

Circadian Adaptation to Shift Work

Quick Facts:

Circadian rhythms such as the sleep-wake cycle are synchronized with 24-hour periodicity by environmental factors such as the light-dark cycle, timing of meals and physical activity. In people who perform shift work, a misalignment of the endogenous circadian rhythm (“intrinsic pacemaker” or “master clock”) with the work schedule can occur. In the U.S., more than 21 million workers usually work alternate shifts that fall at least partially outside the daytime shift range. Of them, 3.1 percent work nightshift and 2.7 percent work rotating shifts.

Timing of shifts and shift schedule changes may significantly affect sleep in a subset of workers. Compared to those on fixed daytime or nighttime shifts, those on rotating shifts may experience significantly more difficulty sleeping, including a longer sleep latency, increased night time awakenings, excessive sleepiness, higher work absenteeism, and more work-related accidents.

Chronic partial sleep deprivation may also result from working a shift work schedule. Night shift workers usually sleep 1 to 4 hours less than daytime workers. This leads to impaired social and cognitive function, as well as pathological sleepiness with safety and health hazards.

Vulnerability to sleep disturbances varies between individuals, and is also dependent on the shift type, the pattern and constancy of the shift schedule, an individual’s age and circadian preference, and one’s susceptibility to sleep disturbance. For example, since it is easier to delay circadian rhythms rather than advance them, clockwise (e.g. day -> evening -> night) shift rotations are easier to adjust to compared to counter-clockwise (e.g. night -> evening -> day) shift rotations. Another example is that individuals who are “night owls” find it easier to adapt to night shifts compared to the “morning larks”. And while older shift workers (ages 53 - 59 years) appear to adapt better to acute sleep deprivation initially compared to younger workers (ages 19 - 29 years), they show a reduced capacity of circadian adaptation when exposed to consecutive night shifts and are more sleepy than younger workers.

Sleepiness and fatigue related to rapid shift changes (i.e. “night float”) are prevalent in medical trainees and the magnitude of this problem is underestimated. According to Folkhard et al., Grantcharov et al., and Friedman et al., there was an 18 percent increase in human error incidents in afternoon shifts relative to morning shifts, and a 30 percent increase in human error incidents on night shifts relative to morning shifts. Post call surgery residents made 20 percent more errors and required 14 percent more time to perform simulated laparoscopy. In sleep deprived internal medicine interns the efficiency and accuracy of EKG interpretation was impaired.



Who is at Risk?

- *Night shift and rotating shift workers.* Tolerance of circadian misalignment and sleep deprivation varies among individuals.
- *Older workers* are more at risk compared to younger workers. “Morning larks” are more susceptible to sleep disturbances with night shift work compared to those with late evening preferences (“night owls”).
- *Counter-clockwise shift rotations* (night-> evening-> day) are more at risk compared to clockwise shift rotations (day-> evening-> night).

Why It Matters

Relative to non-shift work control subjects, shift workers experience more:

- *Sleep-related complaints:* increased sleep loss, excessive sleepiness, and insomnia.
- *Medical complications:* increased risk for obesity, metabolic disorders, cardiovascular disease such as cerebrovascular events and gastrointestinal complaints, poor sexual health and multiple forms of cancer.
- *Psychiatric disorders:* depression, anxiety and alcohol abuse.
- *Neurophysiologic function:* altered attention and memory function (impaired neurocognitive performance) which may increase the risk of human errors at work and motor vehicle crashes.

What You Can Do

- **Recognize that shift work is a necessity** for certain occupations, and understand the risks associated with chronic partial sleep deprivation associated with shift work. Ask your patients about their work schedule.
- Whenever possible, recommend a **clockwise** (day-> evening-> night) **rotational schedule**. Limit night shifts to blocks of three, limit shift duration to eight hours and allow three days of recuperation after night shifts (see Table 1 for an example). For rapidly changing shifts, recommend that the new shift starts and ends with a day(s) off. Use these day(s) to gradually adjust to the new shift. If the shift work schedule is fixed (non-rotational), keep the same schedule on work days and off days.
- Recommend **7 to 8 hours of sleep** as baseline. A sleep diary is likely to be more reliable than data from wearable devices.
- Recommend **protecting sleep times**. Block outside noise during daytime sleep by using fans, white noise machines, or ear plugs; sleep in darkened rooms or wear an eye mask. Avoid sleep disruptions: turn off the phone ringer, disconnect the doorbell or put up a "Do Not Disturb" sign. Turn off any electronics at least one hour before bed. Bed partner and family should be aware of the work schedule to keep a home environment conducive to sleep.
- Recommend **regular exercise and avoidance of excess alcohol and excess caffeine** intake.
- Recommend **structured naps** to improve alertness. Naps can be preventative (pre-shift) or operational (during the shift). Operational naps should be short (no longer than 30 minutes) to prevent sleep inertia. If possible, naps could be strategically timed to coincide with the periods of increased sleepiness (2 to 5 a.m. and 2 to 5 p.m.). Use a sleep diary and a timer to experimentally determine the optimal timing of a preventative nap.
- Low doses of **caffeine** (4 mg/kg, with 1 cup coffee=100 mg of caffeine) administered at 12:20 a.m. and 1:20 a.m. have been shown to reduce sleepiness on the night shift, enhance performance during the first two nights of a block of night shifts, and not disrupt daytime sleep. Avoid using caffeine in the second half of the shift, so that it does not disrupt sleep initiation in the morning.
- **Specific circadian phase shifting maneuvers** may be required for some individuals. In these cases, due to the complexity of appropriate timing and dosing of interventions and medications, **referral to a Sleep Medicine Specialist** is strongly recommended. These maneuvers include:
 - **Bright light therapy:** appropriately timed exposure to artificial bright light may shift circadian rhythms to facilitate sleeping during the day and promote alertness at night. Recommend wearing sunglasses on the ride back home.
 - **Medications:** Melatonin can be used to shift circadian rhythms when appropriately timed and dosed. Modafinil is a stimulant that is FDA-approved to help with alertness during shift work. And finally, judicious use of hypnotics may be considered in some individuals to consolidate off-cycle sleep.

SCHEDULE	SLEEP TIME
Evening Shift (5 p.m. — 1 a.m.)	3 a.m. — 11 a.m.
Night 1 of Transition	5 a.m. — 1 p.m.
Night 2 of Transition	7 a.m. — 3 p.m.
Night 3 of Transition	8 a.m. — 4 p.m.
Night Shift (11 p.m. — 7 a.m.)	9 a.m. — 5 p.m.

Table 1. Example of adjustment from the evening to the night shift.

Patient Information Websites:

- <https://www.sleepfoundation.org/shift-work/content/what-shift-work>
- <https://www.cdc.gov/niosh/topics/workschedules/default.html>
- <http://sleepeducation.org/essentials-in-sleep/shift-work>

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