Endocrinology & Diabetes Research

Editorial

A SCITECHNOL JOURNAL

Circadian Rhythm and Metabolism: Interplay Between Biological Clocks and Energy Homeostasis

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Citation: Oliver G (2025) Circadian Rhythm and Metabolism: Interplay Between Biological Clocks and Energy Homeostasis. Endocrinol Diabetes Res 11:443

Received: 01-Aug-2025, Manuscript No. ecdr-26-182690; **Editor assigned:** 4-Aug-2025, Pre-QC No. ecdr-26-182690 (PQ); **Reviewed:** 19-Aug-2025, ecdr-26-182690; **Revised:** 26-Aug-2025, Manuscript No. ecdr-26-182690 (R); **Published:** 30-Aug-2025, DOI: 10.4172/2324-8777.1000443

Introduction

Circadian rhythms are endogenous, roughly 24-hour cycles that regulate physiological processes, including sleep-wake patterns, hormone secretion, and metabolism. These rhythms are controlled by molecular clocks in the suprachiasmatic nucleus of the hypothalamus and peripheral tissues such as liver, adipose tissue, and muscle. Proper alignment of circadian rhythms with environmental cues is crucial for maintaining metabolic homeostasis. Disruption of these rhythms, due to shift work, irregular sleep, or lifestyle factors, is increasingly linked to obesity, insulin resistance, type 2 diabetes, and other metabolic disorders. Understanding the mechanisms linking circadian biology and metabolism is vital for developing strategies to improve metabolic health [1,2].

Discussion

At the molecular level, circadian rhythms are driven by transcriptional-translational feedback loops involving clock genes such as CLOCK, BMAL1, PER, and CRY. These genes regulate the expression of enzymes and hormones that control glucose and lipid metabolism. In the liver, circadian clocks coordinate glycogen synthesis, gluconeogenesis, and lipid metabolism in a time-dependent manner, ensuring optimal energy availability throughout the day. Peripheral clocks in adipose tissue regulate adipokine secretion, lipolysis, and fatty acid oxidation, while skeletal muscle clocks influence insulin sensitivity and glucose uptake [3,4].

Disruption of circadian rhythms can impair these processes, leading to metabolic dysfunction. Experimental studies demonstrate that misalignment between central and peripheral clocks reduces insulin sensitivity, increases hepatic glucose production, and promotes adiposity. Shift workers and individuals with irregular sleep schedules often exhibit altered cortisol, melatonin, leptin, and ghrelin secretion, contributing to dysregulated appetite, energy balance, and weight gain. Moreover, circadian disruption can exacerbate inflammatory signaling, oxidative stress, and endothelial dysfunction, further increasing the risk of metabolic diseases [5].

Lifestyle interventions aligned with circadian biology, such as time-restricted feeding and structured sleep-wake schedules, have shown promise in improving glucose tolerance, lipid profiles, and body weight. Chronotherapy, the timing of medication administration to coincide with circadian rhythms, is also being explored to enhance the efficacy of metabolic drugs, including insulin sensitizers and lipid-lowering agents.

Conclusion

Circadian rhythms play a critical role in coordinating metabolic processes across multiple tissues, and their disruption contributes to obesity, insulin resistance, and other metabolic disorders. Integrating circadian biology into lifestyle interventions, dietary planning, and pharmacotherapy offers a promising approach to improving metabolic health. Continued research is essential to understand tissue-specific clock mechanisms and to develop chronobiology-based strategies for the prevention and treatment of metabolic diseases.

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