Sleep Loss and Fatigue in Shift Work and Shift Work Disorder

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KEYWORDS

• Sleep • Sleepiness • Shiftwork • Night • Work • Disorder

Work hours that displace sleep to the daytime and work to the nighttime will interfere with the circadian and homeostatic regulation of sleep. Such work hours will in several ways constitute a health problem with respect to sleep and fatigue, cardiovascular disease, accidents, and cancer[1] (see the article by Litinski, Scheer, and Shea elsewhere in this issue). Herein the focus will be on sleep and fatigue. The terminology with regard to work that extends outside the day hours is somewhat diffuse, and several attempts have been made to classify and bring order to the description of the types of schedules.[2] Normally, the term *shift work* is used to denote work schedules that divide the 24 hours into roughly similar sizes and that use three or more teams to provide full 24-hour coverage. The teams can alternate between early morning, afternoon (swing), and night shifts or may work a permanent shift. The latter is more common in the United States, whereas rotating shifts dominate in Europe. Shift work is mainly used in the production industry. "Roster work" or other terms are used to denote schedules that are more irregular but still cover all or most of the 24 hours. Roster work is more common in transport work and health care. Essentially, the same conflict occurs between circadian regulation and the sleep/work pattern, as is true with shift work. For simplicity, we will use the term *shift work* for both of these types. There are also varieties of shift work that do not infringe on the normal sleep hours. These types are not dealt with herein.

CIRCADIAN AND HOMEOSTATIC REGULATION OF SLEEP AND WAKEFULNESS

The quality of waking cognition and of sleep is determined to a large extent by circadian and sleep homeostatic brain processes. From a circadian perspective, cognition is optimal during the internal biologic day, whereas sleep is optimal during the internal biologic night. Homeostatic sleep drive increases with the duration of prior wakefulness, whether due to acute total sleep deprivation or chronic short sleep schedules. Higher homeostatic sleep drive results in impaired cognition, increased sleepiness, and increased propensity for sleep. Importantly, these circadian and homeostatic processes interact to influence the quality of waking cognition and of sleep. As discussed herein, shift work schedules often require work to occur during the biologic night when the circadian system is promoting sleep, and sleep to occur during the biologic day when the circadian system is promoting wakefulness. The resulting misalignment between internal circadian time and the required wakefulness-sleep, work-rest schedules leads to impaired wakefulness and disturbed sleep. The reader is referred to the article by Dijk and Archer elsewhere in this issue for further discussion of the circadian and homeostatic regulation of sleep and wakefulness.

Dr. Wright was funded by NIH grant HL081761 and by National Space Biomedical Research Institute Cooperative Agreement NCC 9-58-202 with NASA.
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Sleep Med Clin 4 (2009) 257–271
doi:10.1016/j.jsmc.2009.03.001
1556-407X/09/$ – see front matter

SHIFT WORK AND SLEEP

The dominating health problem reported by shift workers is disturbed sleep as acknowledged in early studies.[3–5] At least three fourths of the shift working population is affected.[6] Disturbed sleep seems to be the decisive factor with respect to the attitude to one's work hours.[7] Findings from several questionnaire studies[8] have shown sleep durations of around 5 to 6 hours in relation to the night shift. Objective assessment of sleep via electroencephalography (EEG) of rotating shift workers indicates that day sleep is 1 to 4 hours shorter than night sleep.[9–14] Lockely and colleagues have shown similar values for interns on call.[15]

Night shifts are reported to result in greater loss of total sleep time than evening and slow rotating shift schedules.[14,16,17] Although some have argued that permanent night work may have benefits in terms of circadian adjustment to shift work, there is little support for this argument.[18] Rapid shift rotations are reported to be associated with reduced total sleep duration when compared with slower rotations (eg, at least 3 weeks per shift schedule).[16] Rapid counterclockwise rotations appear to especially disrupt sleep immediately prior to the night shift.[19] These effects are thought to be less severe for workers experiencing a clockwise rotation because of the natural tendency of the circadian clock to delay to a later hour[20,21] and because of increased time between shifts.[22] Some individuals have circadian clock periods that are shorter than 24 hours, and these persons would be expected to adapt easier to counterclockwise shift rotations. Before a counterclockwise rotation, 80% to 90% of workers nap before the midnight shift, as opposed to 40% to 60% before a clockwise rotation, which may help to ameliorate some of the expected impairments in sleep and sleepiness during a counterclockwise rotation. This interpretation is also consistent with numerous studies demonstrating the beneficial effects of napping among shift workers.[23–27]

Sleep episodes during shift work are terminated after only 4 to 6 hours, with the individual being unable to return to sleep, presumably because the internal circadian clock is promoting wakefulness during the schedule-induced circadian misalignment. The sleep loss is primarily taken out of stage 2 sleep (the dominant sleep stage) and stage REM sleep (dream sleep). Stages 3 and 4 ("deep" sleep) do not seem to be affected. The latter changes in sleep architecture during shift work schedules are consistent with the sleep architecture changes observed during restricted sleep schedules.[28,29] Furthermore, the time taken to fall asleep (sleep latency) is usually shorter. Night sleep before an early morning shift is also reduced, but the termination is through external means (ie, awakening with an alarm) and the awakening usually difficult and unpleasant.[30–33] In a rotating system, some of the sleep loss appears to be repaid in connection with working the afternoon shift, with sleep durations often extending beyond 8 hours.

