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SHIFT WORK: BALANCING SLEEP, FATIGUE AND WAKEFULNESS

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ABSTRACT

Field study data of deep body temperature, sleep/wakefulness, and the timing of work and social activity are presented. The results are discussed from two viewpoints of sleep function: recovery and behaviour control. The use of deep body temperature as an indicant of fatigue or performance potential is also discussed.

The effect of shiftwork on the daily course of body temperature has been widely studied in both the laboratory[3,10] and the field[5,11,12,13]. In spite of a remarkable consistency in their findings: night shift resulting in a flattened day shift curve with a reduced night fall and a delayed and raised minimum with an immediate return to a day shift curve on return to day work or rest, the literature remains unclear as to whether shiftwork results in a circadian adjustment of body temperature.

Performance has proved a much more illusive variable to study. Laboratory results do not necessarily transfer directly to the field, and at work, job loading itself most commonly varies with shift type. Nonetheless, performance changes appear to broadly parallel those of body temperature[4,8,9], although not without exception[7,20].

Shiftwork, however, is primarily characterised by a work imposed change in the normal activity pattern. Changes in the daily activity pattern may result in displacement of times of high and low activity and, in some cases, a fall in mean daily sleep duration. The timing of high and low activity partially determines the shape of the body temperature curve[6]. Sleep loss and fatigue are associated with performance changes[14,21], and chronic sleep loss with a fall in the daily mean of body temperature[2,21].

Shiftwork thus affects a number of variables which are themselves inter-linked. A possible multi-variable interpretation of the results from shiftwork studies is briefly presented using some of the data collected as part of an extensive field based research programme[15,19].

METHOD

Sleep, body temperature, subjective alertness*, and activity records were kept by two groups of experienced shiftworkers following a supervised self--recording routine[18]. One group, 25 industrial nurses, worked a continuous rapidly rotating $2 \times 2 \times 3$ rota (see Figure 1a) and the second, 17 computer operators, a discontinuous 5 on 2 off rota (see Figure 1b).

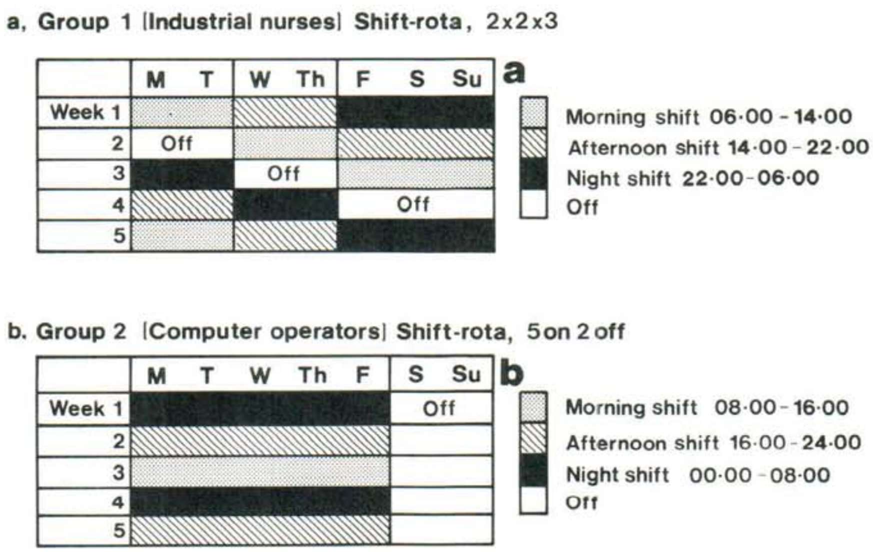

FIG. 1 – The shift rotas followed.

RESULTS

Figures 2.1 to 2.5 show, for both rotas and for each shift type, a plot of the three point moving average over half-hour blocks from the pooled individually z-scored data. Figures 3.1 to 3.5 show the alertness ratings treated similarly.

The data for temperature and alertness both show night shift flattening, with elevated night values and a raised delayed minimum. There is, however, no significant difference between the day (pooled morning and afternoon shift data) and night shift time or level of maximum.

Over successive night shifts the $2 \times 2 \times 3$ rota shows no trend in temperature. For the 5 on 2 off rota there is no clear trend; but between 0000 to 0800 hours the fifth night shift is somewhat higher (about 0.2 °C) than on the first night shift. Comparison of alertness over successive night shifts shows no trend for either rota.

*Using a visual analogue scale: a 10 cm line marked HIGH — LOW[1].

