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Measures to counteract the negative effects of night work

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Objective Night work is associated with several negative health outcomes as well as accidents and reduced productivity. The aim of this study was to identify factors that may counteract the negative effects of night work.

Methods We conducted searches for studies of scientifically based countermeasures of the negative effects of night work in PubMed and Thomson Reuters' ISI Web of Knowledge® and inspected the reference lists of relevant literature.

Results We identified studies describing countermeasures such as proper personnel selection, bright light therapy, melatonin administration, naps, exercise, sleepiness-detection devices, and the use of stimulants to improve wakefulness and hypnotics to improve daytime sleep.

Conclusions There is some research supporting countermeasures (eg, bright light, melatonin, naps, use of stimulants, proper work scheduling) as a means to improve adaptation to night work. However, there is little evidence that such countermeasures reduce the long-term health consequences of night work. Future studies should aim at identifying both work and individual factors which are related to differential health outcomes of night work. Better study designs (eg, longitudinal designs and use of standardized outcome measures) are needed in future research.

Key terms shift work; sleep; health problem; accident.

Shift work is often defined as work which takes place between 19.00–06.00 hours (1). Night work is described as a type of shift work where the majority of the work occurs between 22.00–06.00 hours (2). Globally, the proportion of workers doing shifts seems to be rising. A report based on a survey conducted in European Union countries in 2005 showed that, during the last month, about 45% of respondents had worked ≥1 evening, while about 20% had worked ≥1 night shift (3).

Shift and night work are associated with a wide range of health issues. Night work can cause sleep disturbances, premature awakenings from daytime sleep, and sleepiness during the night shift (4). A meta-analysis concluded that shift work represented a 40% increase in the risk for cardiovascular disease (5). Recent studies have demonstrated that night work is linked to metabolic disturbances (6–11). Poor health habits, such as smoking, have also been associated with shift and night work (12). Most epidemiological studies show that night workers complain more frequently of gastrointestinal symptoms than their daytime counterparts (13, 14) and the prevalence of gastrointestinal disorders is higher among shift and night workers than among daytime workers (15, 16). Also psychological symptoms such as fatigue (17, 18) and poor mental health are more common among night than day workers (19, 20). Negative reproductive health effects in terms of preterm deliveries (21), miscarriage (22–24), irregular menstruation (17, 25), and reduced birth weight of babies (26) have been linked with shift and night work. There is ample evidence of a link between night work and breast cancer in women (27, 28). In some studies, shift and night work have been

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linked with increased mortality (29, 30), although not all studies corroborate such findings (31). Studies have shown a higher accident risk on evening, and especially night, compared to day shifts (32, 33). Based on these facts, an identification of the possible countermeasures of the negative effects of night work is warranted. Our study aimed to provide such an overview and evaluate the current evidence in support of the effectiveness of these countermeasures.

Methods

A literature search was conducted in PubMed and Thomson Reuters ISI Web of Knowledge® for English-language publications. No year constraints were used. Key words such as "shift work", "shiftwork", "night work", "nightwork", "countermeasures", "light therapy/intervention", "tolerance", "schedules/systems", "melatonin", "hypnotics", "medication", "naps", "stimulants", "sleepiness detection", and "exercise" were used, either alone or in combination with each other. In addition, we conducted searches in the reference lists of articles, books, and other relevant literature.

Results

Due to the fact that humans clearly are diurnal animals, night work causes significant health- and safety-related problems as presented in the introduction of this article. Although not all studies have linked shift and night work with increased sickness absence (34, 35), the vast majority of studies have shown that shift work is a risk factor for sickness absence (36–40). Seen strictly from a health perspective, night work should therefore be avoided. Hence, employers should consider organizing work without resorting to night work whenever possible. Based on the strain caused by shift work, employees often regard it as a significant stressor that has been linked to turnover (41, 42). In cases where the worker shows very poor adaptation to night work, transfer to day or afternoon shifts should be considered (43).