Interestingly, day sleep does not seem to improve much across a series of night shifts;[34,35] however, night workers seem to sleep slightly better (longer) than rotating workers on the night shift.[36–38] The same lack of adjustment is seen in subjective sleep reports.[39] The assumed explanation for nonadjustment is the conflict with the external light-dark cycle.[39] Strict control over exposure to light and darkness can facilitate complete or partial circadian adaptation to permanent night work schedules.[40–42] Application of circadian principles to shift work has been demonstrated to adjust the sleep duration, as well as alertness, in real night shift operations on Norwegian oil production platforms.[43]

The long-term effects of shift work on sleep are poorly understood. Dumont and colleagues[44,45] found that the amount of sleep/wake and related disturbances in present day workers were positively related to their previous experience of night work. Guilleminault and colleagues[46] found an overrepresentation of former shift workers with different clinical sleep/wake disturbances appearing at a sleep clinic. Recently, the first author (TA) and colleagues have shown that, in pairs of twins discordant on night work exposure, the exposed twin reports somewhat deteriorated sleep quality and health after retirement.[47] Disturbed sleep is reported as a major problem in shift work, but it is not clear to what extent this actually constitutes a problem when compared with the effect of an extended time awake or work at the circadian trough. No study has attempted to dissect the relative contributions of these factors in shift work, but the findings from other types of studies show that the short sleep durations found in shift work (approximately 6 hours) may cause meaningful sleepiness or impaired performance in the average shift worker.[48–50] It is unknown whether extended sleep, after the night shift or during days off, compensates for prior loss during shift work operations.

In a recent representative health survey it was demonstrated that day and shift workers did not differ on most items of sleep quality on a questionnaire.[51] The only item that did differ significantly was "sufficient sleep." It was concluded that shift workers do not consider their sleep "disturbed" more than do day workers. Furthermore, diagnosed insomniacs, with whom the results were compared, scored much worse on most items. The lack of difference between shift workers and day workers could possibly be due to shift workers not seeing their sleep as disturbed because their sleep, although short, is consolidated, as documented in the polysomnographic studies listed previously. Shift workers also sleep well before an early morning shift, even if the awakening is difficult. They also sleep well after an evening shift. The observations suggest that shift workers in general do not fulfill the criteria for chronic insomnia despite frequent occurrence of reduced sleep duration.

PHYSIOLOGIC SLEEPINESS

Although short or otherwise impaired sleep may be the most common complaint in shift workers, the amount of sleepiness may determine the level of difficulty with shift work. If sleep would be impaired without consequences to alertness, it is doubtful that this would be seen as a problem.

In the sleep clinic, the Multiple Sleep Latency Test (MSLT) is considered the gold standard measure of physiologic sleepiness. The MSLT is a series of brief nap opportunities provided across the day, typically in 2-hour increments. The naps are ended after the patient falls asleep as determined by the EEG. The average latency to sleep across the day is then determined. Average latencies below 5 minutes are considered to represent a pathologic level of physiologic sleepiness[52] that is seen commonly in patients with sleep disorders such as sleep apnea and narcolepsy. An average latency to sleep of between 5 to 10 minutes is considered an intermediate level of sleepiness, and average latencies greater than 10 minutes are considered to represent low levels of physiologic sleepiness. No study has been performed to document the incidence of pathologic sleepiness in shift workers at night, but data from simulated shift work studies suggest that average MSLT sleep latencies are lower during the biologic night.[53,54]

Data from post–night shift bedtimes exist in field studies.[9–14] Essentially they indicate short (<5 minutes) latencies, attesting to excessive sleepiness according to clinical criteria.[52] Other indicators of physiologic sleepiness include EEG measures of alpha (8–12 Hz) and theta (4–8 Hz) activity,[55] slow eye movements,[56] or blink duration.[57] In general, alpha activity is an EEG pattern associated with relaxed wakefulness and increased sleepiness, and theta activity is a sleep EEG pattern. Slow eye movements are commonly seen during the transition from wakefulness to sleep.[58] In laboratory studies, alpha and theta EEG activity, as well as slow eye movements and blink duration measures of physiologic sleepiness, have been shown to be increased when homeostatic sleep drive is high and when wakefulness occurs during the biologic night.[59]

