

**A REVIEW ON CIRCADIAN RHYTHMS THROUGH THE LENS OF AYURVEDA:
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ABSTRACT

The circadian rhythm, a 24-hour cycle regulating vital physiological processes, is critical for maintaining health and well-being. Modern lifestyles—marked by artificial lighting, irregular schedules, and technological overuse—disrupt these natural rhythms, leading to sleep disorders, metabolic disturbances, and mood imbalances. Ayurveda offers timeless solutions through principles like *Dinacharya*, *Ritucharya*, and *Ratricharya*, which align the body's rhythms with nature's cycles. This article explores the physiology of circadian rhythms, their disruptions, and the Ayurvedic approach to restoring harmony. Integrating *Ayurvedic* practices with modern science provide a classical approach to mitigating circadian disruptions promoting a healthier, more resilient lifestyle in today's fast-paced world.

KEYWORDS: Circadian rhythm, *Tridosha*, *Charya*, *Nidra*, Circadian disorders, biological clock.**INTRODUCTION**

All living beings have a natural process within the body that primarily responds to light and darkness. This 24-hour light-dark cycle, caused by Earth's axial rotation, has shaped the evolution of biological rhythms known as circadian rhythms in living organisms. These rhythms are crucial for maintaining synchronized physiological and behavioral functions, ensuring the body operates in harmony with its environment. However, the widespread use of artificial lighting since the 20th century has significantly disrupted these natural light-dark cycles. The majority of humans now experience Light at Night (LAN), which interferes with the alignment between internal circadian clocks and the external environment. This misalignment often leads to various physiological and behavioral changes, emphasizing the need to understand circadian rhythms and their vital role in health and well-being.

In today's world, dominated by technology, irregular schedules, and sedentary lifestyles, this harmony between human biology and natural cycles is increasingly disturbed. Circadian rhythms, governs nearly every physiological process, including sleep, digestion, and mood regulation. Modern science has extensively studied these rhythms, recognizing their profound impact on health and longevity. Unfortunately, disruptions caused by late-night screen use, shift work, and erratic meal times have led to a rise in circadian

rhythm disorders, contributing to chronic health problems like sleep disturbances, obesity, and mood disorders.

Ayurveda, the ancient Indian system of medicine, offers profound insights into living in alignment with natural cycles. Practices such as *Brahmi muhurthe uthishtet*, *Ahara vidhi vidana*, and adjusting routines with seasonal changes are deeply ingrained in *Ayurvedic* classics. Through practices like *Dinacharya*, *Ratricharya* and *Ritucharya*, *Ayurveda* emphasizes maintaining the balance of *Vata*, *Pitta*, and *Kapha* doshas. These principles are remarkably aligned with modern insights into circadian rhythms. Furthermore, *Ayurveda* prescribes, the dos and don'ts of *ahara* and *vihara*, to optimize the body's internal clock by regulating sleep and food habits. This article explores the physiological basis of circadian rhythms, the challenges posed by their disruption, and how *Ayurvedic* wisdom offers solutions to modern-day health issues.

MATERIALS AND METHODS

The literature search was done from the database like PubMed and MEDLINE and classical texts like Charaka Samhita, Sushruta Samhita, *Astanga Hridaya* and *Astanga Samgraha*. Review of peer reviewed original research articles were done. Articles were selected using the search terms "Circadian rhythm", "*Charya*", "*Tridosha*" and "*Nidra*". Articles were screened by

reading titles and abstracts and were initially excluded if they did not refer to Circadian Rhythm.

Circadian Rhythm and Its Regulation

Biological rhythms are recurring physiological, molecular, or behavioral processes characteristic of all living organisms. These rhythms can be classified into four types based on their duration: circadian rhythms, which occur over 24 hours; infradian rhythms, which take longer than 24 hours (e.g., menstrual cycles); ultradian rhythms, which are shorter than 24 hours (e.g., heartbeat); and diurnal rhythms, which occur once a day and are synchronized to external cues like sunlight. The scientific study of these natural rhythms is known as chronobiology.