Shift work tolerance and personnel selection

The term "shift work tolerance" was first introduced by Andlauer and colleagues (44) and denotes the ability to adapt to shift work without adverse consequences. It was assumed that this ability was related to dispositional behavioral and biological characteristics. Although some studies have shown that factors such as age (45, 46) and a preference for mornings ("morning-type orientation") (47) are negatively associated with shift work tolerance, two reviews have concluded that individual differences show only low and inconsistent variation with shift work tolerance. Both noted that current knowledge is not sufficient to carry out a reliable selection of individuals suitable for shift work (48, 49). Still, some authors express confidence that some individual factors are likely to cause problems coping with shift work. Such factors include history of gastrointestinal problems, age >50 years, heavy domestic workload, morning-type orientation, history of sleep problems, psychiatric illness, and a history of alcohol or drug abuse, epilepsy, diabetes, and heart disease (50). More recent studies have also suggested that vigorous types of individuals who score high on flexibility of sleep habits are better suited to night work than languid types who score low on flexibility of sleep habits (51). Some studies have also shown that neuroticism is negatively associated with shift work tolerance (52–54). One recent study found that gene variations on the clock gene Per3 were related to the ability to maintain performance during the night (55). More studies of genetic factors that may be related to shift work tolerance could represent a promising avenue of research and may identify alleles that are related to shift work tolerance. Pregnant women are a special group of workers. Whether they should work night shift or not is an important question. There is hardly any disagreement about night work being a potential risk to reproduction, but the consequences of this knowledge have been discussed in several papers with different conclusions (21, 56). However, most of the studies suggest changes to daytime work schedules for pregnant women (22, 26, 56, 57). As far as we know, only one study has examined and demonstrated a reduced risk of "small-for-gestational-age infants" when applying this preventive measure early in pregnancy (26).

Recommendations for work scheduling

When it comes to the arrangement of shift work, a recent meta-analysis concluded that forward shift work rotation (day–afternoon–night) is better than backward rotation (night–afternoon–day). The same review also concluded that fast is better than slow rotation and self-scheduling of shift is preferable to shift schedules set by the company (58). However, there is some general evidence indicating that adaptation to night work improves with the number of consecutive nights worked (59), while in another meta-analysis, it was shown that sleep duration was longer in shift workers on slow shift rotation compared with those on a fast shift rotation. The advantage of fast rotating shifts is that the worker changes his or her circadian rhythm only to a small degree. Hence, when the shift work period is finished, adaptation back to a daytime schedule is normally relatively smooth. The advantage of the slow rotating system is that a biological adaptation to night work seems to occur (60) that should, in accordance with circadian principles, make the worker less susceptible to making errors on the night shift (61). Several shift work studies from the offshore oil industry have also confirmed that good biological adaptation to shift work does seem to occur after 4–6 days of consecutive night shifts (62). Two studies of 14 days of consecutive night work indicated that good biological adaptation to shift work was achieved during the first week (63, 64). It should be noted that good adaptation to night work found in the offshore sector may be related to a lack of daytime light exposure as well as sleeping at the workplace, both of which are specific for this work setting. When it comes to studies investigating the effects of the duration of shifts, most have compared 12- to 8-hour shifts. Shorter shifts seem to be associated with less fatigue and sleepiness during the work period, whereas longer shifts often imply more time for the family and reduced travel time and cost (65, 66). In terms of accidents, long working hours (eg, 12 hours) present a significantly increased risk compared to shorter working hours (eg, 8 hours) (67, 68). The number of accidents on a shift is inversely proportional to the time elapsed since the last break (69). Concerning the issue of free time between successive shifts, studies have consistently shown that if this time is too short (eg, ≤9 hours) then the sleep duration will be significantly shortened (70). It is therefore recommended to have a rest time of ≥12 hours between shifts (71). In some instances, the worker or the employer may prefer to compress the work week by increasing the work hours per day, allowing for a decreased number of work days in a week. Examples are the 4-day, 40-hour or the 3-day, 36-hour work week (72). Results from a recent review on the effects of a compressed work week showed overall no clear trend in terms of self-reported health or fatigue. However, in most of the included studies, an improvement in the work–life balance was reported. Generally, few positive or negative organizational effects were found (73). Although several single studies on different interventions in terms of work scheduling have been conducted, many have major methodological drawbacks, such as a lack of longitudinal designs, no randomization, no control group, few or no objective measures, low number of subjects, and no long-term follow-up evaluation (65, 66, 73, 74). Hence, future studies in this field should aim at improving the study methodology. Generally, it is recommended that the employer or person in the organization responsible for designing shift work schedules should have knowledge about circadian principles (75). In addition, there is a growing body of evidence suggesting that some of the negative consequences of shift work are lessened when the employees can choose their own schedule (76–80). In a review, Åkerstedt recommends avoiding: (i) morning shifts that begin too early (ie, before 07.00 hours), (ii) too many successive shifts without time off, and (iii) too many successive night shifts (ie, >3) in rotating systems. He further recommends rapid rotation in a rotating schedule (2–3 days on each shift), and placement of night shifts at the end of the shift cycle (2).