Physiologic measures give strong support to the notion of night shift sleepiness. In an EEG study of night workers at work (train drivers), it was found that one fourth showed pronounced increases in alpha (8–12 Hz) and theta (4–8 Hz) activity as well as slow eye movements towards the early morning, but these changes were absent during day driving.[60] The correlations with ratings of sleepiness were high ($r = .74$). In some instances, obvious performance lapses such as driving against a red light occurred during bursts of slow eye movements and of alpha/theta activity. The pattern is very similar in truck drivers during long haul (8–10 hour) drives,[14,61] and similar results have been demonstrated for air crew during long haul flights (**Fig. 1**).[62]

Process operators were found to have not only sleepiness-related increases in alpha and theta activity but also full-fledged sleep during the night shift.[13] Such incidents of sleep proper occurred in approximately one fourth of the subjects. Usually, they occurred during the second half of the night shift and never in connection with any other shift. Importantly, sleep on the job was not condoned by the company, nor was there any official awareness that sleep would or could occur during work hours. Interestingly, the subjects were unaware of having slept but were aware of sleepiness.

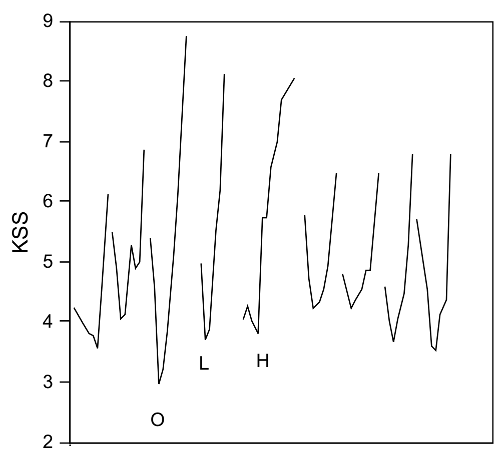

Fig. 1. Mean sleepiness (KSS) in an air crew before, during, and after a westward flight across nine time zones (Copenhagen to Los Angeles). O = outbound flight day; L = layover day in Los Angeles; H = homebound flight day. Ratings are made from awakening to bedtime.

Furthermore, hospital interns on call show "attentional failures" (defined as sleep intrusions in the EEG), particularly during early morning work.[63] The occurrence of sleep intrusions was reduced when continuous on-call duty across days was broken up to permit relatively normal amounts of sleep each day.

Increased alpha and theta activity in the waking EEG have also been demonstrated in truck drivers driving a truck simulator at night,[64] in power station operators during a night shift,[65] and in shift workers driving a simulator home after a normal night shift.[66] Findings from these studies also showed large increases in subjective sleepiness. In addition, findings from the driving simulator studies showed impaired performance in the form of increased variation in lateral position on the road. However, the use of simulated night shift operations is limited in that it is difficult to truly simulate real-world operational demands, interpersonal interactions, and challenges.

Findings from studies of physiologic sleepiness clearly show strong effects of night shifts. Nevertheless, it is possible that the degree of sleepiness is underestimated, because it appears that many individuals start counteracting sleepiness when they start to feel the symptoms. This reaction probably prevents sleepiness from appearing in many physiologic indicators, because EEG and electro-oculogram (EOG) signs of sleepiness only occur at higher levels of sleepiness when the individual is "fighting sleep" and has reached a maximum level of sleepiness.[56] Physiologic changes may occur only when no countermeasures are applied; however, this is an unsystematic impression by the primary author from natural observations in many studies. Findings from laboratory studies indicate that signs of physiologic sleepiness at night are still observed, even when using wakefulness-promoting countermeasures such as caffeine.[67,68]

SUBJECTIVE SLEEPINESS

Subjective sleepiness is obviously easier to measure than physiologic sleepiness; therefore, a wealth of results is available for inspection. Although it has sometimes been argued that subjective measures are less valid than other measures, it is mainly subjective complaints that make individuals seek medical attention. This observation is certainly true for insomnia or hypersomnia, the diagnosis of which is based on complaints of difficulties initiating and maintaining sleep, of nonrestorative sleep, or of excessive sleepiness.[69]

In this context one should also point out that "sleepiness" is not the same thing as "fatigue," at least not scientifically. It would lead too far to try to introduce strict definitions. Nevertheless, "sleepiness" refers to the tendency of falling asleep.[70] Fatigue may include sleepiness but also states such as physical and mental fatigue. Often, the two conepts are interconnected, but they need not be. The issue of the differential definition of sleepiness and fatigue has been subject to a constant debate.[71,72] One clinically useful distinction between fatigue and sleepiness is that cognitive and muscle fatigue symptoms may be reduced by sedentary activity or rest without sleeping, whereas subjective sleepiness and the propensity for sleep are often exacerbated by sedentary activity or rest.