Circadian rhythms, derived from the Latin words "circa" (about) and "diem" (day) are defined as the physical, mental, and behavioural changes that follow a roughly 24-hour cycle and are primarily influenced by environmental cues like light and darkness, referred to as zeitgebers.

It play a crucial role in regulating various physiological processes, such as digestion, hormonal cycles, and immune responses. Disruptions to these rhythms can lead to significant health issues, making their study and management vital.^[1]

The concept of circadian rhythms has evolved significantly since 1729 when Jean Jacques d'Ortois de Mairan observed the rhythmic leaf movements of mimosa plants, even in the absence of sunlight. This hinted at the existence of an internal biological clock. Over time, researchers discovered rhythmic cycles in animals and the critical role of the suprachiasmatic

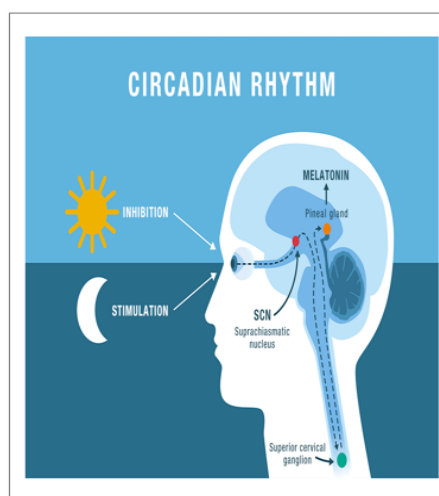
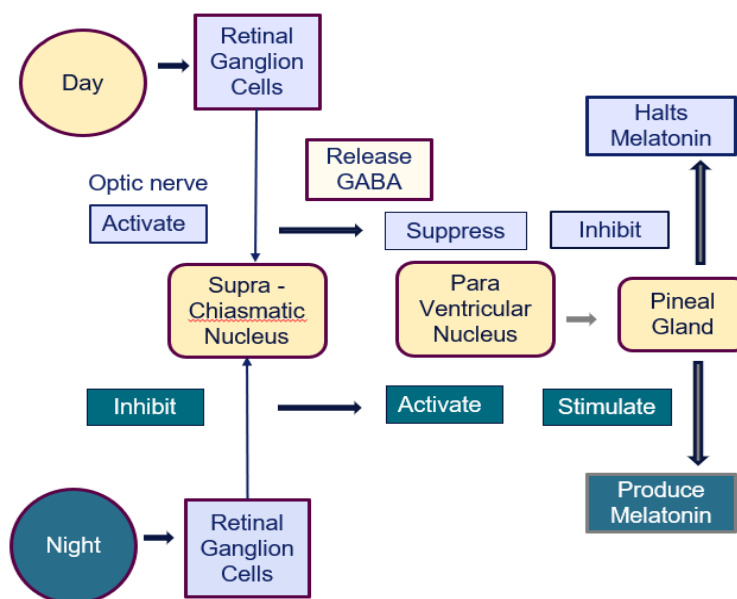
nucleus (SCN) as the master clock in humans.^[2,3] The genetic regulation of these rhythms, particularly through the PER (period) gene, further advanced our understanding. Franz Halberg coined the term "circadian" in 1959, and in 2017, researchers were awarded the Nobel Prize for elucidating the molecular mechanisms of circadian regulation.^[4,5] These discoveries underscore the critical role of circadian rhythms in maintaining health and well-being.

Physiology in humans

In vertebrates, including humans, circadian rhythms are controlled by the suprachiasmatic nucleus (SCN), a cluster of approximately 20,000 neurons located in the anterior hypothalamus. The SCN serves as the body's master clock, synchronizing internal rhythms with the external environment.

