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IN-DEPTH REVIEW: SHIFT WORK

Shift work and disturbed sleep/wakefulness

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Abstract Of the many health-related effects of shift work, disturbed sleep is the most common. This review describes the main observed effects of the three principal shifts (night, morning and afternoon) on patterns of sleep and wakefulness. The mechanism of sleep disruption in relation to circadian rhythms and the specific impact of aspects of shift organization (speed and direction of rotation) are discussed. The most troublesome acute symptoms are difficulty getting to sleep, shortened sleep and somnolence during working hours that continues into successive days off. These are only partially amenable to amelioration by manipulating shift patterns. However, there is no clear indication that chronic sleep problems result from long-term shift work.

Key words Accidents; fatigue; health; long hours; performance; shift work.

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Introduction

As discussed elsewhere in this series of reviews, shift work is associated with cardiovascular disease, gastrointestinal disease, increased accident risk, disturbed sleep and increased fatigue. While all these effects are important, the latter two constitute the dominant day-to-day health problems [1,2], and insufficient sleep is often the reason for leaving shift work. In particular, the resulting fatigue may make remaining a shift worker untenable.

Sleep and the three shifts

Shift workers practically always report more sleep disturbances than day workers [2]. The effects vary, however, depending on the shift timing. The impact of night, morning and afternoon shifts on sleep patterns is summarized below.

Night work

The night sleep the night before the first night shift is usually rather long [3], starts rather early, and lasts to ~08:00 h or later. It is frequently (30–50% prevalence) associated with napping in the afternoon before the first night shift, especially if the preceding main sleep has been short.

The sleep after a night shift is usually initiated 1 h after the termination of the shift [3], with very little variation (30–60 min SD) between individuals. The ensuing sleep is, according to electroencephalogram (EEG) studies, reduced by 2–4 h [4]. Most of the sleep loss involves stage 2 and rapid eye movement (REM) sleep, whereas slow wave sleep (SWS) is unaffected. The subjective aspects of sleep seem little affected, apart from the reports of premature awakenings and of not getting enough sleep [5]. Interestingly, ~50% of individuals experience a spontaneous (and effortless) sleep termination. Figure 1 illustrates a typical sleep pattern in connection with night work [6]. Day sleep after night work is short, involuntary sleep occurs at three points in time during the night shift and the shortened day sleep is compensated for through an afternoon nap.

About one-third of shift workers add a late afternoon nap between the subsequent night shifts [3,5,7]. The nap duration is often >1 h, and the prevalence of napping increases with decreasing length of the prior main sleep [8,9].

Night work is also characterized by increased subjective [6,10] and objective sleepiness [6,11,12]. Several of the latter studies indicate that full-blown sleep may occur at

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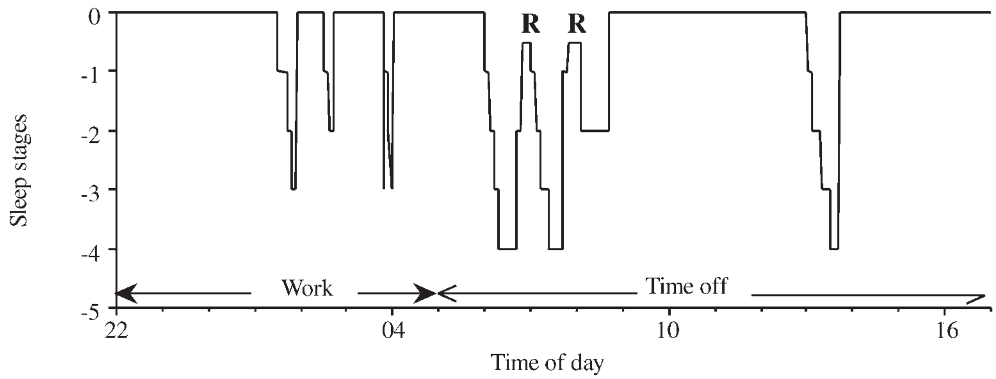

Figure 1. Example of sleep [stages 0–4 + REM sleep (R)] in connection with night work—see text for explanation.

work. The effects are particularly severe in the early morning, often involving incidents of involuntary sleep. Also, during days off, a substantial amount of sleepiness remains. It usually takes two night sleep periods before normal low sleepiness levels have been achieved after the last night shift [13]. The increased sleepiness will, of course, be related to an increased accident risk, but this is discussed elsewhere in this issue [14].

Morning work

The sleep pattern before a morning shift appears to be even more disturbed compared with the night shift [15]. The short sleep (6 h) has been demonstrated in EEG studies—usually a 2–4 h reduction of sleep length occurs [4]. Again, mainly stage 2 and REM are affected.

The main subjective effect is pronounced difficulty with awakening, non-spontaneous awakening and a feeling of not being refreshed by sleep [5]. The difficulty with awakening often makes the morning shift the most unpopular of the three shifts. Again, however, the quality of sleep, in itself, does not seem to be affected. Interestingly, the anticipation of difficulty with awakening is associated with reduced SWS [16]. Thus, sleep before the morning shift seems to contain an extra dimension of sleep disturbance, apart from reduced length.