A wealth of early questionnaire studies suggests that the overwhelming majority of shift workers experience sleepiness in connection with night shift work, whereas day work is associated with no, or marginal, sleepiness.[5,73,74] The studies by Verhaegen[74] and Paley[73] and colleagues report that fatigue increases on entering and decreases on leaving shift work. In many studies, a majority of shift workers admit to having experienced involuntary sleep on the night shift, whereas this is less common on day-oriented shifts.[75–77]

Between 10% and 20% of workers report falling asleep during night work. Although the popular Epworth scale has not been used frequently in relation to shift work, one recent study showed values of 9.2 in night workers, 8.6 in rotating shift workers, and 8.0 in day workers.[78] The differences are small, and the Epworth scale[79] in its present form may not be ideal for studying shift work because it contains questions which often refer to activities that may be difficult to relate to nighttime work, such as falling asleep at a red light (while in the drivers seat of a car).

If one wants to obtain a detailed impression of subjective sleepiness in shift work, multiple measurements must be made across each shift and on days off, including during leisure time. When this has been done, the results indicate moderate-to-high sleepiness during the night shift and no sleepiness at all during the day shifts,[30,80,81] again providing evidence that shift work sleepiness is associated with the work schedule and cannot be considered a primary sleep disorder of excessive sleepiness that is always present. Data are presented herein to illustrate subjective sleepiness at night in the laboratory and during real shift work. We use these studies because the same self-rating scale of sleepiness has been used in all of them, allowing the possibility of making comparisons. The scale is the Karolinska Sleepiness Scale (KSS) which ranges from 1 to 9, with 1 = very alert, 3 = rather alert, 5 = nether alert nor sleepy, 7 = sleepy but no difficulty remaining awake, and 9 = very sleepy (fighting sleep, an effort to remain awake).[56] Physiologic intrusions of sleep in the EEG or EOG usually start at level 7 and dominate the recording at level 9. The KSS has been shown to be sensitive to sleepiness due to total sleep deprivation[82] and circadian phase (eg, **Fig. 2**), chronic sleep loss,[83] sleep disorders,[84,85] as well as treatment of sleepiness with wakefulness and sleep-promoting countermeasures.[85,86]

Findings from a shift work study (**Fig. 3**) show subjective sleepiness ratings in 60 workers in the paper industry working an extremely rapidly rotating shift system with very short rest between the shifts.[7] The schedule started with a night shift (2100–0600 hours) followed by 8 hours off, an afternoon shift (1400–2100 hours) with 8 hours off, and a morning shift (0600–1400 hours). This "triad" was followed by 56 hours off and included two normal night sleeps. The triad pattern was repeated seven times, and the cycle ended with 8 days off. **Fig. 3** shows the last triad, together with the first 2 days off. Sleepiness rose to high levels during the first night shift (6.5), fell to intermediate levels (4–4.5) during the afternoon shift (after 5.4 hours of sleep), and reached high levels (5–5.5) again during the morning shift (after 4.5 hours of sleep). Sleepiness was back to normal levels (mostly <4) on the first recovery day.

The morning shift effect seems to be similar to that seen in the middle of the night shift but seems, on the other hand, to be present throughout the entire shift[80,87] and may reach very high levels[5,6] when the start time is earlier than 6 AM.[88] This sleepiness leads to an early afternoon nap in about