During daylight, specialized retinal ganglion cells detect light and transmit signals to the SCN via the optic nerve. This activation of the SCN prompts the release of gamma-aminobutyric acid (GABA), an inhibitory neurotransmitter. GABA suppresses the activity of the paraventricular nucleus, an autonomic control center in the brain, thereby inhibiting the pineal gland and halting melatonin production. This process keeps the body alert and active during the day.

As night falls and light diminish, the retinal ganglion cells reduce their signals, leading to the suppression of SCN activity. This change activates the paraventricular nucleus, which signals the pineal gland to produce melatonin, a hormone that induces sleep. This cyclic regulation of melatonin production is a fundamental aspect of circadian rhythms, ensuring a consistent sleep-wake cycle.



Beyond regulating sleep, the SCN communicates with peripheral clocks in other organs, such as the liver, to manage essential functions like glucose metabolism and

detoxification. Even in the absence of light-dark signals, circadian rhythms persist due to the activity of specific genes, including CLOCK and BMAL1 (activators) and

PER and CRY (inhibitors), which work in tandem to maintain the body's internal timekeeping. However, environmental cues like daylight and meal timing remain critical for fine-tuning these rhythms to external changes.^[6]

Overview of a typical human biological cycle^[7]

6:00 AM – 8:00 AM: Melatonin secretion stops, leading to increased alertness as the body prepares for the day.
10:00 AM – 12:00 PM: High alertness and optimal cognitive function, making it an ideal time for complex tasks.

2:00 PM – 3:00 PM: dip in energy levels, often leading to feelings of drowsiness.
4:00 PM – 6:00 PM: Peak physical performance, with improved cardiovascular efficiency and muscle strength.
6:00 PM – 7:00 PM: Highest blood pressure and body temperature, marking the end of the active phase.
9:00 PM – 10:00 PM: Melatonin secretion starts, signaling the body to prepare for sleep.
2:00 AM – 4:00 AM: Deepest sleep phase, crucial for restorative processes.

Factors influencing circadian rhythm^[8]

Category	Factors	Impact on circadian rhythm
Environmental Factors	- Light: Blue light exposure at night delays melatonin secretion.	Aligns or disrupts the sleep-wake cycle depending on timing and intensity.
	- Temperature: Ambient temperature fluctuations. - The color temperature of the light also varies at different times of the day	Regulates body temperature, syncing with external cues. warm colours during sun rise or sun set which makes the resting period and blue to white in the midday makes the active period
	- Seasonal Changes: Variation in daylight hours (e.g., winter).	Contributes to disorders like Seasonal Affective Disorder (SAD).
Lifestyle Factors	- Sleep-Wake Schedule: Irregular sleep patterns.	Leads to circadian misalignment and poor sleep quality.
	- Shift Work: Night shifts or rotating schedules.	Disrupts light exposure patterns, causing fatigue and insomnia.
	- Travel/Jet Lag: Crossing time zones.	Misaligns internal rhythms with the new light-dark cycle.
Hormonal Regulation	- Melatonin: Suppressed by light exposure.	Regulates sleep-wake cycles; affected by timing of light exposure.
	- Cortisol: Peaks in the morning and decreases in the evening.	Provides energy in the morning; misalignment leads to fatigue or alertness issues.
Genetic Factors	- Variations in clock genes (e.g., PER, CLOCK).	Determines chronotypes (individual's morning/evening preferences).
Age	- Developmental changes in circadian rhythm.	Teens experience phase delays; older adults have advanced sleep phases.
Food and Meal Timing	- Late-night eating disrupts peripheral clocks (e.g., liver).	Affects metabolism and digestion; regular meal timing enhances synchronization.
Stress	- Elevated cortisol levels due to chronic stress.	Disrupts circadian processes, leading to irregular sleep and poor health outcomes.
Physical Activity	- Morning or afternoon exercise enhances rhythm alignment.	Evening workouts delay melatonin release and sleep onset.
Social and Cultural Factors	- Social obligations, extended wake times due to artificial light.	Extends wakefulness, disrupting the natural rhythm.
Drugs and Medications	- Stimulants (e.g., caffeine, nicotine) and alcohol.	Alters melatonin production and sleep patterns.

