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The impact of shift work and sleep deficiency on health

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Abstract

Shift work refers to work that takes place at different hours, including at night. It is estimated that 15% to 20% of the working population works in shift work, particularly in the healthcare, energy, communication systems, public safety, and hospitality industries. Research indicates that shift work, particularly night work, can lead to health problems such as fatigue, exposure to harmful work environments, increased risk of workplace accidents, and sleep disorders. Night work is also associated with increased risk of hypertension, nervous system dysfunction, cardiovascular dysfunction. Those working at night are also more prone to hormonal disorders, digestive disorders, lowered immunity, and cancer. Sleep-wake cycle disorders, such as excessive sleepiness during waking hours and insomnia at night, are symptoms of shift work intolerance syndrome, which can occur after several months or years of shift work. It is estimated that over 20% of shift workers suffer from sleep-wake cycle disorders, and various factors such as chronotype, age, gender, family and social obligations, medications, medical and psychiatric conditions, and shift work experience can impact tolerance of shift work. The treatment of sleep and wake disorders related to shift work includes planning for main sleep and supplementary naps, appropriate exposure to light, treatment with melatonin, taking sleeping and psychostimulant medications.

Keywords :shift work, sleep deprivation, sleep disorders, sleep-wake cycle

Introduction

Shift work is characterized by changing working hours, including night work. In the Polish Labor Code, the night time is defined as a period of 8 hours between 9:00 p.m. and 7:00 a.m. A person who works at least 3 hours a day during this time or whose at least 1/4 of working time falls during the night is considered to be working at night (Art. 151 § 7 of Polish Labor Code). It is estimated that about 15-20% of the entire working population works in a shift system. This mostly applies to employees in the health care industry, energy industry, communication systems, public safety services, or hospitality. In some cases, this work is performed every day of the year as it cannot be stopped due to production technology, such as power plant and steel mill employees. They work in the "continuous shift" according to a strict shift schedule. [1] Shift work, especially night work, can lead to sleep deficit and sleep-wake rhythm disorders among workers as it clashes with the natural circadian rhythm. [2] The circadian rhythm is a 24-hour cycle of changes that occur in the body and regulate its biological processes. The 24-hour biological clock is located in the brain and is called the suprachiasmatic nucleus and it affects not only sleep and wakefulness, but also many other physiological functions such as body temperature, blood pressure, and hormone secretion, including cortisol and melatonin. [3] [4] Various external stimuli such as light, physical activity, dietary patterns, amount and quality of sleep, and social factors (such as perceived stress) affect the circadian rhythm. Exposure to shift work can cause its disturbance, have behavioral and psychological consequences, and lead to pathophysiological changes in the human body. [5]

Sleep-wake rhythm disorders and sleep deprivation and its effects on human health.

Scientific literature indicates that reduced sleep hours and circadian rhythm disturbances caused by shift work can lead to a range of health problems. [6] Numerous studies have shown that night shift workers experience greater physical and mental fatigue, are more exposed to harmful workplace factors such as chemicals, physical and biological agents, and have a higher risk of causing or being involved in workplace accidents. [7] [8] Long-term night shift work can have adverse health effects that affect many systems in the human body, such as the nervous, cardiovascular, hormonal, digestive, immune system, and lead to sleep disorders and the development of cancer. [9]

- Cardiovascular system

Night shift work is a factor that increases the risk of developing hypertension. Blood pressure is usually higher during the day than at night by about 10%. This is a physiological phenomenon. However, night work disrupts the circadian rhythm, causing blood pressure at night not to decrease. This leads to an overall increase in blood pressure values. [6] Another possible mechanism that causes hypertension in night shift workers is increased activity of the sympathetic nervous system, causing blood vessel constriction, vascular endothelial dysfunction, and increased arterial stiffness. [10] People working in the night shift have lower levels of melatonin in their bodies. Melatonin not only coordinates the work of the master biological clock but also has hypotensive and vasodilation properties. [11] [12] Therefore, people whose circadian rhythm is disrupted are more prone to heart muscle diseases, microinfarcts in the central nervous system, and strokes. [13] [14] Epidemiological studies show that shift workers have about a 40% higher risk of heart disease compared to day workers. The longer the length of service, the greater the risk. [15]

- Metabolism

Laboratory tests have shown that insufficient sleep impairs glucose metabolism, while observational studies have shown that short sleep is associated with an increased risk of type 2 diabetes. [16] [17] Laboratory and cross-sectional observational studies suggest that disturbed or shortened sleep is associated with glucose intolerance, insulin resistance, and reduced acute insulin response to glucose, predisposing to the development of type 2 diabetes. [18] Insufficient sleep and circadian rhythm disturbances can lead to problems with metabolism and weight gain. Circadian processes impact many elements of energy metabolism, such as energy expenditure, metabolic hormones, and appetite regulation. For example, growth hormone levels are greatly influenced by sleep and its peak secretion usually occurs during slow-wave sleep. Cortisol levels also depend on the circadian rhythm, with its peak occurring in the morning. The appetite-regulating hormone, ghrelin, is also dependent on sleep and wakefulness and energy intake. Energy expenditure is highest during wakefulness and lowest during sleep. Thus, when sleep and circadian rhythms are disturbed, changes can occur in energy expenditure and hormonal profiles, leading to a greater tendency towards obesity. [19]