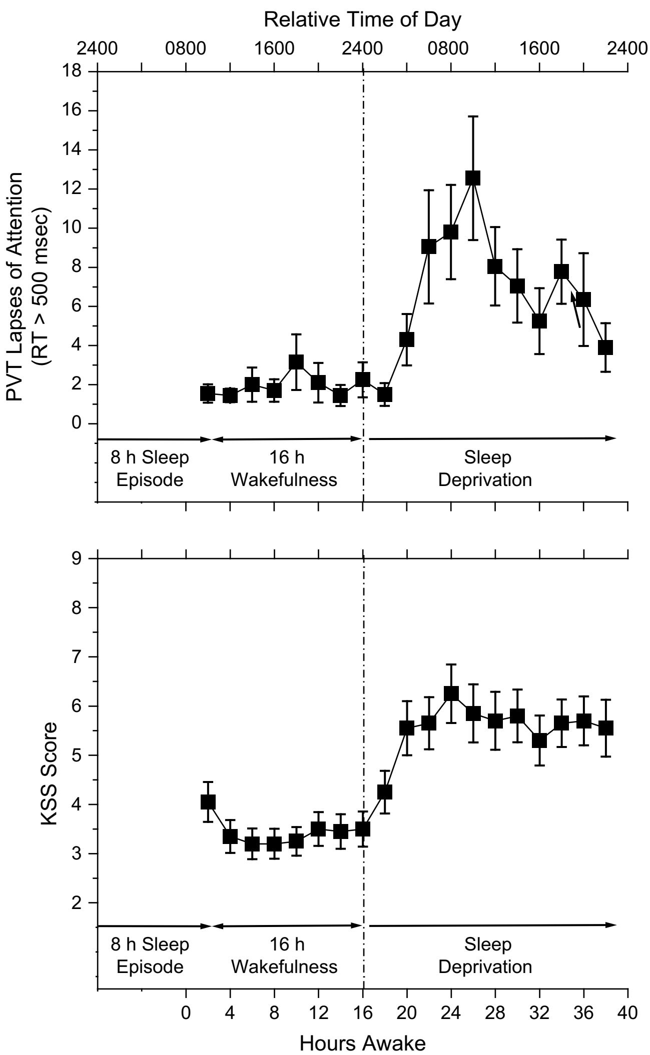

Fig. 2. Subjective sleepiness (KSS) and psychomotor vigilance test (PVT) performance scores (lapses of attention, reaction times >500 ms) across 40 hours of total sleep deprivation. Sleepiness and performance lapses are low during the habitual day across the first ~16 hours of wakefulness, whereas, thereafter, sleepiness and PVT lapses of attention increase across the habitual night with peaks around 26 hours awake. PVT lapses, and to a lesser extent, KSS sleepiness then improve the next day because the circadian clock promotes wakefulness even though sleep did not occur. These data show what would likely happen to sleepiness and performance on the first night shift in a series if shift workers did not nap prior to the shift.

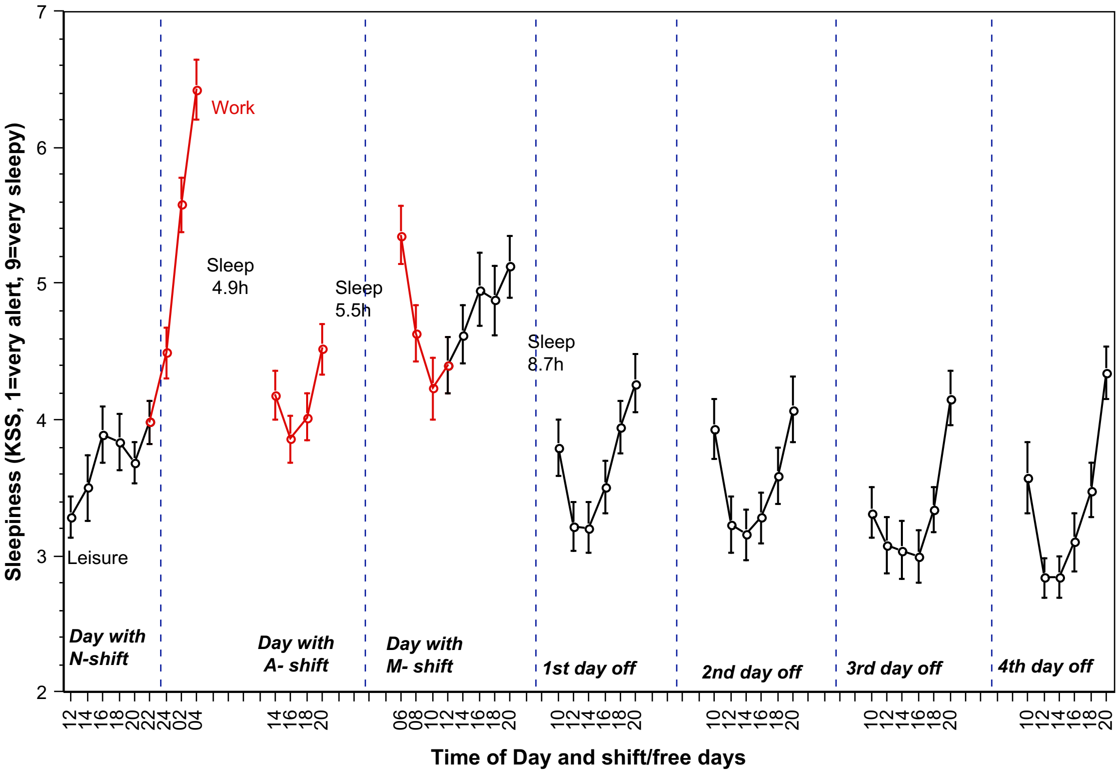

Fig. 3. Subjective sleepiness (KSS) in rapidly rotating shift workers (mean ± SE). Filled points (*grey*) indicate sleepiness during work hours.

one third of the workers.[89–91] Morning work seems to be increasing in many areas, particularly in transport work and in the media. One may also consider the effects of traffic congestion in large populated areas resulting in earlier commuting times in order for travelers to reduce travel time.