Circadian rhythm across major age groups^[9]

The circadian rhythm changes across different age groups, influencing sleep patterns, hormonal regulation, and daily physiological processes.

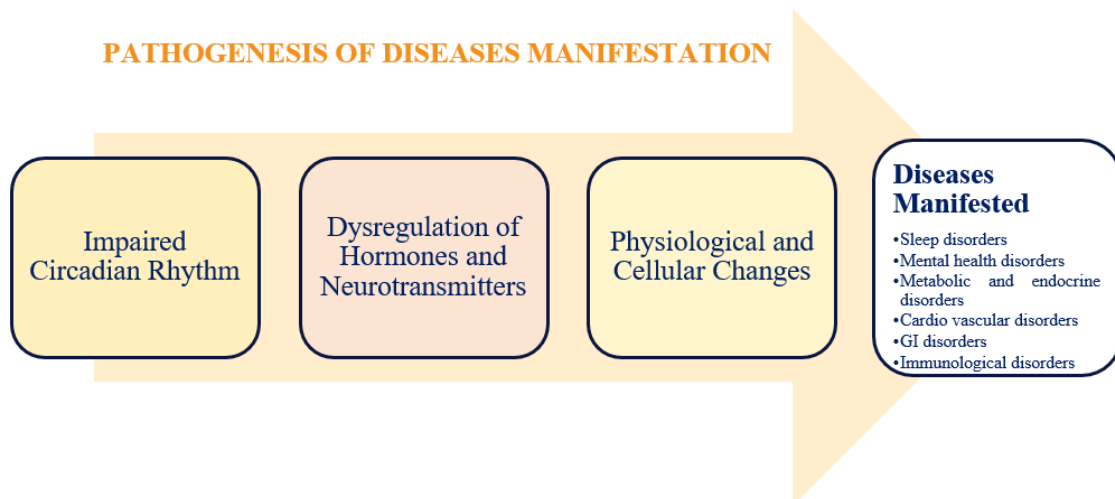
Age group	Characteristics	Sleep duration	Changes in circadian rhythm
Infants (0–1 year)	Immature rhythms; melatonin production starts ~3 months; sleep fragmented.	12–17 hours	Rhythm begins aligning with light-dark cycles.
Children (1–12 years)	Stable circadian rhythm; early bedtime and naps reduce as age increases.	9–14 hours	Regular bedtime and melatonin secretion ensure stable sleep.
Teenagers (13–)	Phase delay; sleep onset later (~11	8–10 hours	Delayed melatonin secretion leads

18 years)	PM); struggle with early wake times.		to mismatch with social timings.
Adults (19–60 years)	Stable rhythms; alertness peaks in the morning; lifestyle affects sleep quality.	7–9 hours	Rhythm stabilizes but influenced by stress, work, and light.
Older Adults (60+ years)	Advanced phase; early bedtime/wake time; reduced total sleep with frequent awakenings.	6–8 hours	SCN decline weakens circadian regulation; melatonin secretion decreases.

Impaired circadian rhythms can have widespread health impacts, including sleep disorders like insomnia and circadian rhythm sleep disorders, along with reduced sleep quality. Metabolic disorders such as obesity, diabetes, and appetite dysregulation arise due to hormonal imbalances, while cardiovascular risks include hypertension, heart disease, and atherosclerosis. Mental health issues, including depression, anxiety, and cognitive impairment, are common due to disrupted serotonin and dopamine regulation. Hormonal imbalances affect cortisol, melatonin, and reproductive

hormones, leading to chronic fatigue, weakened immunity, and fertility issues. Immunosuppression increases susceptibility to infections and chronic inflammation, while digestive problems like irritable bowel syndrome (IBS) and altered gut microbiota are also linked. Long-term disruption is associated with increased cancer risk (e.g., breast and prostate) due to suppressed melatonin and DNA repair inhibition. Premature aging, characterized by oxidative stress and reduced cellular repair, further highlights the severe consequences of circadian misalignment.^[10]

PATHOGENESIS OF DISEASES MANIFESTATION



Circadian rhythm disorders^[11]

Are disruptions in the body's internal clock, misaligning the sleep-wake cycle with environmental or social cues. Key disorders include:

1. Delayed Sleep Phase Disorder (DSPD): Difficulty falling asleep until late night and waking up late.
2. Advanced Sleep Phase Disorder (ASPD): Early sleep onset and waking up earlier than desired.

