EMBJ.ORG FOR YOUNG DOCTORS

EUROMEDITERRANEAN BIOMEDICAL JOURNAL
2023,18 (6) 30-33
(*FORMERLY: CAPSULA EBURNEA*)

Review

SHIFT WORK AND ALTERED SLEEP: A COMPLEX AND JOINT INTERACTION BETWEEN NEUROLOGICAL AND OCCUPATIONAL MEDICINE

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ARTICLE INFO

Article history:
Received 10 Jan 2023
Accepted 27 Feb 2023
Published 20 Mar 2023

Keywords:
Shift work, sleep disease, occupational injuries, medicolegal implication, psychoactive substances abuse.

ABSTRACT

Shift work, including the early start of work, compressed working weeks with 12-hour shifts and night work, especially if prolonged over many years, alters the normal sleep-wake pattern, causing short sleep with reduced quality, daytime dysfunction, and sleepiness. Recently, the effects of shift work on sleep have been investigated more consistently and many studies have supported the existence of an association between shift work and insufficient sleep and many chronic diseases, such as coronary artery disease, stroke, obesity, type 2 diabetes, breast, prostate, and colorectal cancer. In addition, occupational injuries have also been associated with the negative effects of shift work on sleep. However, future studies are still needed to definitively identify shift work as a causal factor of chronic health dysfunctions, which, inevitably, have repercussions on the work activity as a risk factor in the performance of the same. Considering the small number of studies, it is recommended that future research focus on reducing this knowledge gap.

1. Introduction

Sleep is a complex and cyclic behavioral state characterized by a reduction in motor activity, a decreased sensitivity to external stimuli, and stereotypic posture and, unlike other states of altered consciousness, such as coma and anesthesia, is rapidly reversible and self-regulating.[1] Sleep is subdivided in two different behavioral states: non-rapid eye movement (NREM) sleep and rapid eye movement (REM) sleep. In general, the state transition from wake to sleep is characterized by significant changes in the cortical electroencephalogram (EEG) from the desynchronized high-frequency, low-amplitude waves typical of wakefulness. Indeed, at the onset of NREM sleep, the EEG frequency slows, and EEG waves become larger in amplitude, reflecting increased cortical synchrony. NREM sleep is composed of three stages: drowsiness (N1), light sleep (N2), and deep sleep (N3).[1] On the other hand, REM sleep is characterized by activation of the cortical EEG (similarly to wakefulness), rapid eye movements (REMs), skeletal muscle atonia, and often dreaming.[1] REM sleep cycles periodically with NREM sleep, approximately every 90 minutes.

From a physiologic point of view, sleep and wakefulness are regulated by mutually inhibitory populations of neurons in many brain areas, such as the hypothalamus and brainstem, thus generating stability in behavioral state and facilitating rapid switching between sleep and wakefulness. Although the entire neural circuitry underlying the regulation of sleep-wake states is still puzzling, many specific interconnected neuronal pathways, neurotransmitters, and receptors have been identified and these are now the target of pharmaceutical intervention for the treatment of sleep-wake disorders.

The neurobiological bases of "sleep drive" are still unknown, either. However, it has been hypothesized that there exists a complex mechanism characterized by the interplay of an homeostatic pressure, that builds during the waking period and is dissipated by sleep[2], with a putative endogenous somnogen, adenosine (AD), thought to play a critical role, and the circadian timing system which provides temporal organization for virtually all physiologic, neurobiologic, and biochemical processes, including sleep.

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DOI: 10.3269/1970-5492.2023.18.6
 ISSN: 2279-7165 - Available on-line at www.embj.org

The circadian regulation of sleep is ensured by signals originating from the suprachiasmatic nucleus and communicated to the periphery via synaptic and humoral mechanisms to generate circadian rhythms.