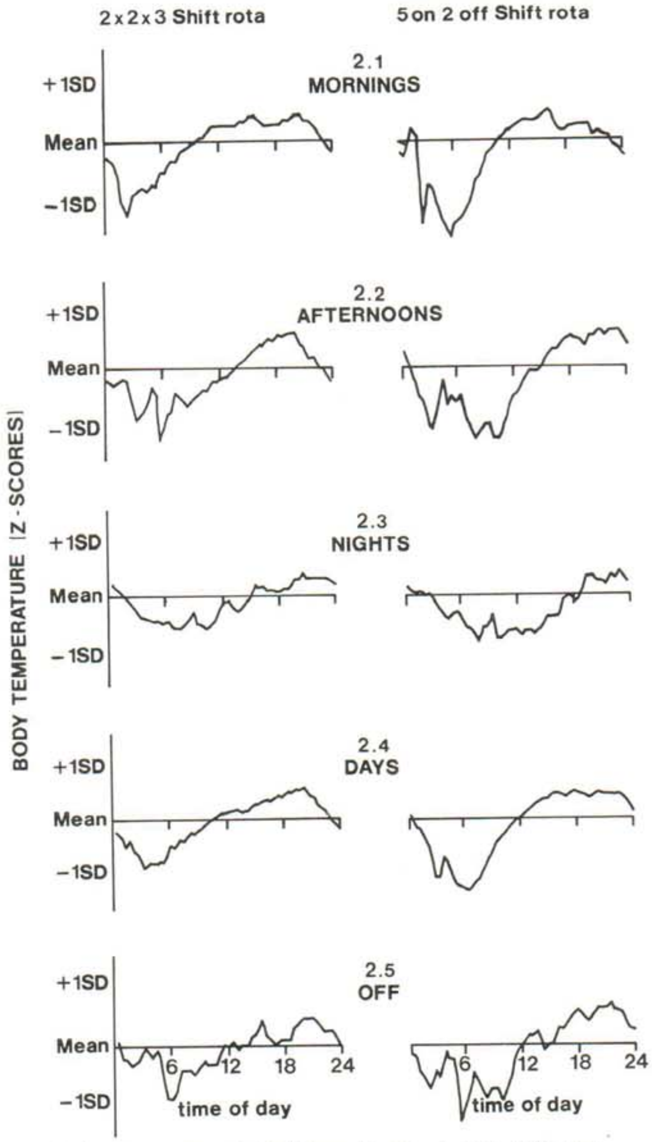

FIG. 2.1–2.5 – Body temperature in half-hour blocks on each shift type.

Table 1 shows, for each rota, the mean sleep length per 24 hours* for each shift type. For both rotas there is no significant difference between sleep length (night sleep) before morning shift and sleep length (day sleep) after night shift.

* The 24 hour period 2200 to 2159 hours is used to avoid splitting main sleep periods. Mean sleep length is computed as main sleep length, plus nap length, minus length of breaks in sleep.

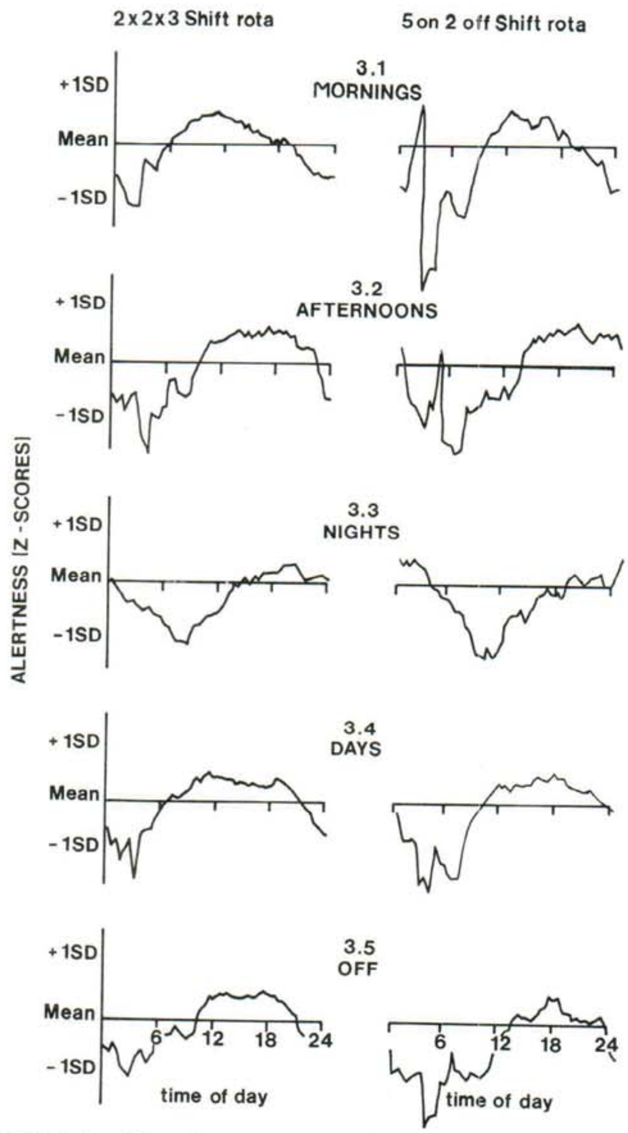

FIG. 3.1 – 3.5 – Alertness in half-hour blocks on each shift type.