3. Non-24-Hour Sleep-Wake Disorder: Common in blind individuals, where the sleep cycle shifts daily due to lack of light cues.
4. Shift Work Disorder: Misalignment caused by working night shifts or irregular hours.
5. Jet Lag: Temporary disruption from crossing time zones, causing difficulty in adjusting to the new schedule.

These disorders lead to poor sleep quality, fatigue, and impaired functioning.

Management

Methods for correcting the circadian rhythm in Regular and challenging environments^[12,13,14]

Method	Normal Environment (Circadian Disorders)	Challenging Environments (Polar Regions, Space)
Light Exposure	Bright light therapy in the morning; avoid bright light in the evening	Light therapy devices (dawn simulators, bright light boxes) to mimic natural light cycles
Sleep Environment	Maintain a dark, quiet, and cool sleep space for better rest	Blackout curtains or sleep masks in polar regions; artificial lighting systems in space
Routine & Scheduled Activity	Regular sleep, meal, and exercise schedule	Consistent sleep, meal, and exercise schedules to stabilize circadian rhythm
Melatonin	Melatonin supplements to shift	Melatonin supplements to adjust sleep in constant

Supplementation	sleep-wake cycles	light/dark environments
Diet & Nutrition	Regular meals with tryptophan-rich foods, vitamin D supplementation	Tryptophan-rich foods and vitamin D to support circadian rhythm and sleep quality
Technological Aids	Wearables and apps to track and adjust sleep patterns	Smart lighting, wearables, and sleep-monitoring apps to manage sleep-wake cycles effectively

DISCUSSION

The intrinsic relationship between chronobiology and health has been recognized for centuries in *Ayurveda*, which regards *Kala* (time) as one of the nine fundamental *dravyas* (Substances) that influence health and disease. Time is an essential determinant of physiological and behavioral changes, as evidenced by the effects of day and night, seasonal variations, and different stages of life on the human body. These concepts are well-documented in *Ayurvedic* scriptures and provide a holistic understanding of how time governs biological rhythms.

Ayurveda presents several profound principles, such as the *Loka-Purusha Samya Siddhanta*, which explains that humans are a reflection of the universe, functioning in harmony with cosmic rhythms. Similarly, the *Pinda-Brahmanda Nyaya* from the *Yajurveda* underscores the concept that “whatever exists in the macrocosm also exists in the microcosm.” Another foundational concept is the *Panchamahabhuta Siddhanta*, which asserts that all substances, including the human body, are composed of the five elements. These principles highlight the interconnectedness of humans with their environment and form the basis of *Ayurveda's* approach to maintaining health through synchronization with natural rhythms. It cautiously examines the effects of chronobiological shifts on human physiology and the manifestation of diseases.^[15]

Ayurveda emphasizes the *Tridosha* system, representing the features of *Vata*, *Pitta*, and *Kapha*, operates in biological rhythms that align with specific times of the day and night, age, and the three stages of digestion (ingestion, transformation, and excretion).

वयोऽहोरात्रिभुक्तानां तेऽन्तमध्यादिगाः क्रमात्^[16]

This diurnal rhythmic variation of doshas corresponds to the circadian cycle, influencing sleep-wake patterns, digestion, hormonal fluctuations, and energy levels throughout the day. Hence can be considered as *Ayurveda's* version of circadian rhythms. For instance, *Kapha* dominates in the early morning and evening, *Pitta* at midday and midnight, and *Vata* during the early hours of the morning and afternoon. To preserve this rhythmic balance, *our* classics prescribes practices such as *Dinacharya*, *Ritucharya*, *Ratricharya*, *Ahara vidhi vidhana* etc.

