



NIDRA UNRAVELLED: CONNECTING AYURVEDIC PROSPECTIVE AND NEUROBIOLOGY OF SLEEP

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ABSTRACT

Nidra is one of the Trayopasthamba mentioned in Ayurveda, indicating its essential role in maintaining normal physiological and psychological functions. It is a physiological state that plays a fundamental role in maintaining physical, mental and cognitive well-being. Ayurveda identifies sleep as an important aspect and describes its influence on Sukha, Pusthi, Bala, Vrishata, Jnana and Jivita. Contemporary science identifies sleep regulation as a dynamic process involving interactions between neurotransmitters and circadian rhythm. Sleep and wakefulness are mediated by neurotransmitters such as GABA, galanin, adenosine, noradrenaline, orexin, acetylcholine, serotonin, dopamine, and histamine. These neurotransmitters regulate neuronal activity, arousal, cognition, and transitions between sleep and wakefulness. Ayurveda explains Nidra as Tamomayi, Nidra is an interplay between Doshas, Manas and Indriyas. The present article explores the functional relationship between Ayurvedic concepts of Nidra and contemporary sleep neurobiology with particular emphasis on neurotransmitters of sleep-wake regulation and its interpretation through Ayurvedic physiology of doshas like Prana vata, Udana vata, Sadhaka pitta and Tarpaka kapha. Rather than proposing a direct equivalence between neurotransmitters and doshas, the article explores the functional relations in the regulation of sleep and arousal. This integrative perspective may facilitate a deeper understanding of Nidra and provide a conceptual bridge between Ayurveda and contemporary neuroscience.

INTRODUCTION

Sleep is one of the fundamental physiological activities, occupying nearly one-third of human life. Although often regarded as a state of rest, it is an active and highly regulated process involving the coordinated activity of multiple brain regions.^[1] Sleep is associated with restoration, regulation, and maintenance of several vital biological functions. Adequate sleep contributes to normal cognitive functioning, emotional regulation, immune competence, and overall physiological homeostasis. Conversely, disturbance in sleep or insufficient sleep have been associated with adverse health outcomes. Ayurveda recognizes sleep as essential not only for physical restoration but also for maintaining the equilibrium of mind and overall health. Ayurvedic classics rightly mentioned proper *Nidra* promotes *Sukha* (Happiness, Health), *Pushti* (Nourishment), *Bala*

(Immunity), *Vrishata* (Virility) and *Jnana* (Cognitive performance).^[2] Insufficient sleep causes *Dukha* (diseases), *Karshya* (Malnutrition), *Abala* (Weakness), *Kliba* (impotence) and *Ajnana* (impaired cognitive performance).^[3] Sleep regulation is controlled by two main biological mechanisms: Homeostatic sleep drive (Process S) and Circadian rhythm (Process C). The transition between wakefulness and sleep is maintained by a balance between wake-promoting and sleep-promoting systems, which is mediated by various neurotransmitters. Neurotransmitters such as acetylcholine, noradrenaline, serotonin, dopamine, histamine, and orexin play a pivotal role in regulating the sleep-wake cycle by modulating neuronal activity and maintaining normal sleep architecture.^[4] Neurotransmitters are emerging as pivotal regulators in the intricate interplay between sleep-wake homeostasis.

They are widely distributed throughout the brain and are responsible for modulating communication between neurons and hence regulate sleep. These neurotransmitters not only influence the architecture of sleep but are also deeply involved in physiological processes such as emotional regulation, memory consolidation, and energy metabolism. Conversely, alterations in sleep wake cycle can impact the synthesis, release and reuptake of neurotransmitters, creating a dynamic bidirectional regulatory system. From Ayurvedic perspective, Nidra is regarded as one of the Trayopasthambas, emphasising its vital role in maintaining normal physiological and psychological functions.^[5] The concept of Doshas, Gunas and Manas provide a distinctive framework for understanding the regulation of sleep and its disturbances. Owing to the increasing prevalence of sleep disorders, understanding the role of neurotransmitters in sleep regulation has become an important area of research. This review aims to provide an overview of the major neurotransmitters involved in sleep regulation and to explore their functional understanding in the light of Ayurvedic principles.

