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The Impact of Circadian Misalignment on Cardiometabolic Health

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Abstract

The circadian system is important in all living organisms because it generates a 24-hour rhythm for physiological and behavioral processes enabling anticipation and adaptation to daily changes in the environment. The prevalence of cardiometabolic diseases, which are linked to lifestyle choices, has been rising at an alarming rate. Modernization and globalization are two of many factors to blame for lifestyle changes resulting in circadian disruption. The purpose of this literature review is to explore circadian misalignment with regards to its mechanism and impact on cardiometabolic health and to determine possible interventional measures. The primary focus is on lifestyle change, particularly sleep, as an interventional measure for circadian misalignment. Studies were included if they included a cardiometabolic disease risk factor studied in the context of circadian alignment/misalignment or sleep duration/architecture. The data indicates that circadian misalignment and sleep deprivation impede cardiovascular function and cause a decrease in glucose tolerance and insulin sensitivity; however, restoring circadian rhythmicity and correcting for sleep deprivation improves several health indices including glucose tolerance, insulin sensitivity, blood pressure, and cardiac remodeling.

Introduction

The circadian system serves one of the most important functions present in almost all organisms because it generates 24-hour rhythms in physiological and behavioral processes enabling anticipation and adaptation to daily changes in the environment (Baron & Reid, 2014). Globalization and modernization, night shift work, and nighttime light exposure have resulted in disruption of sleep which in turn disrupts the circadian system, causing increased prevalence of cardiovascular disorders and metabolic diseases (Chen & Yang, 2015; Krishnan & Lyons, 2015; Paschos, 2015). The circadian system is vital in the regulation of glucose metabolism; if a disturbance occurs in the circadian system, cardiovascular and metabolic diseases will likely be experienced. Therefore, the purpose of this paper is to review the literature about causes, effects, and interventions for circadian misalignment. The primary focus of the literature review is to establish whether lifestyle changes, especially sleep adjustment, can address circadian dysregulation in order to improve an individual's cardiometabolic profile.

Statement of the Problem

Weight loss, physical activity, and nutritional modification are all lifestyle changes currently recommended for improving cardiometabolic health; however, sleep hygiene is rarely addressed though mounting evidence suggests that both sleep deprivation and circadian misalignment contribute to the development of cardiometabolic diseases.

Research Questions

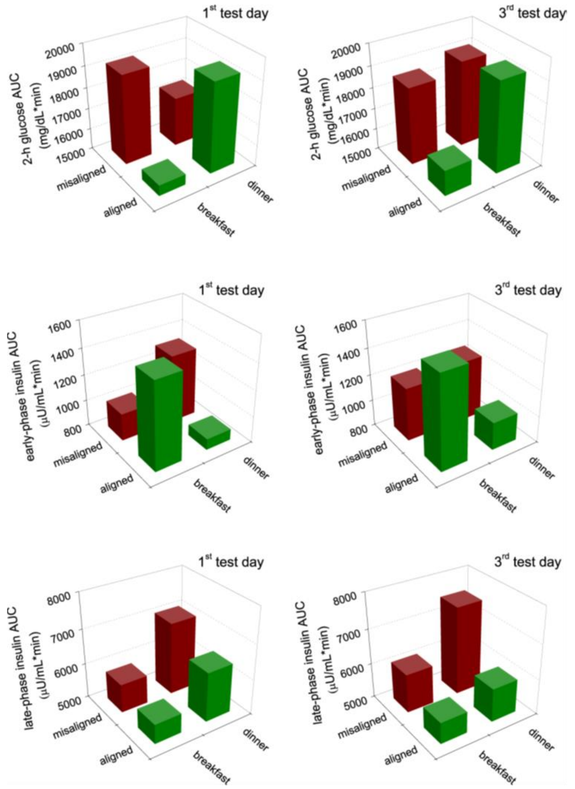
- Does adequate sleep at the appropriate time have the potential to halt pathological progression and improve cardiometabolic health before overt disease ensues?
- Should adjusting one's chronotype to reduce sleep debt, social jet lag, and circadian misalignment be included in lifestyle modification recommendations?

