Occupational Medicine Forum

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What Are the Benefits of Using Circadian Principles When Scheduling Shift Work?

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Shift work, defined as work performed primarily outside typical daytime hours, includes evening shifts, rotating shifts, irregular shifts, extended-duty shifts, and flextime. Shift workers do not follow the conventional pattern of human behavior, where activity is highest in the day and evening hours. Shift work, an integral part of life for much of the working population, continues to affect a growing proportion of workers.[1] Almost 15% of full-time wage and salary workers work variable shifts. One quarter of couples employed full time include at least one spouse who works a non-day schedule. The prevalence of shift work is greatest among workers in protective services and food services.[2] However, many other occupations are affected including health care workers, commercial motor vehicle drivers, miners, air traffic controllers, and utilities workers.

Shift workers obtain less sleep than day workers as daytime sleep is generally shorter than nocturnal sleep. Daytime sleep of night workers is affected by social and environmental factors such as street noise, lighting of the sleep area, social and family activities planned during the day time, ringing telephone, and children playing, and tends to be lighter, more fragmented, and less restful than sleep at night. The effects of mild sleep deprivation appear to be cumulative. One night of reduced sleep may not lead to great impairment in alertness, but the level of fatigue increases each night.[1]

The two general states of sleep are rapid eye movement (REM) and non-REM sleep. Non-REM sleep is subdivided into 4 stages. Each cycle of REM and non-REM sleep lasts 90 to 120 minutes. Stage 1 sleep, the initial part of any sleep episode, lasts 10 to 15 minutes. It is the lightest stage of sleep and most research subjects will deny having been asleep if awakened during this period. Stage 1 sleep is the transition from wakefulness to deeper sleep. Stage 2 sleep accounts for the largest percent of sleep (40% to 50%). Attempts to selectively deprive research subjects of stage 2 sleep may lead to total sleep loss as one needs to go through stage 2 sleep to enter the other stages of sleep. Stages 3 and 4, also called slow-wave sleep (SWS), are considered deep sleep stages. Deep muscle tone is variable and arousal is difficult. SWS is considered important to bodily repair and to the restoration of alertness and energy. It is made up most consistently after sleep deprivation. The first period of REM sleep occurs after 1 to 2 hours of sleep. Most restorative sleep and dreaming occur during this stage. REM sleep is considered important for psychological adjustment and development. The quality and quantity of sleep change with aging. Older people have less SWS, more frequent awakenings, overall decreased sleep time, and an increase in light sleep.[3]

The sleep-wake rhythm naturally cycles 25 hours, in isolation. Endogenous and exogenous mechanisms synchronize the 25-hour circadian rhythms to the 24-hour rotation of the earth. The endogenous component is regulated by an internal clock, located in the suprachiasmatic nucleus of the hypothalamus. This internal clock is also referred to as the master circadian pacemaker or the biological clock. The exogenous component consists of external cues, called zeitgebers. The light or dark cycle is one of the most powerful zeitgebers. Timing of meals, social interactions, and clock time are other external cues. Humans adapt over a normal range of 23.5 to 26.5 hours to resynchronize the rhythm, by phase advancing 0.5 hours or by phase delaying 2.5 hours, depending on environmental cues. Exposure to shift work, jetlag, and short winter days can lead to disruption of the circadian clock.[1,4]

When subjects are deprived of cues in the experimental setting, the internal clock is disturbed and a state without synchronization (desynchronosis) results. Recovery requires realignment with light or dark cues of the earth's rotation, a process called entrainment. However, as different physiologies entrain at different

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rates, they may lose their normal phase relationships to one another. Physiologic and performance parameters that follow circadian cycles, fluctuating with a period of 24-hours, include sleep or wakefulness, core body temperature, hormone and gastric secretion, bronchial reactivity, heart rate and blood pressure, short-term memory, eating habits, and family interactions. Diseases with intrinsic circadian variation include asthma, insulin-dependent diabetes, and seizure disorder.[1]

The circadian clock seems to potentiate wakefulness at certain times of the day. Sleep is more difficult to achieve during the late afternoon and early evening period even if the individual is severely sleep deprived, a period referred to as the "forbidden zone."[5] This may be one of the reasons that daytime sleep may be more difficult to achieve than sleep at night. Midnight to 7 AM is referred to as the nighttime period of increased sleepiness.[6]

Shift work is an occupational stressor, and has been linked to various social, psychological, and medical problems. Shift work interferes with family and social life. A major complaint among shift workers is a reduction in the quality and quantity of sleep. Shift workers face insufficient sleep as well as circadian dysrhythmia. Gastrointestinal complaints such as loss of appetite, constipation, dyspepsia, and abdominal pain have been reported to be more common in shift workers. Some of the reasons postulated for gastrointestinal complaints are that food available to night-shift workers is often of poor quality, that shift workers may be more likely to eat at irregular times with meals out of phase with their internal body clocks, and that they consume more caffeine, alcohol, and tobacco in an effort to regulate their sleep or wake cycles. Shift work has been associated with a higher incidence of cardiovascular disease has also been linked to adverse reproductive outcomes. Psychological disturbance such as despondency and depression have been reported to be more common in shift workers.[1]

Epidemiological studies have linked shift work to increased rates of cancer, including breast and endometrial cancer, since the 1980s. This is felt to be due, in part, to the reduced production of melatonin that occurs when individuals are exposed to light at night for prolonged periods of time.[1] Based on increasing evidence in this regard, the International Agency for Research on Cancer (IARC) classified shift work as a group 2A carcinogen (probably carcinogenic to humans) in November 2007.