Bright light & melatonin: improving adaptation to permanent/long-term night work

The circadian rhythm can be altered with the use of bright light and/or the administration of exogenous melatonin. Bright light and melatonin can be used separately or together. In the latter case, the time of the administration of light and melatonin is often separated by 12 hours (81). Light affects the circadian rhythm according to a phase-response curve (see figure 1). Light exposure prior to the nadir for core body temperature (which typically occur about two hours prior to the habitual wake up time) delays the circadian rhythm, whereas light after the nadir phase advances the circadian rhythm (82). Figure 1 also

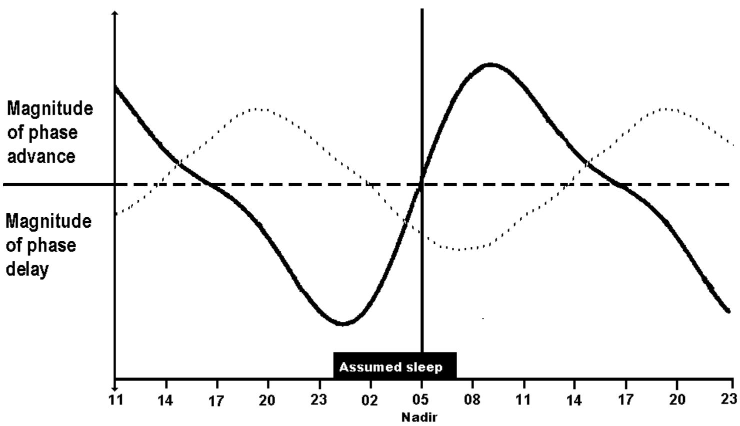

Figure 1. Phase-response curve for light (full line) and melatonin (dotted line) based on Khalsa et al (82) and Lewy et al (83). The differences in effect between light and melatonin are not necessary, as shown in this figure, but will depend on the doses of light and melatonin. When the curves for light and melatonin are above the horizontal line in the middle of figure, then light and melatonin administered at the corresponding times shown at the bottom of the figure will phase advance the circadian rhythm. When the curves for light and melatonin are below the horizontal line in the middle of figure then light and melatonin administered at the corresponding times shown at the bottom of the figure will phase delay the circadian rhythm. Be aware that the figure is based upon a normal circadian rhythm. If the circadian rhythm for instance is delayed by 4 hours then the curves in the figure should be moved to the right by 4 hours.

shows the phase-response curve for melatonin. Melatonin administered in the biological evening phase, advances the circadian rhythm, whereas melatonin taken in the biological morning phase delays the circadian rhythm (83). Normally, interventions based on bright light exposure use light in the visible part of the spectrum with light intensity ≤10 000 lux (84). When natural daylight is available at the appropriate times for light exposure, it can replace bright light exposure from artificial sources – such as bright light therapy lamps (85). In order to improve adaptation to permanent night work, it is currently recommended to expose night workers to bright light (10 000 ux for ≥30 minutes) in the middle of the night (before nadir) on the first night shift. The timing of bright light exposure can be successively delayed by 1–2 hours on the subsequent third to forth night. On the first night, the worker should avoid bright light exposure after 05.00 hours, if necessary by wearing sunglasses/goggles. Also, the timing of this can be successively delayed by one hour on the subsequent third to forth night. Following the night shift, the worker should go to bed as soon as possible and take melatonin at this point for the first 1–2 days (81). Melatonin is normally administered in doses between 0.5–5.0 mg (86). In many countries, melatonin is a prescription drug. The evidence suggests that short-term use (≤3 months) does not result in serious side effects, but more research is needed to determine its long-term safety (87). When following this procedure, we do not recommend using melatonin for more than the first two mornings as the worker may run the risk of administering melatonin in the advance phase of the response curve for melatonin (81). It is also recommended that the bedroom should be shielded from day light (eg, by dark curtains) (85). In shift work studies of the offshore oil industry, bright light and melatonin have been used in order to hasten adaptation to night work (81, 88). Still, more studies are needed concerning bright light and melatonin as remedies for adaptation to night work, in particular in natural contexts and with long-term follow-up.