Mean sleep lengths on afternoon and off shifts are significantly greater than those on either morning or night shifts ($p < 0.05$ 2-tail). The mean sleep patterns for both rotas are shown in Figures 4 and 5. The number of naps between main sleep episodes and the number of breaks in main sleep episodes are not great (see Table 2).

TABLE 1
Mean sleep length per 24 hours (see text) for each shift type.

		Morning shift (hrs)	Afternoon shift (hrs)	Night* shift (hrs)	Off shift (hrs)
2 x 2 x 3 rota	Mean	4.73	8.14	5.29	7.86
	S.D.	0.57	0.72	1.00	0.72
5 on 2 off rota	Mean	6.83	8.94	6.99	9.10
	S.D.	0.80	0.78	0.85	0.78

*day sleep

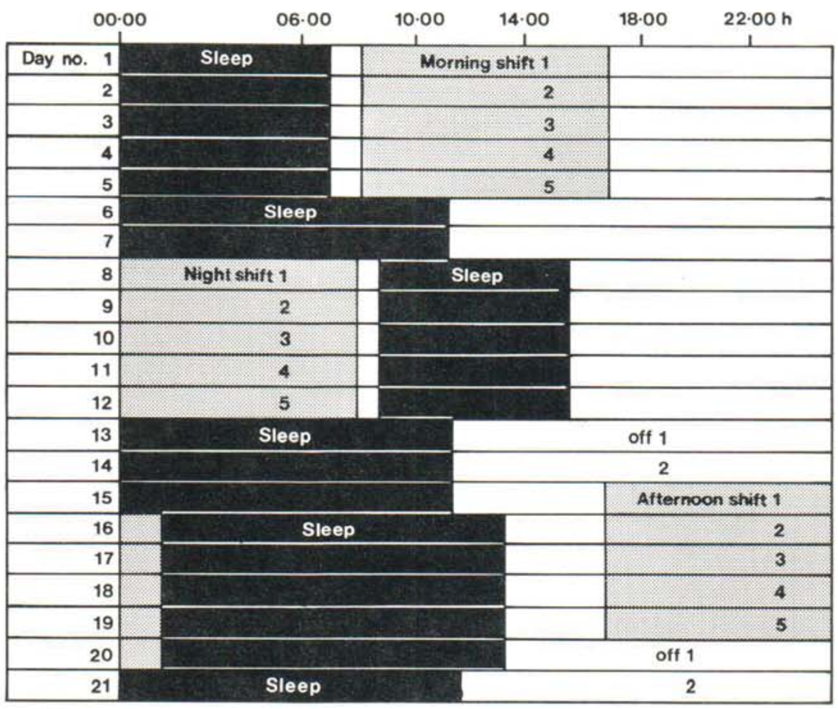

FIG. 4 – Outline diagram of the sleep and work periods – 5 on 2 off rota.

TABLE 2
Latency to sleep onset, nap frequency, and frequency of breaks in main sleep for each shift type.

Shift	Parameter	2 × 2 × 3 rota	5 on 2 off rota
Morning	Sleep latency (min)	32	27
	Nap frequency per shift	0.23	0.34
	Break frequency per shift	0.14	0.05
Afternoon	Sleep latency (min)	33	22
	Nap frequency per shift	0.00	0.03
	Break frequency per shift	0.48	0.24
Night*	Sleep latency (min)	21	16
	Nap frequency per shift	0.24	0.09
	Break frequency per shift	0.29	0.14