For comparison, burnout subjects (extreme exhaustion) show daytime values of 5 to 6, whereas controls show values of 3 to 4 and even lower values during days off.[92] Healthy subjects reach levels of 6 to 7 after 5 days of 4 hours of night sleep.[83]

The second shift work illustration (**Fig. 4**) concerns adjustment to night work under special circumstances. Adjustment to night shifts normally does not occur because shifts alternate, or because of the exposure to daylight when returning home from the night shift, which counteracts the expected delay of the circadian clock.[93] When light is not interfering, such as when night workers are provided with strong sunglasses for the morning commute home, partial adjustment can occur.[40,93] This adjustment may also be seen in situations when no daylight is present. **Fig. 4** shows the results from a study of seven workers on an oil production platform in the North Sea.[94] They worked 14 consecutive days between 1900 and 0700 hours. These days were followed by 3 weeks off. The workers were not exposed to outdoor light because the platform was a self-contained work place in which all aspects of life took place indoors. **Fig. 4** shows the sleepiness pattern across the working days and the first

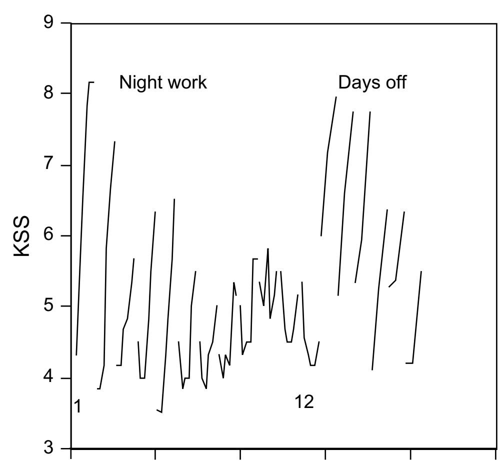

Fig. 4. Mean subjective sleepiness in oil platform workers on 12-night shifts and 6 days off (*dashed lines*).

6 days off. Sleepiness reached extremely high levels during the first days, but the pattern gradually changed. In about the middle, the pattern and levels become similar to day work patterns, although at a level of intermediate sleepiness. On return home, the pattern was strongly changed again, and sleepiness levels remained high for 4 to 5 days. In fact, daytime levels never seemed to reach normal day life levels. Because the study did not include further weeks off, it is unclear whether recovery may have proceeded further.

The daytime sleep data during the night work schedule showed that the bedtime gradually changed from 0800 hours to close to 1100 hours. Similarly, the time of awakening changed from 1700 hours to 1800 hours, yielding a sleep length of just below 8 hours. During the days off, a midnight bedtime was adopted throughout, but the time of awakening changed from 0600 hours to 0800 hours on day 6. Taken together, the results suggest that the circadian system adjusted strongly to night work, although not perfectly, and that the readjustment back to reasonably normal levels took around 6 days. Indeed, it is possible that even some days more would have been required to reach full recovery.

An important question is the implications of the rated sleepiness discussed previously, such as impaired performance. Is there a level of sleepiness that might be "acceptable" considering a putative right of individuals to lead their lives at reasonable levels of alertness? We have suggested that the KSS level of 5 to 6 characterizes subjects high on burnout[92] and patients with a burnout diagnosis at slightly higher levels.[95] One might also consider the level of sleepiness in individuals with a negative attitude to shift work in the study by Axelsson and colleagues.[7] That group reached a maximum of 7.2 on the night shift, 5.2 on the afternoon shift, and 5.9 on the morning shift. The corresponding values for workers with a positive attitude were 5.7, 3.9, and 4.8, respectively. Similarly, Czeisler and colleagues[85] showed that workers diagnosed with shift work disorder (SWD) had a mean KSS value of 7 out of 9 on the night shift. The comparisons attempted here suggest that night shift sleepiness for average shift workers is higher than acceptable, and that some shift workers have even higher levels of night shift sleepiness.

The effects of shift work on sleepiness are obviously profound, but an important question is whether it is related to the ability to function. This seems to be true,[82,96] although the relation between subjective sleepiness and many performance tasks appears to be moderate.[83,97–103] Yang and colleagues[104] have reported that if the self-rating is carried out after a minute of sitting quietly with closed eyes, the correlation is increased, although it is still moderate. In most studies, self-ratings are carried out without any control of the situation leading up to the rating, whereas performance tests are carried out under controlled conditions and with a task load that may unmask sleepiness.

PERFORMANCE AND ACCIDENTS AT WORK

As might be expected from the effects of shift work on sleepiness, performance and safety are also affected.[105] Road transport is the area where the link between safety and night work sleepiness is most pronounced. Harris[106] and Hamelin[107] and Langlois and colleagues[108] convincingly demonstrated that single-vehicle truck accidents have, by far, the greatest probability of occurring at night (early morning). Single-vehicle automobile highway accidents are also greatest at night.[109–111] Furthermore, the United States National Transportation Safety board (NTSB) found that 30% to 40% of all US truck accidents are fatigue related (and grossly underestimated in conventional reports). The latter investigation was extended to search for the immediate causes of fatigue-induced accidents.[112] The most important factor was the amount of sleep obtained during the preceding 24 hours and split-sleep patterns, whereas the length of time driven seemed to have a minor role.