Bright light & melatonin: improving readaptation to a daytime schedule following long-term night work

Bright light and melatonin can be used for readaptation to a daytime schedule among workers who have adapted to night work (eg, who have worked at least 5–7 consecutive night shifts). Readaptation can be done either by "phase-advancing" or "phase-delaying" the circadian rhythm (81). In order to phase-advance the circadian rhythm, the worker should take melatonin about 5 hours before he/she falls asleep on the first day off (ie, if sleeping from 08.00 hours, melatonin should be taken at 03.00 hours). The worker should get up 1–2 hours earlier than the rise time at the end of the night shift working period and expose him or herself to bright light (10 000 lux) for 30–45 minutes. The next days, the procedure should be repeated but the timing of melatonin administration, sleep, and bright light exposure should be advanced by 1 hour per day (85). In order to phase-delay the circadian rhythm, on the first day, the worker should expose him or herself to light about 3–4 hours before the habitual time of awakening. On the following days, the time for sleep and light exposure should be delayed by 2 hours every day (81, 88).

In sum, there is evidence that correctly timed bright light exposure and melatonin administration can significantly hasten adaptation to night work and readaptation to a daytime schedule. In line with previous recommendations for phase-advance/delay (89, 90), we suggest that the worker readapts by phase-advancing the circadian rhythm if his or her final wake up time following the night shift period is delayed by ≤8 hours compared to the habitual wake-up time on non-working days (81). When the delay is ≥12 hours, we recommend a phase-delay approach. When the delay is between 9–11 hours, it seems that some individuals spontaneously phase-advance, while others spontaneously phase-delay their circadian rhythms (91). Hence, it is difficult to make specific recommendations in these cases. The worker may attempt to advance and delay, respectively, following two night shift periods and adhere to the direction of entrainment that seems most practical and provides the best and fastest readaptation.

Bright light & melatonin: readaptation to a daytime schedule following short-term night work

Normally, in cases of ≤3 consecutive night shifts, it is not recommended to delay the sleep–wake rhythm to improve adaptation to short-term night work because time for readaptation to a daytime schedule will be prolonged (60). Still, the circadian rhythm often becomes somewhat delayed following a few days of night shift. This is probably due to a lack of natural light exposure in the phase-advance portion (normally in the morning) of the phase-response curve for light as the night worker is usually asleep at this time. In addition, the night worker naturally obtains light exposure in the evening or at night, which comprises the phase-delay portion of the response curve (81). Studies have, for example, shown that a late bedtime combined with a fixed wake-up time delay the human dim light melatonin rhythm (92). The same has been shown for a fixed bedtime combined with a late wake-up time (93). Expecting a 2–3 hour delay in the circadian rhythm following 3 consecutive night shifts, it would be advisable for the worker to be exposed to bright light immediately upon awakening. This procedure could be supplemented with melatonin taken 12 hours earlier. The melatonin and light exposure could then be advanced by 1 hour the next two nights if necessary (81).

