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Chronobiological Disruption and Metabolic Dysregulation in the 24-Hour Economy: A Narrative Review

M. Bharath Bala[1*]; R. Yogalakshmi[2]; Dr. Muthu Gopal[3]

[1;2;3]Department of Integrative Medical Research, Sri Manakula Vinayagar Medical College and Hospital, Puducherry – 605107, India

Corresponding Author: M. Bharath Bala[1*]

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Abstract:

- ***Background***

The transition to a 24-hour economy has necessitated a workforce that operates in opposition to endogenous circadian rhythms. Night shift work is increasingly recognized not merely as a logistical requirement but as a significant occupational health hazard associated with sleep disorders, metabolic syndrome, and cardiovascular disease.

- ***Methods***

A narrative review of the literature was conducted using PubMed, Embase, and Google Scholar databases. The search targeted studies published between 2015 and 2025 focusing on "circadian misalignment," "night shift work," "chrononutrition," and "sleep quality." Special attention was given to recent data regarding Information Technology (IT) professionals and high-cognitive-demand sectors.

- ***Results***

The literature consistently demonstrates a high prevalence of poor sleep quality among night shift workers, with recent cohort studies in IT sectors reporting prevalence rates as high as 100% (PSQI > 5). Evidence identifies a bidirectional relationship between sleep disturbance and maladaptive dietary behaviors, specifically increased food frequency and nocturnal snacking. Physiologically, this is driven by the desynchronization of the central suprachiasmatic nucleus (SCN) and peripheral metabolic clocks, characterized by inverted leptin-ghrelin profiles and insulin resistance.

- ***Discussion***

The core pathology of night shift work is chronic circadian misalignment. The negative correlation between food frequency and sleep quality suggests that "grazing" behaviors act as a zeitgeber that further desynchronizes peripheral clocks. Mitigation strategies must move beyond basic sleep hygiene to include organizational changes (forward-rotating schedules, spectral light management) and individual chrononutritional interventions (Early Time-Restricted Eating).

- ***Conclusion***

Night shift work induces systemic physiological dysregulation. Future research must prioritize longitudinal studies to overcome the "healthy worker effect" and establish causal pathways for the metabolic risks observed.

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I. INTRODUCTION

The evolution of human physiology occurred under the strict governance of the solar light-dark cycle. This environmental periodicity is encoded in the human genome, orchestrating a temporal segregation of physiological processes: diurnal activity associated with energy acquisition, and nocturnal rest associated with fasting and cellular repair.[10] However, modern economic demands have decoupled work schedules from the solar day. It is estimated that approximately 20% of the workforce in industrialized nations engages in shift work. While the economic necessity

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of these schedules is undeniable, the biological costs are becoming increasingly apparent.[1,2,4]

Historically, occupational health focuses on the acute safety risks of fatigue. However, recent decades have seen a paradigm shift, reframing night shift work as a chronic environmental toxicant. Epidemiological evidence now links long-term shift work to a cluster of pathologies including metabolic syndrome, type 2 diabetes, cardiovascular disease, and mood disorders.[7,8,10]

The central mechanism proposed for these outcomes is "circadian misalignment." This occurs when the body's master clock in the brain (the suprachiasmatic nucleus or SCN) remains partially anchored to the solar day due to light exposure, while peripheral clocks in metabolic organs are phase-shifted by nocturnal feeding and activity. This review aims to synthesize current evidence regarding the physiological mechanisms of this misalignment, with a specific focus on the interaction between sleep quality and dietary patterns in high-demand sectors such as Information Technology (IT).

II. METHODS

This study was designed as a narrative review to synthesize diverse streams of evidence ranging from molecular chronobiology to occupational epidemiology.

➢ *Search Strategy*

A comprehensive literature search was performed using the electronic databases PubMed/MEDLINE, Embase, and Google Scholar. The search period covered the last decade (January 2015 to early 2025) to ensure the inclusion of the most recent data.

➢ *Selection Criteria*

The search strategy utilized the following Medical Subject Headings (MeSH) and keywords: "Circadian Rhythm," "Shift Work Schedule," "Sleep Disorders," "Dietary Habits," "Eating Behavior," "Ghrelin," "Leptin," and "Metabolic Syndrome."

- *Inclusion Criteria were:*

✓ Studies involving adult human populations engaged in night shift or rotating shift work.
✓ Articles published in peer-reviewed English-language journals.
✓ Studies reporting quantitative outcomes related to sleep quality (e.g., Pittsburgh Sleep Quality Index) or dietary patterns (e.g., Food Frequency Questionnaires).

Exclusion criteria included studies focused solely on animal models (unless elucidating specific molecular mechanisms), editorials without data, and studies lacking specific definitions of shift schedules.

➢ *Data Synthesis*

Relevant articles were screened by title and abstract. Selected full-text articles were analyzed to extract data regarding the prevalence of sleep disorders, specific dietary behaviors adopted by shift workers, and proposed physiological mechanisms. Data from a recent key case study by Bala et al. (2025) regarding IT professionals was integrated to provide context on high-cognitive-demand sectors.

III. RESULTS

The literature search yielded a robust body of evidence confirming the deleterious effects of night shift work. The findings can be categorized into three primary domains: the prevalence of sleep pathology, the characterization of dietary behaviors, and the underlying neuroendocrine dysregulation.

