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Review Article

Tick–tock–tick–tock: the impact of circadian rhythm disorders on cardiovascular health and wellness

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Abstract

Humans spend a third of their lives asleep. A well–balanced synchrony between sleep and wakefulness is needed to maintain a healthy lifestyle. Optimal sleep is based on an individual's inherent sleep requirement and circadian rhythm. If either one or both of these critical elements are disrupted, daytime dysfunction, non–restorative sleep, and/or reduced sense of well-being may result. While the medical community is more familiar with sleep disorders such as sleep apnea, insomnia, and narcolepsy, circadian rhythm sleep wake disorders (CRSWDs) are less known, despite these being common within the general population. CRSWDs are comprised of the following: shiftwork disorder, delayed sleep phase disorder, advanced sleep phase disorder, jet lag disorder, non–24–hour sleep–wake disorder, and irregular sleep–wake rhythm disorder. In general, a CRSWD results when there is misalignment between the sleep pattern and the desired sleep schedule, dictated by work, family, and social schedules. Subsequently, patients have difficulty falling asleep, maintaining sleep, and/or experience poor quality sleep predisposing them to insomnia or excessive sleepiness. In this article, we review the core concepts related to sleep, and sleep deprivation in the context of CRSWDs. J Am Soc Hypertens 2014;8(12):921–929.

Keywords: Circadian rhythm sleep wake disorders; health and wellbeing; sleep; sleep disorders.

Background: The Delicate Interplay of Sleep and Circadian Drive

Healthy sleep must include the optimization of an individual's sleep quality and quantity. To achieve this, an individual must avail themselves with an adequate sleep opportunity that occurs in line with his/her natural sleep–wake pattern. An individual's optimal sleep timing and duration depends upon factors such as age and gender, and varies from individual to individual depending upon genetic and physiological factors.[1]

The sleep need varies across age groups and is impacted by lifestyle and health. Sufficient sleep duration improves overall alertness, mood, and performance in addition to long–term health benefits. Chronic sleep restriction has been shown to be associated with a variety of physiologic consequences including: increased heart rate and blood pressure,[2] increased inflammation as measured by C–reactive protein,[3] impaired glucose tolerance,[4] and increased hunger/appetite.[5] For example, sleep deprivation (on account of circadian misalignment, poor sleep quality, or voluntary sleep restriction) is a possible risk factor for cardiovascular disease.[6] Lack of sleep in hypertensive patients may lead to increased blood pressure and heart rate, which may represent an increased risk for both organ damage and cardiovascular disease.[7] Additionally, diurnal fluctuations in blood pressure have been found to take on a circadian rhythmicity.[8] Therefore when the circadian rhythm displays evidence of dysynchrony it may also play a role in the potential risk of developing not only cardiovascular disease, but related conditions that affect cardiovascular health such as metabolic diseases (eg, microalbuminuria)[9] and endocrinologic conditions (eg, diabetes). For instance, in a recent study, more than a 2-fold increase was reported in the circadian blood pressure pattern of hypertensive patients with type 2 diabetes compared with those without diabetes.[10] The disruption of diurnal blood pressure may also lead to other health consequences such as renal damage and hypertension.[11]

Conflict of interest: none.

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Interestingly, too much sleep can also have negative effects on the cardiovascular system,[6,12] indicating that too much of a good thing can also be a bad thing. (Table 1)[13,14]

Typically, the adult sleep requirement averages 7–8 hours, but can range from 4–9 hours. Sleep need is innate and is likely genetically determined (eg, short sleepers who have a sleep requirement <4 hours).[15] The ability to optimize sleep quality so that an individual can efficiently get restored sleep, meeting the adequate amount of ''genetically'' determined sleep requirement is significantly impacted by behavioral and environmental factors. As America progressively becomes a sleep–deprived society[16] and individuals increasingly engage in poor sleep practices and behaviors such as the use of electronic devices near bedtime,[17] sleep quality will continue to be negatively impacted. For example, sleep can be delayed by the use of electronic devices at bedtime as backlit LED from LCD screens may suppress endogenous melatonin, subsequently increasing alertness and promoting arousal.[18] On the flip side, other activities such as routine moderate to intense exercise may be not only effective at increasing the quality and physiologic depth of sleep (ie, greater slow wave sleep),[19] but also improve sleep architecture and quality of those individuals with chronic insomnia.[20] Exercise, as well as proper timing of light exposure, have been identified as powerful mediators to align the circadian rhythm and sleep drive.