The NTSB also concluded that the Exxon Valdez accident in 1989 was due to fatigue, caused by reduced sleep and extended work hours.[113] The extent of fatal, fatigue-related accidents is considered to be approximately 30%.[114] This rate is approximately the same level of incidence in the air traffic sector, whereas equivalent accidents at sea are estimated at slightly below 20%.

In industry, a classic study by Bjerner and colleagues[115] showed that errors in meter readings over a period of 20 years in a gas works had a pronounced peak on the night shift. There was also a secondary peak during the afternoon. Similarly, Brown[116] demonstrated that telephone operators connected calls considerably slower at night. Woyczak-Jaroszova found that the speed of spinning threads in a textile mill went down during the night.[117] From conventional industrial operations, less data are available[118,119] but indicate that overall accidents tend to occur, not surprisingly, when activity is at its peak. These values do not take account of exposure. Findings from some other studies show night shift dominance for accidents[120–122] but not all.

It is also believed that the (nighttime) nuclear plant meltdown at Chernobyl was due to human error related to work scheduling.[123] Similar observations have been made for the Three Mile Island reactor accident and the near miss incidents at the David Beese reactor in Ohio and at the Rancho Seco reactor in California. These observations are all anecdotal, and few additional data are available.

The most carefully executed study, from car manufacturing, indicates a 30% to 50% increase in accident risk on the night shift.[124] Åkerstedt and colleagues[125] showed that fatal occupational accidents were higher in shift workers in a prospective study (controlling for physical work load, stress, and other factors). Extended duration work shifts also increase the risk of automobile accidents.[126] A study of interns on call showed that improving rest conditions (maximum of 16 consecutive hours of work and 60 hours per week) greatly reduced many types of medical mistakes, of which several were serious.[15] The performance decrement during simulated[127] and actual shift work[128] has been compared with the effects of blood alcohol levels of 0.05% and greater.

Several studies have tried to evaluate the costs to society of alertness-related accidents and loss of performance (which does not reflect only the costs of shift work). One estimate from the 1990s exceeds $40 billion per year in the United States.[129]

SPECIAL CASES

With regard to shift scheduling, attempts have shown that clockwise shift changes should be less negative for performance than counterclockwise ones, but the results are not encouraging.[23,130,131] There has also been a continuous discussion of whether permanent shifts are better than rotating ones[16,132–134] This issue has not been resolved. One could also conceive of longer shifts because they would leave more days free for recuperation. This approach is probably not applicable to all occupations because of too high a work load, but in many studies shifts up to 12 hours have been shown not to affect performance negatively[80,135–137] and seem to be attractive to the employees. Findings from other studies indicate that shifts of 10 hour duration and greater increase sleepiness[138,139] and the risk of accidents.[126,137,140]

SHIFT WORK (SLEEP) DISORDER

The effects of shift work are relatively pronounced, such as a reduction of sleep by 1.5 to 2 hours when working the night shift schedule and considerable sleepiness (reaching 2–3 minutes on average for the MSLT and average subjective sleepiness of 7 on the 1–9 level KSS scale). Clearly, some individuals appear to be more negatively affected by shift work than others. There is a diagnostic category called "shift work sleep disorder" (SWSD), also referred to as SWD or shift work type (DSM IV).[141] SWSD is defined as the "report of difficulty falling asleep, staying asleep, or non-restorative sleep for at least one month" associated with "a work period that occurs during the habitual sleep phase." The International Classification of Sleep Disorders (ICSD)[69] defines the diagnosis of SWD (the word "sleep" has been dropped) on four criteria: (1) a complaint of insomnia or excessive sleepiness temporally associated with a recurring work schedule that overlaps the usual time for sleep, (2) symptoms associated with the shift work schedule over the course of at least 1 month, (3) circadian and sleep-time misalignment as demonstrated by a sleep log or actigraphical monitoring for 7 days or more, and (4) the presence of a sleep disturbance not explainable by another sleep disorder, medical or neurologic disorder, mental disorder, medication use, or substance use disorder.

The prevalence of SWD is not clear because most studies have not used standardized diagnostic criteria;[142] however, one estimate arrives at 10% using the ICSD-2 criteria (sleep difficulties or sleepiness sometimes or often at a severity level of 6 on a 1–10 scale).[78] In another study, a figure of 8% was found when using "very negative or rather negative to present work hours" as a criterion.[7]

Czeisler and colleagues[85] used ICSD-2 SWD criteria, with MSLT values of less than 6 minutes during the night to objectively verify excessive nighttime sleepiness, and sleep efficiency of less than 87.5% during day sleep (8-hour time in bed) after a night shift to objectively verify daytime insomnia. The resulting group showed a mean MSLT during the night shift of less than 2 minutes, an average sleepiness rating of approximately 7 on the KSS,[56] and an average sleep duration of 6 hours. The MSLT and sleepiness ratings were clearly below what is usually found to be average in other studies, whereas the sleep duration was similar to that in most other studies. The controlled and soporific laboratory situation may not be representative of the real-life situation, at least not with respect to absolute levels of sleepiness.