General comments on the use of bright light therapy

Bright light therapy is generally associated with mild and normally transient side effects. The most common side effects are headache, eyestrain, feeling wired, and irritability. In some rare cases, light therapy may cause hypomania. Persons using photosensitizing medications should avoid light therapy (94). Opththalmologic evaluations have shown no damage to the eyes of long-term light therapy (95). Still, for subjects with eye diseases, we recommend light therapy only after consultation with an ophthalmologist. Studies have shown that circadian phase shifts in humans are most sensitive to short-wavelength light (eg, blue light) (96). Some manufacturers promote blue-light devices, but due to safety concerns, some experts argue against such devices and suggest using broad-spectrum white illumination (94). In addition to the phase-shift effects, bright light can have an immediate, although normally transient, activating, and alerting effect (97). Hence, we recommend against the use of light therapy 30 minutes prior to bedtime.

It is well-documented that bright light suppresses melatonin (98). Melatonin has been shown to suppress estrogens, hence when working at night with light exposure the melatonin production is suppressed and estrogen levels may increase (99). Elevated levels of estrogen may induce hormone sensitive tumors in the breast, on which melatonin may have an additional oncostatic effect (100). Therefore, it has been hypothesized that exposure to bright light during the night may elevate the risk of breast cancer (101). Although this hypothesis has not been well documented, it cannot be ruled out that light exposure during the night may increase the risk for breast cancer. This should be taken into consideration in terms of long-term bright light exposure during night shifts.

Sleep medication

Due to the fact that daytime sleep following night shifts is often shorter than preferred, some night workers use hypnotics in order to obtain sleep of longer duration. Several simulation studies of shift work have shown increased daytime sleep following administration of hypnotics such as triazolam, zopiclone, flunitrazepam, estazolam, and temazepam in the morning (102–107), but findings regarding alertness or performance-enhancing effects on the following night shift are more equivocal. Some studies have reported no improvement (104, 108) while others have noted improved alertness and performance (102, 105, 106). In one study of actual night workers, triazolam was found to increase daytime sleep, but unfortunately sleepiness or performance during the night work was not examined (109). In a simulation study of very early morning shifts, zolpidem was found to be helpful in initiating sleep relatively early on the preceding evening (110). One problem with all of these medication studies is that they investigated outcome over a very short timespan. Hence, there has been some debate whether hypnotics in general may be advisable as an aid for night workers. Most researchers would not recommend the continuous use of hypnotics, but some are more positive about their intermittent use (111). Problems such as tolerance and dependency may arise from continuous and long-term use of hypnotics (112).

Naps

As naps counteract many of the performance impairments caused by sleep deprivation and long working hours, napping has been suggested as a mean for sustaining performance when working at night (113). Several studies have shown that naps increase performance on objective measures of sleepiness such as vigilance and time reaction tests (114–117). Studies on the effects of naps during night work have also shown improvement on measures of subjective sleepiness (114, 116, 118–120). However, other studies have shown that the effects of naps on night shifts have been small and inconsistent (121, 122). The practice of napping on the night shift may also represent some problems as there is not always an opportunity to nap. There is also a risk that the subsequent daytime sleep will be impaired, especially if the nap on the night shift lasts for too long (116). In addition, when waking from a nap, the worker may be in a state of "sleep inertia" which is a transitional state of lowered arousal occurring immediately after awakening from sleep. This inertia produces a temporary decrement in subsequent performance and is probably most intense when the person awakens at a time near the circadian trough (123). Short naps (<15 minutes) are associated with a small risk for subsequent sleep inertia (124). Overall, the majority of evidence suggests the positive effects of naps on the night shift, both in terms of subjective sleepiness and performance. Based on a meta-analysis, a simple mathematical formula has been generated that can be used to calculate how long a nap should last in order to sustain performance for a specific period of time (125).