➢ *Prevalence of Sleep Pathology*

Sleep disturbance is the most immediate and prevalent symptom of shift work intolerance. Systematic reviews indicate that the prevalence of "poor sleep quality" varies significantly by industry.

- General Industries: Prevalence rates for insomnia and sleep disturbance typically range from 20% to 60% in manufacturing and general services.[7,8,10]
- Healthcare: Nurses and physicians report higher prevalence rates (60–70%), likely due to the additive effects of high emotional and physical labor.[3,5,6]
- High-Cognitive Demand Sectors: Recent data highlights extreme prevalence in specific subgroups. For instance, the 2025 study by Bala et al. focusing on sedentary IT professionals in Puducherry, India, reported a prevalence of poor sleep quality (PSQI > 5) of 100%. This suggests that the combination of circadian inversion, sedentary behavior, and high cognitive arousal may overwhelm natural resilience mechanisms.

➢ *Dietary Patterns and Behavioral Correlates*

The results consistently identify a "shift work dietary pattern" characterized by altered meal timing rather than necessarily altered total caloric intake.

- Nocturnal Eating: Shift workers consume a significant proportion of their daily calories during the biological night.
- Food Frequency: High snacking frequency is a recurrent theme. Correlations identified in recent cohorts show a moderate negative relationship ($r = -0.490$) between food frequency and sleep quality; meaning that as the frequency of eating events increases, sleep quality significantly declines.[3,5,6]
- Food Choice: There is a documented preference for high-carbohydrate and high-fat "comfort foods" during the night shift, often driven by convenience and hedonic cravings rather than hunger alone.

➢ *Neuroendocrine Dysregulation*

The review of physiological studies identifies specific hormonal signatures associated with this lifestyle:

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- Leptin/Ghrelin Imbalance: Circadian misalignment disturbs the hormones regulating appetite. Ghrelin (hunger) levels are often elevated or fail to suppress during the night, while leptin (satiety) levels show flattened diurnal rhythms. This creates a physiological drive for hyperphagia.[7,8,10]
- Insulin Resistance: Eating during the biological night, when melatonin levels are high, results in impaired glucose tolerance. Melatonin inhibits insulin secretion from the pancreas; thus, carbohydrate intake during the night results in prolonged hyperglycemia compared to the same intake during the day.[10]

IV. DISCUSSION

The evidence synthesized in this review supports the hypothesis that night shift work is a systemic physiological stressor. The core pathology is internal desynchronization. The human body functions via a multi-oscillator system. The SCN is entrained primarily by light, while peripheral clocks (liver, gut, pancreas) are entrained by food intake. In night shift workers, these zeitgebers are in conflict. The SCN receives mixed signals from artificial light at night and sunlight during the commute, often remaining partially anchored to the solar day.[1,2,4] Conversely, the peripheral clocks are phase-shifted by nocturnal eating. This explains the strong correlation between "food frequency" and poor sleep. Frequent snacking during the night continuously resets peripheral clocks, keeping them out of phase with the central brain clock. This metabolic alertness prevents the body from entering a deep, restorative state during daytime sleep attempts, leading to the high PSQI scores observed in the literature.[3,5,6] The relationship between diet and sleep is modulated by occupational stress. Stress triggers cortisol release, which further disrupts sleep architecture and drives cravings for energy-dense foods a "stress-eating" loop. The high prevalence of poor sleep in IT professionals, as noted in the Results, likely reflects the synergistic impact of cognitive stress and blue-light exposure from screens, which suppresses melatonin more potently than dim ambient light.[7,8,10]

➢ *Therapeutic Implications*

Current "sleep hygiene" recommendations are insufficient for this population. Interventions must target the circadian system directly:

- Organizational Strategies: Forward-rotating schedules (Day-Evening-Night) are biologically superior to backward-rotating ones. Elimination of "quick returns" (<11 hours between shifts) is essential for recovery.[10]
- Chrononutrition: Interventions such as Early Time-Restricted Eating (eTRE) show promise. By restricting the eating window to the biological day (or avoiding food during the deep biological night, e.g., 1 AM to 5 AM), workers can prevent the desynchronization of peripheral clocks, potentially improving glucose handling and sleep quality.[1,2,4]
- Light Management: Strategic use of bright light during the early shift to promote alertness, followed by blue-light blocking glasses during the morning commute to prevent SCN activation, can aid in circadian phase management.[3,5,6]

V. CONCLUSION

The transition to a 24-hour society has outpaced human biological adaptation. The literature reviewed herein demonstrates that night shift work is associated with profound disruptions in sleep and metabolic health, driven by chronic circadian misalignment. The near-universal prevalence of poor sleep in certain high-risk cohorts serves as an urgent alarm signal. The data suggests that the adverse health outcomes of shift work are not inevitable consequences of sleep loss alone, but of the timing of behaviour specifically feeding relative to the biological clock. Future research should focus on longitudinal studies to correct for the "healthy worker effect" bias and should rigorously test chrononutritional interventions. Until then, medical and organizational guidelines must recognize night work as a distinct risk factor requiring proactive management through schedule design, light environment control, and dietary timing support.

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