Among these, melatonin is a hormone produced by the pineal gland that is suggested to play a fundamental role in sleep-wake regulation.[4]

Although a unified theory of sleep function has not been established, it has been clearly demonstrated that sleep deprivation produces deleterious cognitive and physiologic consequences, thus supporting a restorative effect of sleep for the brain and body.

Recently, increasing evidence suggest that these harmful consequences could be particularly emphasized in shift workers.

Shift work indicates work time arrangements outside of conventional daytime hours (from 6 am to 6 pm), including fixed early morning, evening, and night work, as well as roster work and rotating three shift work, in which workers rotate between a day, an evening, and a night shift. It has been reported that shift work is evenly diffused in Western countries ranging from 20 to 30% of workers,[1] and many of these work nights, at least once a month.[4,] Because of its intrinsic nature, shift work forcefully disrupts the normal sleep-wake cycle, leading to short sleep, poor sleep quality, excessive fatigue, and reduced well-being[5]. It has also been reported that shift work may affect long term health and safety, with several studies reporting elevated risks for different chronic health disorders,[6] probably because insufficient sleep may produce adverse cardiometabolic changes, cognitive impairment, thus increasing the risk for chronic diseases[7, 8] and repercussions in the performance of work activities[9].

2. Shift work reflections on sleep

The relationship between shift work and reduced sleep quality is well established (Figure 1).[8, 10] Night work and early morning work are those more affected, and about 20%-30% of shift workers report insufficient sleep and excessive sleepiness in relation to night and early morning work.[5] In line with these concepts, a recent systematic review reported a 16% increased risk for shift workers to develop chronic sleep disturbances, such as insomnia symptoms [9].

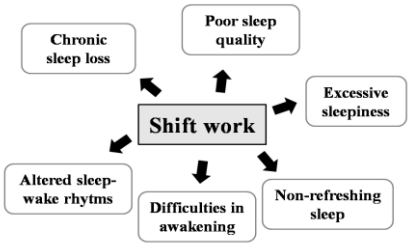

Figure 1. Negative effects of shift work on sleep.

In addition, a systematic review on sleep in shift work in the offshore petroleum industry found that shift workers reported more sleep problems than day workers did.[11] When the sleep-wake disturbances become chronic (that is, lasting for more than three months), it is possible to diagnose a "shift work sleep disorder" (SWD), which is a clinical circadian rhythm sleep disorder according to the international classification of sleep disorders,[12] with a prevalence of 10-23% in rotating shift and night shift workers,[5] and further increased prevalence in those with more night shifts[13] and global stress condition during waking hours[14].

As stated, circadian effects of shift work highly impact on subjective sleep quality, and sleep episodes that end close to the circadian trough (that is, before starting early morning shifts) are often perceived as non-refreshing, with difficulties in awakening.[15] On the other hand, although daytime sleep occurring after a night shift is usually reported to have short subjective sleep latency and reduced awakenings, it is often terminated prematurely after less than six hours[16] similar to that found in subjects practising sport in the evening or in the lunchtime intervals due to the alteration of circulating cortisol levels[17].

Sleep duration is also impaired by the effects of shift work[15-17] and daytime sleep after night work is frequently and significantly reduced, as well as sleep before morning shifts, particularly those with an early start time (before 6 am), or if preceded by an evening shift.

In addition, short recovery times (<11 hours) between shifts, stressful work under extreme conditions, e.g. during the pandemic, showed the occurrence of sleep disturbances even in young subjects[18].

Speed of rotation, is another characteristic of shift schedules that impacts on sleep duration, since it has been observed that slowly rotating schedules (i.e. four to seven consecutive shifts of the same type) gave a slightly longer sleep duration as compared to rapidly rotating schedules (i.e. one to three consecutive similar shifts).

Although there are no systematic reviews on sleep duration on days off in connection with shift work, a prolonged sleep period has been observed in the first day off after a spell of work shifts.[19]

Despite these findings, there is still no substantial evidence of significant chronic sleep loss among shift workers, and no difference in sleep duration over an entire shift cycle has been observed between permanent day workers and shift workers.[20] However, this field of study in shift workers is biased by subjective reports that often overestimate sleep duration and general paucity of objective assessments of sleep such as polysomnography.