Use of stimulants

Several central nervous system stimulants have been shown to counteract sleepiness and improve performance during sleep loss (126). By far, the most commonly used stimulant is caffeine. It blocks the adenosine receptors and thereby stops the sleep-inducing effects that adenosine seems to have as it accumulates in the basal forebrain during sustained wakefulness (127). Several studies have confirmed that caffeine can prevent impairment in functioning due to sleep loss on night shifts (128). Normally a dose of 2–4 mg/kg in the beginning of the night shift is recommended (71). Large doses of caffeine near the end of the night shift should be avoided as it has been shown that caffeine disrupts daytime more than nocturnal sleep (129). Amphetamine and its derivates work as dopamine- and noradrenalin-agonists. These two neurotransmitters are central for promoting wakefulness. Studies have shown that they counteract performance impairment caused by sleep deprivation (130). However, due to the unfavorable side effects and the potential for misuse/liability, neither amphetamine nor its derivates can be recommended as countermeasures for performance impairment associated with night work (126). Modafinil is a relatively new wake-promoting agent. It probably interacts with many wake- and sleep-promoting neurochemicals in the brain, such as dopamine, noradrenaline, serotonin, glutamate, gamma-aminobutyric acid (GABA), orexin, and histamine (131). Several studies have shown that modafinil improves performance among sleep-deprived subjects (132) and reverses the negative effects of night work on performance (133). The side-effect profile of modafinil is more benign than that of amphetamines, and the abuse potential is lower (131). It is normally used in doses of 200–400 mg. As studies (134, 135) have shown that modafinil can improve alertness and performance in subjects with shift work disorder (characterized by insomnia or sleepiness due to a working schedule that overlaps with the normal time for sleep), it has been suggested as a drug to be prescribed for this condition (136). In one of the shift work disorder studies where modafinil was administered, the participants still had worrisome high levels of sleepiness (135). The use of modafinil for this disorder is controversial and modafinil is not indicated for use in such cases in many countries. It has also been emphasized that the introduction of a diagnosis, such as shift work disorder, may represent pathologization of a normal reaction to an abnormal or unhealthy work environment. Obviously, there are ethical implications involved when shifting the focus of the problem from the working environment to the individual (137). Since modafinil is a relatively new medication one should exercise caution concerning the long-term prescription thereof. In sum, although several psychostimulants exist that may improve alertness during night work, there is still not enough evidence to recommend strongly their routine use, with the exception of caffeine, as a means of counteracting sleepiness and impaired performance associated with night work.

Physical exercise

In general, physical exercise has been found to result in moderate improvements of several sleep parameters (138). Exercise can be recommended for shift workers. Physical exercise may reduce the levels of biomarkers for cancer risk (139, 140) and prevent cardiovascular diseases (140). Studies also indicate that physical exercise can cause phase-advances and delays. In one study, where exercise took place ≥4–5 hours around nadir for the core body temperature, phase-delays of the thyrotropin and melatonin rhythms were found. The largest delays were found when the exercise was done early in the morning (141). In another study where melatonin offset was used as the circadian marker, only exercise in the evening (starting at 18:24 hours) was associated with phase-advance, whereas nocturnal (starting at 00:33 hours), morning (starting at 09:36 hours), and afternoon (starting 12:56 hours) exercise, were all associated with phase-delays (142). Based on such studies, a phase-response curve to exercise in humans has been constructed indicating " … phase-advancing effects of exercise in the evening and a phase-delaying effect of exercise during most of the usual sleep period, extending into the morning and possibly in the afternoon as well" (143). Hence, appropriately timed physical exercise may be used to adapt to night work and readapt to a daytime schedule. In one experimental study, physical exercise was prescribed as an intervention for female 3-shift workers. The exercise group performed 2–6 training sessions per week for 4 months, whereas the control group exercised <2 sessions per week. At the end of the experiment, the intervention group had increased their physical performance on several parameters. Their alertness and short term-memory during the night shift had increased relative to the control group. The intervention also seemed to have positive effects on several somatic health complaints (144, 145). Overall, physical exercise in general seems to be a recommended activity for night workers.