The ideal time period for the individual to obtain sleep relates to a genetically predetermined sleep–wake pattern. Sleep patterns are typically determined by the interplay between the homeostatic drive (Process S) and the circadian drive (Process C).[21] The homeostatic process regulates sleep intensity, which increases linearly during wakefulness and dissipates during sleep. The circadian process, however, helps to maintain wakefulness during the day by counteracting this mounting homeostatic sleep drive (see Figure 1 below). In order to initiate sleep, the Process C ideally decreases at the same time that the Process S is peaking. For most individuals, this occurs generally around 11 pm. A similar interface occurs between 1 pm and 3 pm, which results in the normal post-lunch (ie, post-prandial) or ''siesta'' period of sleepiness. Most individuals require approximately 7–8 hours to ''pay back'' the homeostatic drive (Process S), which results in natural wakefulness when the process restarts again. As mentioned earlier, sleep time and duration as well as sleep depth, intensity, and continuity all vary as people age.[22] Consolidation of sleep based on the interplay of processes C and S also assumes a developmental process. By 3 months of age, which represents the time upon which most infants begin to centrally release cortisol and melatonin,[23,24] 70% of infants are able to have at least 5 hours of consolidated sleep at night (see Figure 2 for more details).[25] Between 3 and 6 months, infants have multimodal sleep (ie, sleep without much pattern, napping 3–4 times a day), which is marked by naps in the morning and afternoon in addition to night–time sleep. At 1½ years after birth, infants demonstrate a bimodal sleep with one mid–day nap and night–time sleep. By age 6, most children adjust to the single consolidated nocturnal sleep period with the natural physiologic tendency to nap between 1 pm and 4 pm in line with the dip in the circadian drive during that time period.[26] As teenagers approach puberty, they may develop a resistance to sleep pressure or their sleep ''need,'' and the circadian rhythm may become relatively delayed,[27] potentially priming youth for poor sleep quality as they merge into an already sleep–deprived society that promotes poor sleep practices and behaviors.

Table 1
Sleep duration and potential health related consequence

Hours of Sleep	Compared with Normal 7–8 Hours of Sleep
Less than 6	15% higher risk of cardiovascular disease[8] 23% higher incidence of coronary heart disease[8] 1.4-fold association with a diagnosis of hypertension[9] 1.9-fold association with stroke[9]
Less than 6 + poor sleep quality	63% higher risk of cardiovascular disease[8] 79% higher incidence of coronary heart disease[8]
Greater than 9	1.3-fold association with a diagnosis of hypertension[9]

Circadian Rhythm Disorders: When the Two (Processes C and S) Do Not Meet

Circadian rhythm sleep wake disorders (CRSWDs) are characterized by normal sleep quantity and quality at *undesired* times. Specifically, CRSWDs occur when the natural interplay between process C and S is out of sync or processes C and S are outside of the desired time to initiate and maintain sleep. As a result, patients with CRSWDs may suffer from insomnia, excessive daytime sleepiness, and/or early morning awakenings. Frequently, symptoms similar to those of attention deficit hyperactivity disorder (ADHD; ie, inattentiveness) develop in children.[28] Table 2[29] provides six of the most common CRSWDs that will be discussed in greater detail in the following subsections.

The Two Opposite Extremes: Delayed Sleep Phase Syndrome and Advanced Sleep Phase Syndrome

There exists a continuum of circadian preferences (ie, phenotype) in individuals, with one extreme referred to as