*day sleep

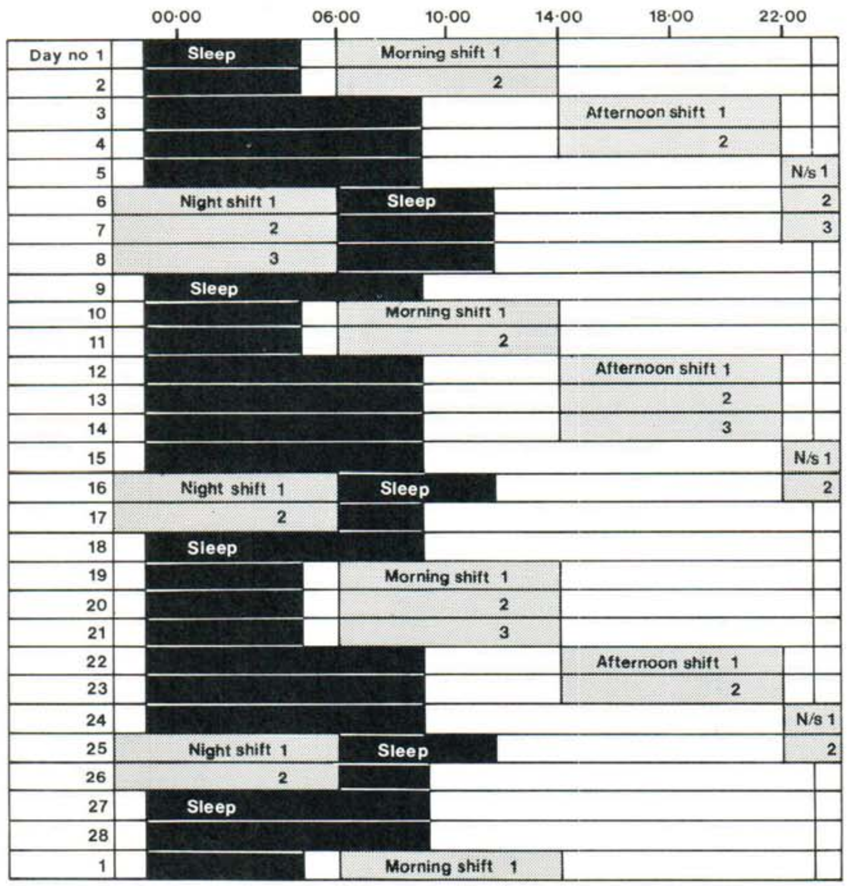

FIG. 5 – Outline diagram of the sleep and work periods – 2 × 2 × 3 rota.

DISCUSSION

The results lend support to neither a phase shift nor the build up of chronic fatigue occurring as a response to night work with 2, 3, or 5 consecutive night shifts.

A true phase shift would have been supported by a shift of both minimum and maximum alertness and temperature values; and possibly also by a trend over successive shifts and a delay in return to a normal circadian curve on the first complete day off. None of these conditions are met by the data.

Chronic fatigue would have been supported by a trend of declining alertness, or a fall in the daily mean of body temperature over successive night shifts. Again, these conditions are not met.

Rather than a phase shift it appears that the ongoing circadian rhythm on night shift is expressed through the imposed activity change. Thus, the similar evening maxima reflect a similarity between night and day shift evening activity patterns; and the different minima the fundamental activity pattern differences between day and night work.

The activity patterns associated with the two rota are reflected, in part, by the sleep patterns.

The mean sleep length across both rotas is similar to that reported for day workers by Tune[17]. Mean sleep is less for the fast rotating $2 \times 2 \times 3$ – but this may reflect differences between populations, or shift start times rather than rotation speed.

Sleep is lost on both morning and night shifts. On morning shift this appears to result from truncated sleep due to an early rise time not being compensated by an earlier time of going to bed. However, post shift napping is greatest on morning shift, and this sleep pattern maximises useful social time. On night shift typically no evening nap is taken before the first night shift and day sleep is taken shortly after the end of the night shift. The short latency to day sleep onset and the low frequency of breaks in day sleep may be positive outcomes of the sleep loss incurred by this day sleep pattern – indeed, several shift workers argued that they adopted this pattern for these benefits. The sleep pattern is similar for 2, 3, and 5 successive night shifts. However, with 2 night shifts a shorter day sleep is typically taken after the last night shift whereas with 3 and 5 night shifts day sleep is not shortened after the last night shift in spite of it being followed a few hours later by night sleep. The morning and night shift sleep pattern results in greatest cumulative sleep loss with the more slowly rotating 5 on 2 off rota.

Sleep length is greatest on afternoon shift. This is typically achieved by extending the main sleep period by later rising. The link between afternoon shift and the highest break frequency appears to reflect this "oversleeping".

The sleep pattern adopted by these experienced shift workers is best described as the establishment of a balance between useful hours of wakefulness for both work and leisure with the maintenance of an individually acceptable level of fatigue for both sleep and wakefulness. Mortality and morbidity data for shift workers[16] suggest that this balance is achieved without disastrous consequences. The temperature and alertness data presented here lend further support to this. Nonetheless, in the absence of widespread monitoring of physiological, psychological, and social indices the disruption of the sleep/wakefulness pattern remains a potential hazard of shiftwork.

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