Although many people are able to tolerate shift work with few or transient problems, some individuals are unable to adjust and may be labeled as problem employees. This is referred to as shift work intolerance. A history of preexisting sleep problems may worsen the prognosis for adaptation to shift work. Tolerance to shift work declines with advancing age. It has been suggested that medical restriction from shift work should be considered in workers with unstable angina, severe irritable bowel syndrome, and chronic depression, and that shift workers with conditions such as mild asthma, insomnia, age older than 40 years, cardiac risk factors, history of depression, history of seizures, frequent indigestion, and excessive family responsibilities be counseled and advised on coping strategies.[1]

Various agents, such as caffeine, alcohol and sedative-hypnotic drugs, can alter the sleep architecture. Caffeine may lead to dyspepsia and results in more rapid than usual cycling between the stages. Alcohol may lead to frequent awakenings leading to interrupted sleep, and it suppresses REM sleep. Sleep medications are potentially addictive and cannot reset the biological clock. Sedative-hypnotics increase sleep time by increasing stage 2 sleep, but this may not be restorative sleep. Stage 2 sleep is the least likely to be made up after periods of sleep deprivation.[3] Modafinil is approved to improve wakefulness in patients with excessive daytime sleepiness associated with narcolepsy and shift work sleep disorder (SWSD), and as adjunctive therapy for obstructive sleep apnea or hypopnea syndrome.

Fatigue resulting from shift work, whether from lack of sufficient sleep, circadian dysrhythmia or both, has been associated with increased rates of accident and injury at work, sometimes resulting in fatalities. Accidents at Three Mile Island, Bhopal, and Chernobyl, as well as the Exxon-Valdez oil spill, each occurred between midnight and 4 AM. An increase in error rates has been seen in workers from several occupational groups exposed to shift work, truck drivers, air traffic controllers, fast food employees, boaters, train engineers, brakemen, night shift nurses, medical residents and interns, and emergency physicians among them.[5,7] Research suggests that long working hours in some health care workers may be associated with an increased risk of sustaining body fluid exposures.[8] Increased accident rates have been reported in shift workers traveling to and from work.[5] "Maggie's Law," a New Jersey statute signed in 2003 addresses the issue of driving while fatigued and views vehicular homicide committed by fatigued drivers as criminal homicide. Fatigue is defined as being without sleep for more than 24 consecutive hours.

In designing shift work schedules, one should consider daily sleep requirements and circadian principles in an effort to minimize the negative effects of circadian dysrhythmia. Adequate, quality, flexible time off should be built in, allowing workers the opportunity to achieve sufficient quality and quantity of sleep, as well as carry out family and social obligations. The American College of Emergency Physicians Practice Committee (in their policy statement: "Emergency physicians and shift work") and the National Institute for Occupational Safety and Health have published guidelines on

shift work. Some factors to consider when scheduling based on these guidelines are:

- Design schedules to phase delay or shift clockwise even if there are intervening days off, placing less strain on the adaptive ability of the internal clock.
- Schedule night shifts as single nights when possible.
- Keep consecutive night shifts to a minimum.
- Avoid overly long shifts; shifts should last 12 hours or less (8 to 10 hour shifts may be preferable).
- Provide adequate rest periods (schedule at least 24 hours off) and days off between shifts.
- Keep long work shifts and overtime to a minimum.
- Plan some free weekends to help worker meet family and social responsibilities.
- Avoid quick shift changes.
- Avoid several days of work followed by 4 to 7 days mini-vacations.
- Schedule shifts in a manner to acknowledge work responsibilities and adequate staffing at night.
- Avoid doing the heaviest or more dangerous work in early morning hours.
- Minimize daytime responsibilities for night-shift workers to avoid worsening sleep deprivation and further disrupting entrainment.
- Consider incentives for those who work primarily night shifts.
- Use individualization of schedules and employee input to help workers meet daily and social responsibilities.
- Educate shift workers regarding the use of alcohol and sedative hypnotics as sleeping aids.[1]

Shift work may be considered a necessary part of the twenty-first century. Nevertheless, it has ramifications for employee health, safety, and productivity. Work schedules constructed to reflect worker preference and variability and minimize circadian disruption may result in improved worker health and well-being, as well as in decreased injury and accident rates. Considering these factors when scheduling, should help mitigate the negative consequences of shift work, with resultant benefits to both employees and employers.

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