Early times of rising (between 04:00 and 05:00 h) are also strongly associated with increased sleepiness during the rest of the day [12]. This sleepiness leads to an early afternoon nap in about one-third of workers [3,7,17]. The nap is taken soon after returning home from the morning shift [8]. Again, a short prior sleep seems to be the main precipitating factor for the nap.

Afternoon work

Compared with morning and night shifts, fewer studies have investigated the effect of afternoon shifts on sleep. On the whole, one sees a pattern of slightly late bedtimes (23:00–01:00 h), with awakenings at ~08:00 h and with an absence of napping [3,5,7]. However, the pattern is less homogeneous than for the other shifts and there is more variation in the timing of sleep for the afternoon shift.

The mechanism

The circadian rhythm

The reason for the health problems in shift work is the conflict between displaced work hours and the output of the biological clock. The latter resides in the suprachiasmatic nuclei of the hypothalamus [18], and generates a signal that results in a pronounced 24 h oscillation in virtually all physiological and psychological functions. Thus, for example, rectal temperature has a maximum (acrophase) at ~17:00 h and a minimum (nadir) at ~5:00 h [19], while melatonin has a maximum at ~04:00 h in the morning and a minimum at ~16:00 h, and seems closely related to temperature and alertness. If no adjustment occurs, work at the circadian nadir will be carried out at low levels of physiological activation, subjective alertness or behavioural efficiency.

Adjustment to night activity may occur, at least in the laboratory or in connection with jet lag. The speed of adjustment tends to be 1 h per day [20]. The mechanism seems to be light exposure at a particular circadian phase—the hours before the circadian nadir [21]. The circadian adjustment of shift workers, however, is counteracted by a light exposure during the early morning. Thus, adjustment to night work is seldom accomplished and at least partial day orientation is maintained.

The night shift

One reason for the night shift sleepiness is that the individual is exposed to work at the nadir (low point) of the well-established circadian pattern, characteristic of most physiological and psychological variables [22].

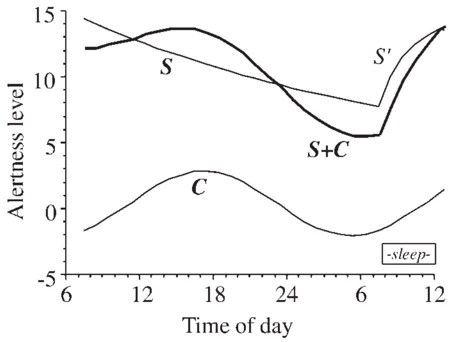

Figure 2. The main temporal components influencing alertness/sleepiness. S = homeostatic effect of time awake or recovery during sleep; C = circadian influence; S+C = the sum of circadian and homeostatic effects, in this case illustrating wakefulness extended to 07:00 h. Note the low level of alertness towards late night.

Essentially, alertness, performance and metabolism peak in the late afternoon and reach a nadir in the early morning. The period of maximum alertness will also strongly interfere with sleep, whereas the nadir will equally strongly promote sleep [19,23]. Daytime sleep will thus be truncated.

The other reason for night shift sleepiness is that the time awake before a night shift ends is extended to 20–22 h (since prior sleep termination), in comparison with, for example, the corresponding 9 h of the day worker. Alertness starts to fall immediately after the termination of sleep and continues for the duration of the time awake [22]. In addition, reduced prior sleep length will increase sleepiness, although alertness seems rather robust against small curtailments of sleep [24]. The two latter studies show that the effects accumulate over time; a week with 4.5 h of sleep may yield sleepiness close to levels seen in total sleep deprivation.

The homeostatic and circadian systems will combine to exert their influence (Figure 2). Thus, alertness and performance during sleep deprivation will have a circadian pattern superimposed on the gradual fall of alertness and performance [22]. Even after several days without sleep, one can clearly discern a slight increase of alertness during daytime, even if the mean level is low. The same combination of effects will be seen on sleep. Thus, the daytime circadian interference with sleep near the acrophase may be partly counteracted by a high need for sleep (through prior sleep loss), whereas a low need may make daytime sleep virtually impossible [23].

On the other hand, one would expect some adjustment of the circadian system across days of night work, which would ameliorate the negative effects of daytime sleep. Under optimal conditions, adjustment to a new circadian phase position will occur at the speed of ~1 h per day, probably through light exposure at the sensitive portions of the circadian phase [25]. Exposure before the nadir would lead to a delay, and after the nadir to an advance. However, in shift workers, the adjustment is counteracted by a light pattern in opposition to night work hours [26]. Thus, it appears that only very marginal circadian adjustment occurs in shift workers [27]. On the other hand, exposure to artificial light during the hours before the circadian trough may remove most of the sleepiness during night work and improve subsequent sleep [28]. It should be emphasized that there are very few systematic field studies of the application of light in real life work settings.

The morning shift

The reason for the short sleep before the morning shift is mainly the need to terminate sleep very early in the morning without being able to advance the bedtime to fully compensate for this. The latter failure may be partly social, but there is also a strong circadian influence on sleep latency. To phase advance the bedtime before a morning shift would be difficult since that would bring the bedtime close to the circadian acrophase and make sleep difficult to initiate [14,29].

