent sleep measures taken. The shift workers, for example, took significantly more sleep (about 16 min.) than the control subjects. This sleep was no more disturbed in the shift workers than in the controls. However, it is clear that the shift workers took significantly longer naps than their non-shift-working counterparts.

The second way in which the data were analysed was an attempt to find out when the shift workers took their sleep and thus achieved more sleep than their matched controls. Fortunately, the shift workers were given fairly frequent days off. Of the 69 days of the study, a mean of 40·4 were working days (a range of 32 to 45) and a mean of 28·6 (a range of 24 to 37) were recorded as non-working days. The five dependent measures were compared

TABLE 1

RESULTS OF MANN-WHITNEY U TESTS COMPARING SHIFT WORKERS WITH CONTROL SUBJECTS

	Shift workers (n = 52)	*Controls (n = 52)*	*Z*	P< *(2-tailed)*
1. Mean age	41·327	42·327	t = 0·480	N.S.
2. Mean duration of sleep (hr.)/24 hr.	7·648	7·373	1·964	0·050
3. Mean no. of disturbances of major sleep period/10 weeks	10·692	18·404	1·585	0·1118
4. Mean duration of 3. (hr.)	0·621	0·582	0·439	0·6600
5. Mean no. of naps taken outside major sleep period/10 weeks	7·019	5·442	2·885	0·0038
6. Mean duration of 5. (hr.)	1·148	0·521	4·516	0·001

TABLE 2

RESULTS OF WILCOXON TESTS COMPARING SHIFT WORKERS WITH THEMSELVES WHEN ON AND OFF DUTY

	On-duty days	*Off-duty days*	*Z*	P< *(2-tailed)*
1. Mean no. of days recorded	40·4	28·6	—	—
2. Mean duration of sleep (hr.)/24 hr.	7·206	8·208	5 441	0·001
3. Mean no. of disturbances of major sleep period	6·74	4·36	2·507	0·0050
4. Mean duration of 3. (hr.)	0·678	0·678	1·882	0·0688
5. Mean no. of naps taken outside the major sleep period	3·60	3·60	0·604	0·5486
6. Mean duration of 5. (hr.)	0·947	1·333	2·762	0·0058

Two shift workers did not note on their charts on which days they were on and off duty, and were therefore omitted from this analysis. n therefore was reduced to 50.

for working and non-working days by means of Wilcoxon tests (Siegel, 1956) and the results of these are given in Table 2.

Inspection of Table 2 shows that the shift workers achieved about 60 min. more sleep per day when off duty, a highly significant difference. Furthermore, the sleep taken during off-duty days was significantly less disturbed than that taken during on-duty days. This increase in sleep on non-working days was obviously due to the lengthy naps taken, since the duration of the naps taken on the rest days was significantly greater than those taken during working days.

Initially, it was hoped to perform a third analysis comparing the amount of sleep taken after working one shift (*e.g.*, the 'night shift') with that taken after working another shift. This did not prove possible, however, because the hours of the shifts varied, depending on where the men worked, and from time to time men would be called upon to work for two consecutive shifts when a colleague was ill and it was essential for someone to remain on duty.

Discussion

The data from the present study indicate two main findings. First, that although the shift workers studied reported taking a higher mean duration of sleep per day than their non-shift-working controls this sleep was more episodic (it was more frequently disturbed during working days) and was made up of a considerable number of lengthy naps. The second point is that the shift workers apparently built up a sleep debt, to use Masterton's (1965a, 1965b) term, during the time they were on duty which was paid off or even overcompensated for during non-working days. These findings are in accord with previous studies by Masterton (1965b) and Lille (1967), who also found evidence of sleep debts being repaid among shift workers and other occupational groups.

The fact that the shift workers relied on taking naps in order to achieve a high mean duration of sleep per day and to pay off their sleep debt is of some importance. Episodic, or polycyclic, sleep such as this is typical of the newborn human infant (Kleitman, 1963) and a not atypical feature of older humans (Tune, 1968c). It cannot be inferred from this, however, that polycyclic sleep is the more natural or desirable state of affairs, particularly when the cycle of sleep and wakefulness is irregular and depends upon an exogenous factor, such as the rotating shift system experienced by the shift workers in the present study. Neither can it be assumed that the naps taken outside the major sleep period are an adequate compensation for disturbed or shortened sleep. The total duration of sleep achieved may well be of less importance than the amount of time spent in the various levels of sleep.