Sleepiness-detection devices

In terms of safety and accident prevention, detection of sleepiness/drowsiness is pivotal. This is particularly warranted within the transport sector where night work is common (3). It is estimated that as much as 20% of traffic accidents are sleep/sleepiness-related (146). In general, sleepiness can be measured and characterized in different ways. EEG can be used to detect changes (such as alpha and theta power density) indicative of sleepiness (147). However, EEG measures are not practical in real work settings. Sleepiness can also be detected by performance tests, such as the Psychomotor Vigilance Test (148). However, the use of such tests implies interruptions of the ongoing activity and is therefore difficult to implement (149). Subjective measures of sleepiness are also an option, however studies have shown that subjects may have a tendency to underestimate their own sleepiness in terms of impairment potential in operational settings (150). So far, the most promising, non-invasive measures of sleepiness are based on oculomotoric measures. Studies have, for instance, consistently shown that the number and duration of eye blinks increase and the distance between upper and lower eyelid decreases with increased sleepiness (149). In addition, saccadic movements (149), pupillometric parameters (151), and posture (152) have all been found to be related to sleepiness. However, measures based on the abovementioned parameters are, to date, not really well established, although they have been tested within the transportation sector (153). Ongoing research within this field may result in more and better real-time devices that detect sleepiness in a reliable, non-invasive manner, which can be applied in a wide area of settings (154). In addition to these oculomotoric measures, sleepiness-detection devices based upon steering analysis/lane departure warning systems (155) and speech analysis (156) have also showed promising results.

Other countermeasures

As the risk of accidents increases with the length of the shift, ideally the shifts should be as short as possible. If long shifts (such as 12 hours) are necessary, frequent breaks should be incorporated in the work schedule (67). Stimuli such as social interaction, job variation, physical activity (such as standing or walking), and exposure to sound and light may increase alertness. From research on sleep deprivation, it is fairly well documented that such interventions counteract sleepiness (157–160), although more research is needed in order to establish the usefulness of such interventions as countermeasures to the negative effects of night work. High temperatures should be avoided as these may reduce alertness. Good ventilation may also be important as high levels of CO and CO_2 can induce sleepiness (71). As sound sleep prior to night work is vital for sustained performance, the sleeping conditions should be good. As a result, shift workers should receive sleep hygiene advice (161). For shift workers who experience that shift work interferes with domestic life, family counseling may be used (162). As night work is associated with several health problems, night workers should undergo health assessments at regular intervals. It is also recommended that management or those responsible for the working schedule are familiar with basic circadian principles (163).

Discussion

Research has brought us a long way in identifying the negative impacts of shift work and possible coping mechanisms. There is some evidence to suggest that countermeasures (such as forward shift work rotation, naps, stimulants, bright light therapy, and breaks) may reduce the risk of accidents, and consequently improve safety and performance during night shifts. However, many issues still remain unsolved. This pertains in particular to the question of how one should eliminate or reduce the possible long-term health consequences of night work. Since research on humans may pose both practical and ethical restrictions, the use of animal models for shift and night work should be considered as an important supplement to research with human subjects (164). In addition, there are currently several methodological challenges that future research should take into consideration. Night and shift work have been defined in different ways in different studies, making it difficult to compare results. Thus one should strive for consensus regarding these definitions. Studies measuring biological parameters should also take into account the point in time of measurement as many biological parameters show circadian variation. In addition, it is recommended that the scientific community use common measures of the amount of shift work exposure. One major potential problem in shift work research is denoted as the "healthy worker effect", which points to a series of selection factors (both in and out of shift work) that are assumed to result in better health (at least initially) in the population of shift compared to day workers. Hence, many of the cross-sectional studies comparing the health of shift with day workers may actually underestimate the detrimental effects of shift work on health. Longitudinal designs may partly correct for this bias. More research using this approach is necessary in order to identify work and individual factors that may be related to differential health outcomes of shift and night work. As many shift work studies are based on simulation, future studies should also aim to investigate the effects of shift work and related countermeasures in real-time settings and among different shift work populations (165).

General recommendations

In sum, persons with illnesses that make them vulnerable to the negative effects of night work should not be recruited to such work. In terms of work scheduling, forward should be favored over backward rotation. Breaks may lower the risk of accidents, especially on long shifts. Bright light and melatonin may hasten adaptation to long-term night work, but are not recommended for shorter periods of night work. Still, these measures may be used to help readapt the circadian rhythm following night work periods, also when these last only a few days. Sleep medications may improve daytime sleep. A short nap, if feasible, in the beginning of the night shift is recommended for improving alertness. Caffeine in the beginning of the night shift may help sustain performance. Due to the potential negative health consequences of shift work, exercise is recommended as a countermeasure. In order to sustain attention and alertness, the night shift environment should be stimulating in terms of work variation, social interaction, and physical activity.

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