The principles of *Ayurveda* not only emphasize daily routines but also seasonal regimens, providing a comprehensive framework for maintaining harmony between the body and external environment.

Nidana for circadian disruptions

Ayurveda identifies disruptions in circadian rhythms as a result of improper utilization of *Kala* (time), *Artha* (objects of perception), and *Karma* (Actions). These improper uses can occur in three ways:

- *Heenayoga*: Lack of exposure to natural rhythms, such as inadequate sunlight or physical inactivity.
- *Mithyayoga*: Engaging in irregular behaviors like late-night screen time or erratic meal timings.
- *Atiyoga*: Overexertion, overstimulation of *indriyas*. Additionally, *vega dharana*, or suppression of natural biological urges, is another significant cause of *doshic* imbalance. For example, suppressing *nidra* *vega* interferes with melatonin secretion, delaying the initiation of sleep. Chronic suppression of natural urges can lead to stress and dysregulation of the nervous system, overactivating the sympathetic nervous system. This alters the hypothalamic-pituitary-adrenal (HPA) axis, which is critical for maintaining circadian homeostasis.^[17]

Ayurvedic practices for maintaining circadian rhythm *dinacharya*

Dinacharya helps maintain the cyclic predominance of doshas throughout the day, aligning with circadian rhythms. Key practices include:

1. **Early morning:** Waking up 45 minutes before sunrise in *Brahma Muhurta* stimulates the suprachiasmatic nucleus (SCN) through early morning light, which signals the awakening and prepares the body for the day. Morning light triggering the Cortisol Awakening Response^[18] and the ultraviolet rays stimulates serotonin production, improving mood, mental clarity, and cognitive function. Serotonin is also a precursor to melatonin.^[19] Also oxygen levels in the atmosphere are higher, improving the formation of oxyhemoglobin, which boosts energy, immune strength, and mental alertness.^[20]

Practices like *mala tyaga*, *danta dhavana*, *abhyanga* and *udhwartana* prevent the accumulation of *Kapha* and activities such as *Vyayama* enhance serotonin levels, promoting alertness and energize the body.

2. **Midday:** Consuming the largest meal during the *Pitta*-dominant optimizes digestion and metabolism. This aligns with research showing that insulin sensitivity and metabolic efficiency peak at midday.^[21]

3. **Late afternoon:** *Vata* enhances mental clarity and creativity, making it ideal for productive work or intellectual tasks.

Ritucharya

Adapting to seasonal changes by following the prescribed ritucharya (seasonal regimens) ensures the proper functioning of doshas and the internal clock. For instance, performing rutu shodhana during the appropriate season helps address prakupita doshas and prevents imbalances in the subsequent seasons.^[22]

Ratricharya

- *Sandhya varjya karma* - एतानि पंच कर्माणि सन्ध्यायाम वर्जयेत् बुधः। आहारं मैथुनं निद्रां सम्पाठं गतिं अध्वानि ॥^[23]

Avoid stimulating activities during *Sandhya Kala* (Dusk): because during this time, cortisol levels begin to drop, and melatonin secretion starts. Activities like excessive movement or screen time disrupt this process.

- *Ratri Bhojana vidhi*: *Ayurveda* recommends an early, light dinner during the first prahar of the night.

रात्रौ च भोजनं कुर्यात् प्रथम प्रहर अन्तरे। किञ्चिद् ऊनं सम अशनीयात् दुर्जरं तत्र वर्जयेत्।^[24]

Heavy meals consumed later interfere with melatonin secretion, hindering sleep initiation.

- *Ayurveda* also says Early Bedtime, sleeping during *Kapha kala*, facilitates the body's transition into rest. Melatonin secretion begins around this time, promoting deep, restorative sleep.