Literature Review

- The circadian clock is an endogenous timekeeping system that has evolved to anticipate one's daily behavioral and physiological needs.
- Circadian disruption occurs when one's behavior is misaligned with external environmental cues.
- Circadian disruption is associated with obesity, insulin resistance, cardiac arrhythmias, and hypertension.
  - ✓ Buxton et al. (2013) found that glucose levels increased 8 % above baseline while subjects were fasting and by 14 % above baseline postprandially during circadian disruption accompanied by sleep deprivation and that fasting and postprandial glucose levels returned to normal when circadian rhythmicity was restored.
  - ✓ Morris et al. (2015) identified and investigated three separate contributors to glucose tolerance:
    - The behavioral cycle (normal meal timing, meaning breakfast after waking and dinner a few hours before sleeping) had no effect on fasting glucose but postprandial glucose was 8 % higher after dinner than after breakfast.
    - Circadian phase inversion (sleep during the light phase and wakefulness during the dark phase) had no effect on fasting glucose but postprandial glucose was 12 % higher in the biological evening versus the biological morning.
    - Circadian misalignment (meal timing adverse to the exogenous light/dark cycle) had no effect on fasting glucose but postprandial glucose increased by 6 %.
  - ✓ Glucose intolerance increases during sleep restriction with circadian alignment, and both glucose intolerance and inflammatory markers increase during sleep restriction coupled with circadian misalignment (Leproult et al., 2014).
- Adequate sleep can help mitigate the damage done by circadian misalignment.
  - ✓ Insulin resistance decreases as sleep time increases per Leproult et al. (2015).
  - ✓ Extending sleep time by one hour each night lowers systolic and diastolic blood pressure (Haak et al., 2013).
  - ✓ Killick et al. (2015) found that three nights of catchup sleep on the weekend resulted in a 45 % increase in insulin sensitivity.

Discussion

- Weight loss, physical activity, and nutritional modification are all lifestyle changes currently recommended for improving cardiometabolic health; however, sleep hygiene is rarely addressed.
- Individuals experience circadian misalignment when they artificially curtail their weekday sleep via the use of alarm clocks, use artificial light at night, or work a shift adverse to the natural light/dark solar circadian cycle.
- The finding of insulin insensitivity and glucose intolerance has been consistently replicated in individuals who experience circadian misalignment, with or without chronic sleep loss, indicating a close relationship between sleep and cardiometabolic health.
- Sleep extension as a behavioral intervention effectively curbs the development and progression of cardiometabolic disease risk factors.
- The data indicates that circadian misalignment and sleep deprivation impede cardiovascular function and cause a decrease in glucose tolerance and insulin sensitivity Therefore, every effort should be made to reduce the health impact of sleep deprivation by focusing on sleep hygiene and circadian realignment as a means of reducing cardiometabolic disease risk factors.



Applicability to Clinical Practice

Though it is important to address the problem of circadian misalignment in order to slow the ever-increasing prevalence of cardiometabolic diseases, sleep hygiene is rarely recommended as a lifestyle change to reduce cardiometabolic disease risk factors. Extending sleep time by less than one hour each weeknight for six weeks in habitually sleep restricted subjects improves insulin sensitivity (Leproult et al., 2015) and lowers both systolic and diastolic blood pressure (Haak et al., 2013). When daily sleep extension is not possible then day off, catch up sleep helps mitigate the adverse consequences of sleep deprivation (Killick et al., 2015) Exploiting the connection between circadian alignment, sleep, glucose tolerance, insulin sensitivity, and blood pressure, by recommending sleep hygiene as a corrective measure is an important step toward curbing the worldwide epidemic of cardiometabolic disorders.

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