- Reproductive system

Women with disrupted circadian rhythm due to night shift work experience menstrual cycle disturbances, fewer pregnancies and births, and longer waiting periods for pregnancy. [20] Sleeping less than 6 hours a day is associated with a 20% lower level of follicle-stimulating hormone, a main component of the reproductive system. Peak levels of this hormone, necessary for conception, occur directly before ovulation. [21] Men who sleep less have significantly lower testosterone levels, sperm count, and sperm quality, as proven by scientists at the University of Chicago. [22]

- The immune system

Night work and circadian rhythm disruptions negatively impact immune cell functions, weaken the body's natural defense against diseases, and increase the risk of inflammation. The strength of the immune response changes throughout the day, and disruption of the biological clock can lead to the development of inflammatory disease or even immune deficiency. [23] During a 6-8 hour sleep period, there is a change in the proportion between Th1 and Th2 lymphocytes. Higher values of Th1 are observed in the first hours of sleep, and in the following hours Th2. An improper amount of sleep in the first or second phase can lead to an improper ratio of these lymphocytes, increasing the risk of infection, allergy, and tissue damage. [24] More and more research suggests that biological clock genes play a crucial role in regulating cytokines before and during infection. Cytokines are proteins produced by immune cells and play a key role in the fight against infections. Thus, the

circadian rhythm, affecting cytokine production, regulates the host's ability to fight infections. [25] Circadian rhythm disruption caused by shift work negatively affects the expression of pro-inflammatory cytokine IL-6 and anti-inflammatory cytokine IL-10. [26]

- Cancer

The International Agency for Research on Cancer (IARC) in 2007 declared circadian rhythm disturbances and shift work as carcinogenic factors. [27] Clinical studies indicate that disruptions in the biological clock rhythm in the endocrine system can affect the functions of immune system cells and enhance the inflammatory response, which can lead to the development of cancer, the formation of new blood vessels (angiogenesis) that promote tumor growth, and the formation of metastases. [28] Being during the night under artificial light, particularly in the range of 460-480 nm wavelengths, has a negative impact on health by weakening melatonin secretion, which is characterized by protective antioxidant, immunomodulatory and oncostatic properties. [29] Abnormal melatonin secretion can increase the risk of developing breast gland cancer, colon cancer, and non-Hodgkin's lymphoma, as well as lead to the development of ovarian, endometrial, and prostate tumors. [28]

Shift Work Disorder (SWD)

In 1992, the International Classification of Sleep Disorders introduced a disorder called Shift Work Sleep Disorder. The symptoms of this disease can occur after several months or years of working on a shift basis and are characterized by excessive drowsiness during wakefulness and/or insomnia during night hours when sleep is desired. Under physiological conditions, the level of melatonin is low during the day and then increases in the evening to prepare the body for sleep. For shift workers, this process is disrupted during night work, leading to a negative impact on sleep and wakefulness. These individuals experience excessive drowsiness during night shifts, as melatonin is produced in larger quantities, while the lack of sleep causes a sleep deficit. Shift workers therefore catch up on sleep during the day when the natural level of melatonin is lower, so this sleep is often short and fragmented, further deepening the sleep debt. [30] It is estimated that over 20% of shift workers suffer from sleep-wake rhythm disorders. Many factors that affect shift work tolerance have been identified, such as the length of the shift and the stability of the shift schedule, as well as individual factors that include shift work experience, accompanying sleep and/or medical and psychiatric disorders, medication use, and amount of time spent in bed over the past few weeks, as well as family and social obligations. [31] There are predisposing factors for their development, such as chronotype, age, and gender. Shift workers with a "lark" chronotype, who prefer to go to bed early in the evening, are more predisposed to developing circadian rhythm disturbances than "owl" individuals who naturally go to bed later. [32] Older workers have more difficulty adapting to the demands of shift work because they generally sleep less and more often complain of insomnia. [33] The current state of knowledge does not allow a precise explanation of the neurophysiological mechanisms of this phenomenon, but they are probably related to neurodegenerative changes in the hypothalamus. [34] Women working shifts compared to men more often complain of greater sleep loss, daytime sleepiness, and psychological stress. [35]

Treatment Standards for Circadian Rhythm Sleep-Wake Disorders.

In the treatment of sleep and wake rhythm disorders associated with shift work, the following therapeutic methods are used: creating a main sleep and supplemental nap plan, exposure to light, melatonin therapy, taking sleeping pills and psychostimulants. [36]

1. Before going to work for the night shift, it's recommended to take a short nap (around 30 minutes) as it improves psychophysical efficiency and reduces the risk of accidents during work, while not worsening the quality of sleep after the night shift. On the other hand, after the night shift, it is not advisable to sleep too much. It is recommended to set an alarm after 6-7 hours of sleep and make up for sleep deprivation with a nap before the next night shift." [37]
2. It is recommended to be in bright light during the first half of the night shift, while avoiding intense light during the last hours of the night shift and during the return home. [38]
3. After the end of a night shift, in order to improve the quality of sleep, melatonin can be used. It should be taken in a low dose (0.5-3 mg) after coming home. However, when transitioning to a morning shift,

when it is necessary to shift sleep time to the evening, melatonin should be used in a higher dose (3-5 mg) 3 hours before planned sleep. [37]

4. Sleeping pills should only be used on an as-needed basis, in emergency situations. Although there is evidence of their effectiveness, there is a high risk of dependence on them. Therefore, caution should be exercised when using this form of treatment regularly. [37]
5. Substances and stimulant drugs such as caffeine and modafinil should only be used in situations where it is necessary to improve alertness for safety reasons. Taking a dose of caffeine equal to two espressos three hours before normal sleep in healthy adults can delay the phase of the melatonin circadian rhythm by around 40 minutes. [39]

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