NEUROTRANSMITTERS AND NEUROMODULATORS INVOLVED IN SLEEP-WAKE REGULATION

Sleep is a process that involves the activation and inhibition of certain brain circuits, and the physiological basis for healthy sleep patterns is formed by the connection between these systems, which ensures the appropriate initiation, maintenance and cycling of sleep. The neurophysiology of sleep and wakefulness is best understood as a balance between wake-promoting and sleep -promoting systems. The ascending reticular activating system (ARAS) involving neurotransmitters such as noradrenaline, dopamine, acetylcholine, orexin, and serotonin promotes arousal and wakefulness, whereas the Ventrolateral preoptic area (VLPO) area facilitates sleep through inhibitory neurotransmitters, predominantly GABA and Galanin. The reciprocal interaction between these systems enables the transition and maintenance of sleep and wakefulness.^[6]

Sleep Promoting Neurotransmitters^[7]

GABA (Gama Amino butyric acid): The hypothalamus and adjacent basal forebrain contain sleep-active GABAergic neurons that play a major role in sleep initiation and maintenance. Their activity increases with sleep onset and is prominent during NREM sleep. By inhibiting wake-promoting and arousal-related neuronal systems, including cholinergic neurons of the basal forebrain, GABA facilitates cortical deactivation and promotes sleep.

Galanin: It is an inhibitory neuropeptide of the VLPO area, where it is commonly co-expressed with GABA. These galaninergic neurons are involved in promoting NREM sleep and exert inhibitory effects on wake-promoting neuronal systems.

Adenosine: It is an important endogenous regulator of sleep homeostasis. It is a product of ATP metabolism and accumulates in the extracellular space during prolonged wakefulness, particularly in the basal forebrain. This accumulation contributes to the increasing homeostatic pressure of sleep. Adenosine promotes sleep primarily through A1 and A2A receptors, and activation of these receptors increases slow-wave sleep and slow-wave activity during REM sleep.

Wake-Promoting Neurotransmitters^[8]

Noradrenaline: Noradrenaline (NE) in the central nervous system is primarily associated with neurons of the locus coeruleus (LC), located in the dorsolateral mesopontine region. Noradrenergic neuronal activity increases during wakefulness, particularly in response to novel stimuli. Experimental stimulation of these neurons promotes wakefulness, whereas their inhibition facilitates the transition to NREM sleep.

Acetylcholine: Acetylcholine (ACh) is synthesised from choline by choline acetyltransferase and acts through nicotinic and muscarinic receptors. Cholinergic neurons located in the laterodorsal tegmental and pedunculopontine nuclei (LDT-PPT) and basal forebrain (BFB) contribute to the maintenance of wakefulness. Their activity and cortical ACh release increase during wakefulness, decrease during NREM sleep, and become reactivated during REM sleep. Experimental activation of basal forebrain cholinergic neurons reduces slow-wave activity during NREM sleep, while cholinergic stimulation within the pontine reticular formation can induce a REM sleep-like state.

Orexin: Orexins A and B are excitatory neuropeptides that promote and stabilise wakefulness through their actions on orexin receptors. Experimental administration or activation of orexin neurons induces wakefulness, while orexinergic activity is influenced by metabolic and feeding-related signals.

Serotonin: Serotonin (5-HT) is an important neuromodulator involved in the regulation of the sleep-wake cycle. Its overall action predominantly favours wakefulness and suppresses REM sleep. Activation of several serotonergic receptor subtypes has been shown to increase wakefulness and reduce NREM and REM sleep, indicating that serotonergic signaling contributes to the maintenance of arousal and modulation of sleep architecture.

Dopamine: Dopamine contributes to the regulation of wakefulness and behavioural arousal through its actions on D1 and D2-like receptors. Activation of D1 receptors promotes wakefulness and reduces both slow-wave and REM sleep. Dopaminergic effects through D2 receptors are more complex and may vary according to the receptor, site of action, and dose, with both sleep-promoting and wake-promoting effects being reported.

Overall, dopaminergic signalling participates in the regulation of arousal and sleep–wake behaviour.

Histamine: Histaminergic neurons play an important role in promoting and maintaining wakefulness. Histaminergic stimulation inhibits sleep-promoting neurons in the ventrolateral preoptic area (VLPO), thereby favouring wakefulness. Reduction of brain histamine levels increases slow-wave and REM sleep while reducing wakefulness. Conversely, H1 receptor antagonism promotes sleep, supporting the role of histamine as an important wake-promoting neurotransmitter.