The difficult early morning awakening which seems to be a burden to workers on the morning shift is also a result of circadian 'interference'. Thus, an early awakening will coincide with the circadian nadir, and this circadian phase seems to be very protective against sleep termination [21] and seems to make forced awakenings very difficult. The early morning awakening will, furthermore, reduce sleep length and thus contribute to morning shift sleepiness. This is exacerbated by the fact that the early morning awakening also adds further sleepiness by extending the time spent awake by 2–3 h. Finally, the difficulties of having to rise at a very difficult time in the early morning seem also be associated with anticipation stress, suppressing some of the SWS that would normally occur [26].

Particular aspects of the shift system

The three shifts mentioned above can be organized in a multitude of ways, some aspects of which may affect sleep and alertness.

Speed of rotation

Shift schedules will frequently differ with respect to the number of shifts that are worked consecutively. While there are no data that indicate that the pattern of attempted sleep would differ depending on such a speed of rotation, there are discussions on the amount of sleep permitted by certain types of schedules. Thus, Foret and Benoit [30] found that neither the total sleep length nor the amount of stages 3 and 4 recovered (changed) significantly across four consecutive night shifts (all were strongly reduced on the initial day sleep).

Permanent night workers tend to sleep somewhat less than day workers [31]. The latter study showed that the first day sleep was reduced by 1.1 h (compared with normal night sleep) and decreased a further 0.8 h over the six night shifts. Also, Wilkinson [31] found in a review that permanent night workers on the whole reported longer sleep (6.7 h) than weekly (6.3 h) or rapidly rotating (5.8 h) shift workers. However, while correct, this work did not take account of the effect of days off and of free time. Apparently, permanent day workers seem to sleep somewhat less than rotating shift workers when averaged across the entire shift cycle [32,33].

Interestingly, in a group of workers on North Sea oil rigs we have seen a very rapid [3–4 days) adjustment of sleep, with very little loss and quite good quality [34]. It was suggested that the lack of daylight and of competing social activities helped to promote a rapid adjustment.

Direction of rotation

A third concern is the direction of rotation. It has frequently been claimed that rotation should occur clockwise (i.e. morning–afternoon–night). While there is some theoretical support for this, there is no solid evidence that sleep should differ depending on the direction of rotation [35].

One interesting point often made by shift workers is that clockwise rotation leads to them having to use the first one or two days off for recovery from the night shift. To most employees, it is more attractive to have the night shift earlier in order to recover from night work 'on company time'.

Time of changeover

Apart from the speed of rotation, one would expect the timing of the shifts to affect sleep. The first concern is the time of the changeover between night and morning shifts. Traditionally, this time is at ~06:00 h. However, judging from field experiments, it appears that sleep before the night shift will be sharply curtailed with increasing phase advance of this time, and sleep after the night shift will be improved by the same procedure [36]. The obvious compromise seems to be to end the shift at ~07:00 h.

Quick changeovers

A second concern is the quick changeovers, i.e. short rest periods (= 8 h) between shifts. The prevalence of this aspect of scheduling is not known, but experience from field work suggests that it is very common. The reason for it is that this behaviour will compress the work week (compared with the conventional 16 h between shifts), yielding a longer consecutive period of time off from work. This practice invariably curtails sleep and data seem to indicate that the effects start already at a time between shifts of 11 h [36].

The nap

Apart from scheduling work hours to permit long sleep and limited time awake, the most obvious countermeasure is taking small portions of sleep (naps) whenever possible. Several studies have shown that 0.5–2 h naps taken during the first night awake will counteract the profound fall in alertness around the circadian trough during the early morning [37]. The only experimental field study of napping showed improved performance by 30 min 'cockpit naps' [38]. All implementation of napping at work should allow for the short period, 5–15 min, of impaired alertness (sleep inertia) after awakening. The overall impression is that napping may be the most effective countermeasure against sleepiness at work.

Long-term effects

There has been considerable speculation whether long-term shift work would lead to chronic insomnia. However, to date, very few studies have addressed this issue. The reason for the lack of prospective studies is the difficulty following up large groups for long periods of time, and keeping track of those who leave shift work—the self-selection problem is considerable. However, a few studies have used a retrospective approach [39], and the results seem to suggest a cumulative effect, although the results are not easy to interpret.

Individual differences and strategies

A number of individual factors may affect sleep disturbance associated with shift work [40–42]. Both individual factors affecting tolerance to shift work and appropriate measures to reduce sleep disruption are discussed in detail in separate reviews in this issue, by Costa [43] and Knauth and Hornberger [44] respectively.

Conclusion

Irregular work hours seem to exert strong, acute effects on sleep and alertness in relation to night and morning work. The effects seem, however, to linger, and also affect days off. The level of the disturbances is similar to that seen in clinical insomnia, and may be responsible for considerable human and economic costs due to fatigue-related accidents and reduced productivity. There are, however, no clear indications that irregular work hours cause chronic insomnia. The mechanism behind the disturbances is the sleep-interfering properties of the circadian system during day sleep and the corresponding sleep-promoting properties during night work.

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