It is known, for example, that it is usual for certain proportions of a normal night's sleep to be given over to various stages of sleep and that a loss of the 'Rapid Eye Movement' (REM) dreaming state, or of the more profound stages III and IV delta sleep, leads to the accumulation of specific sleep debts for these stages (Dement, 1960; Agnew, Webb, and Williams, 1964). It is not known exactly which kind of sleep debt shift workers accumulate. However, a comparison of the E.E.G. characteristics of the daytime sleep of night shift workers (Lille, 1967) with those of normal young males (Williams, Agnew, and Webb, 1964) suggests that the shift workers lack REM sleep and have an excess of light (stage I) and delta sleep. Whether or not this more subtle form of debt can be repaid during naps is unknown.

The E.E.G. characteristics of shortened nocturnal sleep are largely dominated by stages III and IV (Webb and Agnew, 1965); such brief sleep is not a miniaturization of a full night of normal sleep. Daytime naps are also unlike nocturnal sleep in that the proportions of the REM state occurring depends upon the time of day at which the nap was taken. It has been suggested (Maron, Rechtschaffen, and Wolpert, 1964) that there is an inverse relationship between body temperature and the potentiality of REM sleep occurring. It is known that it takes time for the circadian temperature curve to adapt from a day shift to a night shift routine (Bünning, 1967), but to what extent and how rapidly sleep patterns, as measured by E.E.G. characteristics, adapt to such changes remains unknown.

It is apparent that even within the limitations of the crude behavioural measures used in the present study, shift workers found it necessary to spend more time asleep than non-shift-workers, presumably in order to meet the criterion of 'satisfactory' sleep. How well this was accomplished cannot be estimated from the evidence yet available. It is likely, however, that intensive physiological studies of the sleep profiles of shift workers' sleep and naps may help to provide some of the answers.

I should like to thank Dr. J. R. Bowker for his considerable help in making this study possible, and both Mrs. A. Day and Mrs. V. Pierce for tabulating the data and computing the results.

References

Agnew, H. W., Webb, W. B., and Williams, R. L. (1964). The effects of stage four sleep deprivation. *Electroenceph. clin. Neurophysiol.*, 17, 68-70.

Bünning, E. (1967). *The Physiological Clock*. 2nd ed. Longmans, London; Springer, New York.

Dement, W. (1960). The effect of dream deprivation. *Science*, 131, 1705-1707.

Dirken, J. M. (1966). Industrial shift work; decrease in wellbeing and specific effects. *Ergonomics*, 9, 115-124.

Kleitman, N. (1963). *Sleep and Wakefulness*. 2nd ed., University of Chicago Press, Chicago.

Lille, F. (1967). Le sommeil de jour d'un groupe de travailleurs de nuit. *Travail. Hum.*, **30**, 85-97.

Maron, L., Rechtschaffen, A., and Wolpert, E. A. (1964). Sleep cycle during napping. *Arch. gen. Psychiat.*, **11**, 503-508.

Masterton, J. P. (1965a). Sleep of hospital medical staff. *Lancet*, **1**, 41-42.

——(1965b). Patterns of sleep. In Edholm, O. G., and Bacharach, A. L. (Eds.) *The Physiology of Human Survival*, pp. 387-397. Academic Press, London.

Siegel, S. (1956). *Non-parametric Statistics for the Behavioral Sciences*. McGraw-Hill, New York.

Tune, G. S. (1968a). A note on the sleep of shift workers. *Ergonomics*, **11**, 183-184.

—— (1968b). Sleep and wakefulness in 509 normal human adults. *Brit. J. med. Psychol.* (In press).

—— (1968c). Sleep and wakefulness in normal human adults. *Brit. med. J.*, **2**, 269-271.

Webb, W. B., and Agnew, H. W. (1965). Sleep: effects of a restricted regime. *Science*, **140**, 1745-1747.

Williams, R. L., Agnew, H. W., and Webb, W. B. (1964). Sleep patterns in young adults. An E.E.G. study. *Electroenceph. clin. Neurophysiol.*, **17**, 376-381.

Received for publication April 9, 1968.