Table No. 1: Sleep and wake promoting hormones.

Sleep promoting hormones	Wake promoting hormones
GABA (Gama Amino butyric acid)	Noradrenaline
Galanin	Acetylcholine
Adenosine	Orexin
	Serotonin
	Dopamine
	Histamine

ROLE OF DOSHAS AND MANAS IN NIDRA

Nidra is one of the Trayopasthamba mentioned in Ayurveda along with Ahara and Bramhacharya, indicating its essential role in maintaining normal physiological and psychological functions. However, it is not merely a passive state of rest. Ayurveda suggest that sleep represents a distinct functional state in which the process of Jnanaotpatti does not occur. During consciousness, perception depends on the coordination between Atma, Manas, Indriyas, and their respective objects. In contrast, this coordination becomes dormant during sleep. When the mind becomes fatigued or experiences emotional, mental, or physical exhaustion, it withdraws from the action.^[9] When the mind stops directing the activity of the senses, the Indriyas, or sense organs, also cease to function. As a result of this mental withdrawal, the indriyas detach from their respective objects. This withdrawal is a gradual process supported by Kapha and Tamo guna predominance. Acharya Charaka has highlighted the importance of Klama in the process of sleep. According to Acharya Sushruta, the heart is the seat of consciousness in living creatures; when the heart is overwhelmed by Tamas, sleep occurs.^[10] Acharya Vagbhata states that when the srotas are impeded by kapha, and the sense organs withdraw from their objects due to exhaustion, sleep occurs.^[11]

INTEGRATIVE PHYSIOLOGICAL CORRELATIONS BETWEEN NIDRA AND NEUROTRANSMITTERS

The Ayurvedic regulation of Nidra involves the coordinated functions of different Dosha subtypes and Manas. These functions may be interpreted through modern sleep neurobiology as interacting sleep-promoting and wake-promoting neurotransmitter

systems; however, these associations reflect functional correlations rather than direct biochemical equivalences.

Prana Vata: It is situated in the Shiras, governs Buddhi, Indriya and Manas and plays an important role in the maintenance of awareness and coordination of their activities.^[12] Its functions can be broadly understood under two categories. The first includes higher mental functions, comprising regulation of Manas and Buddhi, coordination of sensory activities and maintenance of awareness. The second includes lower physiological and reflex activities occurring outside the brain. In the context of the sleep-wake cycle, the higher mental and sensory regulatory functions of Prana Vata can be functionally correlated with acetylcholine and dopamine pathways involved in cortical activation and arousal. Cholinergic neurons in the brain play an important role in the regulation of the sleep-wake cycle. During wakefulness, these neurons exhibit increased firing activity and release acetylcholine (ACh) at the level of the cerebral cortex, thereby promoting cortical activation and alertness. During normal sleep, particularly with the transition into slow-wave sleep, the activity of these neurons decreases. Persistent activation of cholinergic neurons can therefore interfere with the initiation and maintenance of sleep. Dopamine also contributes to the modulation of arousal responses and has an opposing relationship with acetylcholine in the basal ganglia. Thus, the functions attributed to Prana Vata in maintaining awareness, regulating Manas and coordinating Indriya activity may be understood in relation to these cholinergic and dopaminergic pathways. In this context, Prana Vata vitiation may be considered to manifest as a state of heightened mental and sensory activity, interfering with the withdrawal of the Indriyas required for sleep. Such persistence of arousal may disturb the normal reduction in cholinergic activity associated with sleep and thereby contribute to difficulty in sleep initiation and maintenance, ultimately manifesting as Nidranasha.