COUNTERMEASURES

The most logical countermeasure for the sleep/wake problems in night work is to discontinue that activity. If that is not possible, several aspects of scheduling have been recommended as improvements.[7] Among them are clockwise rotation (the sequence of morning-night-afternoon shifts), but the empirical support is rather weak.[143] Some obvious adverse types of schedules should be avoided. One includes short rest periods between shifts. In many countries, 8 hours of rest frequently appear in between, for example, a night shift and a morning shift. This results in short sleep and sleepiness during work.[7,80]

One should probably also avoid several night shifts in succession, because sleepiness will 22accumulate, as will accidents.[144] Flexibility and influence on scheduling will have positive effects on sleep.[145] Strategic distribution of rest days will improve alertness.[136] Rest breaks seem to be efficient barriers to increased accident risk (and presumably sleepiness/fatigue) across the night shift.[146] Late changeovers seem preferable to early ones.[147]

Education of shift workers is needed regarding good sleep habits and environment, the need for protected time for sleep, as well as recognition of critical times of vulnerability. Among acute countermeasures for night shift fatigue/sleepiness, is are one possibility,[148] but few real-life shift work studies are available.[24,26,149,150] If naps are used as a countermeasure to shift work–induced sleepiness, evidence from laboratory studies suggests that prophylactic naps of 2 hours in duration before an overnight shift (eg, late afternoon) are more effective at reducing nighttime sleepiness than are 2-hour naps during the night shift.[151] The latter effect is likely due to the negative impact of sleep inertia[152] following long work shift naps, because such naps are likely to include deep slow wave sleep and sleep inertia is worst when awakening from deep sleep. If naps are used during shift work operations, very short naps of less than 10 minutes may be effective because there is less sleep inertia after short naps. Short 10-minute naps have been reported to reduce sleepiness during the daytime;[153] however, the effectiveness of short naps to reduce sleepiness has not been tested at night.

Sleepiness at night can also be reduced by wakefulness-promoting drugs. Caffeine is perhaps the most common self-selected countermeasure used by shift workers. No operational field studies have been performed with caffeine; however, findings from laboratory studies indicate that caffeine can reduce nighttime sleepiness and improve performance.[67,150,154] Prophylactic use of caffeine before the onset of sleepiness[67,154] appears to be more effective than use of caffeine to reverse sleepiness.[155] Recent work on alertness-enhancing drugs such as modafinil has shown improvement in nighttime sleepiness in patients with SWD, although clinically significant sleepiness is still present.[85] Treating otherwise healthy shift workers with pharmaceutical products is questionable, however, and the risks associated with treatment need to be weighed against the risks associated with no treatment or the effectiveness of alternate treatments. The case is probably the same with the "chronobiotic" melatonin.[156] Exogenous melatonin has been tried in an actual shift work situation but with moderate success.[157] Light treatment is a third possibility, but little applied field work has been carried out and with modest effects.[40–42,154,157–159]

With respect to driving, rolling down a window, turning on the radio, and stopping for exercise have been tried in simulator studies without success.[160] Interestingly, a recent study by Anund and colleagues[161] showed that hitting a so-called "rumble strip" due do sleepiness only brings back alertness (physiologic, behavioral) for 1 to 2 minutes. The sleepiness then returns to pre-hit levels.

Perhaps the most effective way of promoting wakefulness at night is through the use of combined countermeasures. In laboratory studies assessing nighttime performance, it has been demonstrated that combinations of bright light and caffeine, naps and caffeine, as well as naps and modafinil improve cognitive performance and alertness at night more than either treatment alone.[150,154,155,162]

SUMMARY

Shift work that includes the night will have pronounced negative effects on sleep, sleepiness, performance, and accident risk. Misalignment between internal circadian physiology and the required work schedule is thought to be a primary cause of shift work schedule–induced sleepiness and sleep disruption. Wakefulness and sleep-promoting countermeasures can provide some help to reduce sleepiness and improve sleep, but, currently, there are no effective treatments that can counteract all of the negative impact that shift work schedules have on human physiology and behavior. Additional research is necessary to determine why some individuals have particular vulnerability to nighttime sleepiness and daytime insomnia. In addition, more research is needed to develop effective countermeasures for both sleepiness and insomnia associated with shift work, because shift work is now an important and established component of local and world economies.

ACKNOWLEDGMENTS

The authors wish to acknowledge the many helpful discussions and research collaborations with Drs. Göran Kecklund and Charles A. Czeisler, which have influenced our thinking on shift work and shift work disorder.

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