3. Health consequences of shift work and poor sleep

Shift work, short sleep (defined as four to seven hours of sleep a night), and poor sleep quality are in relationship with a wide range of medical conditions and safety problems, and many studies analyzed these potential effects, although some methodological problems mitigated the generalization of many results. First of all, they have been associated with a significantly increased risk of cardiovascular and cerebrovascular disease[25], especially night shifts, although incomplete evidence exist for a definite causal relation.[19-28] Individual factors could probably be at the root of this.

Moreover, shift work, short sleep, and poor sleep quality also have a role in the development of metabolic disorders, including obesity and type 2 diabetes,[29-35] and have been associated with breast cancer, particularly long exposure to night work (>20 years), thus suggesting a dose-response relation.[36-42] Furthermore, shift work has been associated with prostate and colorectal cancer.[43-44] Other studies also show that sleep alterations affect the onset of respiratory and auditory disorders, which is probably also

related to the common increase in BMI and the sequelae of metabolic disorders on the microcirculation[45].

Finally, rotating shift work and permanent night work were associated with a 21% to 36% increased relative risk of workplace accidents, and it has been shown that car accidents are significantly increased in drives following night shifts. Occupational accidents are also associated with short sleep and poor sleep quality.

In this regard, studies conducted on groups of workers divided by shift time (day vs. night) have shown that sleep disturbance is followed by an increased susceptibility to the consumption of alcohol (with ethanol-central effects by his metabolites) and psychotropic substances, probably to compensate for the subjectively experienced disturbances during waking hours. The consumption of such substances inevitably affects the driving and attention paid when using machinery and/or structural devices in the working environment.

The corresponding significant associations between shift work and disturbed sleep support the hypothesis that short sleep or poor sleep quality (experience of insomnia symptoms) is a plausible pathway for how shift work increases the risk for adverse health outcomes and accidents.

The mechanisms linking shift work with adverse health outcomes are complex and still not fully understood. They include: behavioral mechanisms (such as altered light exposure, wrong eating patterns, insufficient sleep patterns, inadequate physical activity, smoking, and alcohol use), psychosocial stress related to work-life balance (including disruption of social rhythms, lower job control, and lower individual control over work times), physiological mechanisms (such as circadian disruption, immunologic, neuroendocrine and cardiometabolic stress, cognitive impairment), and genetic predisposition (such as polymorphisms in genes associated with homeostatic processes and circadian rhythms).

On the other hand, there is a lack of good quality intervention studies aimed at mitigating the adverse health outcomes of shift work and poor sleep, although the strongest support for improving sleep is for use of forwardly rotating schedules (day-evening-night) and allowing at least 11 hours of recovery time between shifts.

Notwithstanding this intricate framework, a better understanding of the mechanisms that link shift work and poor sleep with impaired health should be a priority objective of future research since better scheduling, precise legislation on working hours, screening plans, and effective countermeasures could be implemented in order to increase productivity, minimize workplace accidents, and improve quality of life for shift workers.

4. Conclusions

Shift work, especially when prolonged, disrupts the sleep-wake pattern, thus causing short sleep, reduced sleep quality, daytime dysfunction and fatigue. Although, there is still insufficient evidence to definitively identify shift work as a causal factor for chronic health dysfunction, many studies supported a significant role for shift work and insufficient sleep and many chronic medical conditions such as coronary heart disease, stroke, obesity, type 2 diabetes, breast, prostate, colorectum cancer, and those linked to occupational accidents. For this reason, more studies should be conducted to deeply investigate these potentials and unfavorable causal links. Moreover, since there is paucity of interventional studies on health and sleep problems in shift work, it is advisable that future research could be focused on reducing this gap of knowledge.

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