Udana Vata: It is described as responsible for Vak-pravrtti, Prayatna, Urja, Bala, Varna and Smriti.^[13] Among these functions, Prayatna is particularly relevant to the regulation of the sleep-wake state. As explained in the Sarvangasundara commentary on Ashtanga Hridaya, Prayatna refers to the effort or initiative involved in performing actions and engaging with objects. Thus, Udana Vata can be understood as contributing to the active purposeful engagement of the individual with the external environment. In the context of the sleep-wake cycle, this function of Prayatna can be considered in relation to the physiological processes responsible for wakefulness, alertness and activation. From the modern neurophysiological perspective, norepinephrine (noradrenaline) is an important wake-promoting neurotransmitter. Noradrenergic neurons are located predominantly in the locus coeruleus (LC) of the brainstem. Their activity varies according to the sleep-wake state: firing is high during wakefulness, decreases

during NREM sleep and becomes minimal during REM sleep. The reduction in noradrenergic activity is therefore associated with the transition from an activated waking state towards sleep. The functions of Udana Vata such as Prayatna and Urja may therefore be viewed as having a functional correspondence with the wake-promoting activity of the noradrenergic system. During normal wakefulness, increased activity of noradrenergic neurons supports the state of alertness and engagement, whereas their reduction during sleep permits the organism to move away from the active waking state. Thus, Udana Vata may be discussed in the context of maintaining the functional state required for wakefulness, while its appropriate reduction is compatible with the physiological transition towards sleep.

Sadhaka Pitta: It is situated in Hridaya and is associated with higher mental functions such as Buddhi, Medha, Smriti and emotional processing.^[14] In the context of higher mental functions, Hridaya may be understood functionally as Shirogata Hridaya,^[15] which is concerned with cognitive and emotional activity. According to the explanation of Dalhana, Sadhaka Pitta contributes to the removal of the Avarana of Tamas and Kapha, thereby facilitating clarity of perception and cognitive functioning.^[16] Bhela also attributes functions related to the conduction and processing of sensory information to Sadhaka Pitta. Thus, its role may be understood primarily in relation to the active cognitive and emotional functioning of Manas, rather than merely as a mediator of physical wakefulness. From the modern neurophysiological perspective, cognitive and emotional activation during wakefulness involves the coordinated activity of several neurotransmitter systems, including dopamine, noradrenaline, serotonin and acetylcholine. These systems contribute to arousal, attention, cognition and emotional processing. Therefore, the functions attributed to Sadhaka Pitta may be considered functionally comparable to the neurochemical mechanisms underlying cognitive and emotional activation, without equating Sadhaka Pitta with any single neurotransmitter. When Sadhaka Pitta becomes disturbed due to Manasika Nidanas such as Krodha, Shoka, Bhaya and Chinta, excessive mental activity may occur. Such persistent cognitive activity can oppose the mental withdrawal required for sleep and interfere with the transition from wakefulness to Nidra. In this manner, disturbance of Sadhaka Pitta may be understood as contributing to Nidranasha predominantly through the cognitive-emotional component of hyperarousal.

Tarpaka Kapha: It is situated in the Shiras and is described as performing the functions of Snehana and Indriya tarpana, thereby nourishing, protecting and stabilising the Indriyas and supporting the stability of Manas.^[17] During Nidra, there is a physiological reduction in sensory responsiveness and interaction with the external environment, allowing the Indriyas to undergo uparama and the Manas to become relatively disengaged from external sensory stimuli. Thus, the

nourishing and stabilising functions of Tarpaka Kapha may be understood in relation to the maintenance of this state of reduced sensory and cognitive activity. From the perspective of modern sleep neurobiology, sleep is maintained through coordinated inhibition of wake-promoting neuronal systems, with GABAergic mechanisms constituting an important component of this process. However, GABA should not be considered a direct biochemical equivalent of Tarpaka Kapha. Rather, Tarpaka Kapha can be interpreted at a functional level, representing the stabilising and sustaining aspect that supports the withdrawal and quiescence of the Indriyas and Manas during sleep.

CONCLUSION

The understanding of Nidra can be approached through both Ayurvedic and modern neurophysiological perspectives. Modern sleep physiology explains the regulation of the sleep-wake cycle through the coordinated activity of multiple neurotransmitter systems, while Ayurveda describes Nidra through the functional interplay of Dosha, Manas, Indriya and Tamas. The roles of Prana Vata, Udana Vata, Sadhaka Pitta and Tarpaka Kapha can be functionally discussed in relation to different aspects of arousal, cognition, emotional activity, sensory regulation and sleep stability. Such correlations provide a conceptual bridge between the two systems without implying a direct one-to-one equivalence between an Ayurvedic entity and a specific neurotransmitter. This integrative understanding may provide a broader framework for interpreting the pathophysiology of Nidranasha and for exploring Ayurvedic approaches to sleep disorders.

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