Nidra being the key ensures that the body functions optimally throughout the day and night. Both Our classics wisdom and modern science emphasize the importance of good sleep for restoring the circadian rhythm, and they often point to various foods and habits that can enhance sleep quality.

Ahara for good sleep^[25,26,27]

Modern Food	Ayurveda	Reasons
Red meat, poultry, eggs, fish	Gramya-Anup-Oudaka mamsa Rasa, Sneha	Rich in tryptophan, which is a precursor to serotonin and melatonin, aiding in mood, sleep, and appetite regulation.
Milk, dairy	Ksheera, (Maheesha Ksheera), Dadhi	Contains tryptophan, calcium (helps produce melatonin), and magnesium (promotes muscle relaxation and induces sleep).
High GI foods, rich in carbohydrates	Shali	Eating at least 1 hour before bed enhances sleep quality, as insulin surge helps the brain absorb tryptophan.
Tart cherries, mushrooms	Draksha	Rich in melatonin, which regulates sleep-wake cycles.
Fruits like kiwi, berries, bananas		Rich in tryptophan, magnesium, potassium, and vitamin B6, all of which support sleep quality.
Walnuts, peanuts		High in melatonin, magnesium, and potassium, promoting better sleep.

Vihara for good sleep^[28-33]

Modern Habit	Ayurveda	Reasons
Massage	<i>Abhyanga, Uthsadana</i>	Activates the parasympathetic nervous system, promoting relaxation, lowering cortisol, and increasing serotonin levels.
Counseling therapy	Prayer and <i>Dhyana</i>	Helps relieve stress, reduce cortisol, and support mental clarity and relaxation.
Showering, spa	<i>Snana</i>	Lowers core body temperature, signaling the body to prepare for sleep by aligning with circadian rhythms.
Mild exercise	<i>Vyayama</i>	Forms like running can boost serotonin, promoting brain health and sleep regulation; helps stabilize mood.
Sleep Hygiene (warm light, soothing curtains, comfortable bed)	<i>Shayana Vidhi</i> (clean, well-ventilated room, soft bed at knee height)	A comfortable environment reduces stress, signaling the brain to prepare for rest.

Yoga, pranayama, and mudras play a vital role in regulating the circadian rhythm by balancing the autonomic nervous system, reducing stress, and promoting relaxation. Morning yoga practices energize the body, activate the sympathetic nervous system, and

help set the tone for a productive day, while evening yoga focuses on calming postures that stimulate the parasympathetic system, preparing the body for sleep. Pranayama techniques, such as alternate nostril breathing in the evening, lower cortisol levels, induce relaxation,

and enhance melatonin production, aiding sleep. Mudras, when performed with meditation, help stabilize energy and calm the mind, further supporting the body's natural sleep-wake cycle. The timing of these practices is crucial: energizing in the morning and calming in the evening to align with the circadian rhythm. These practices have been shown to improve sleep quality and reduce anxiety, contributing to better overall health.^[34,35,36]

CONCLUSION

The challenges of the modern era, such as stress, irregular schedules, and excessive screen time, often disrupt circadian rhythms and exacerbate *Dosha* imbalances. Applying *Ayurvedic* principles like *Dinacharya*, *Ratricharya*, and *Ritucharya* helps synchronize the body's internal biological clock with nature's cycles, enabling better regulation of circadian rhythms at a cellular level.

The concept of *Lokapurusha Samanya Vadha*, which emphasizes close association with nature, fosters longevity, improves quality of life, and supports overall health. Adopting *Ayurvedic* practices ensures proper sunlight exposure, a consistent sleep routine, balanced nutrition, regular exercise, and stress management, all key to maintaining a harmonious circadian rhythm. Additionally, modern technology such as artificial lighting and wearable devices can complement these practices, helping the body stay aligned with natural cycles.

By integrating these *Ayurvedic* principles with modern tools, we can balance the *Doshas*, prevent circadian disruptions, and promote optimal health in today's fast-paced world.

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