



Review Article

CHRONOBIOLOGY AND ITS AYURVEDIC UNDERSTANDING

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ABSTRACT

Rhythm is an essential component of life. Chronobiology is a branch of biology concerned with biological rhythms i.e., the time related phenomena in living organisms. It is a relatively young and fast evolving research field. Circadian rhythm, ultradian rhythm and infradian rhythm are some examples for biological rhythm. The three important divisions of Chronobiology are chronophysiology, chrono pathology and chrono pharmacology.

Although chronobiology has been considered as a relatively new branch of human biology, its roots can be traced out in ancient archives and cultural practices. Ancient Ayurvedic scholars observed the chronobiological changes in physiology and pathology giving utmost importance to rhythmicity which in turn signifies *Kaala*. Physiologic factors such as *Tridosha*, *Agni*, *Bala*, *Vega* and so many other factors like *Artava* exhibit rhythmicity. Loss of such rhythmicity affects health. Also, the *Hina*, *Mithya* and *Atiyoga* of *Kaala* are one among the three main etiological factors for diseases. Hence, proper health needs maintenance of the rhythm. This can be achieved by following Ayurvedic guidelines like *Dinacharya*, *Rithucharya* etc. Rhythmic temporal patterns play an important role in the therapeutics also.

INTRODUCTION

The relationship between chronobiology and Ayurveda is characterized by a harmonious interplay that acknowledges the intrinsic connection between the body's natural rhythms and holistic well-being. While chronobiology, a field of study dedicated to understanding biological cycles and their impact on physiological processes, explores the intricate patterns of ultradian rhythm, circadian rhythm, infradian rhythm and circannual rhythm. In addition to its application in physiology, chronobiology extends its relevance to pathology and pharmacology. Ayurveda, recognizes the importance of aligning daily routines with nature's rhythms for optimal health. Both disciplines converge in their emphasis on the cyclical nature of life, with Ayurveda guiding individuals to harmonize with these natural cycles to promote balance in physical, mental, and emotional aspects.

Chronobiology is a field of biology that examines the generation of biological rhythms in various creatures and in many parts of body, and their adaptive fitness to solar and lunar related periodic phenomena.^[1] Chronobiology derives its name from the ancient Greek words "Chronos," meaning time, and "biology," pertaining to the study or science of life ^[2]. As such, Chronobiology is the scientific exploration of biological rhythms, specifically examining the impact of the 24-hour cycle on our biochemistry and subsequent behaviours. Biological rhythms manifest ubiquitously, evident in daily alterations in sleep and wakefulness, annual bird migration, flowering and fruiting patterns in certain plants, and the tidal variations in the behaviour of coastal animals. These rhythms in living organisms, known as biological rhythms, i.e., periodic biological fluctuation in an organism that corresponds to, and is in response to, periodic environmental change^[3]. Chronobiology as a field of study investigates how these rhythms are influenced by cues from the external environment. Biological rhythms are broadly classified into Ultradian rhythm, Infradian rhythm, Circannual rhythm and Circadian rhythm.^[4] Ultradian rhythm involves recurrent cycles lasting less than 24 hours, such as the minute REM cycle, hourly nasal cycle, and various physiological activities like growth hormone

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production, blood circulation, blinking, pulse, hormonal secretions, heart rate, thermoregulation, micturition, and bowel activity. Infradian rhythm comprises cycles with periods exceeding 24 hours, exemplified by the menstrual cycle and Seasonal Affective Disorder (SAD). Circannual rhythm represents cycles with an approximate one-year period, evident in phenomena such as migration to and from breeding sites, hibernation, reproduction cycles, and aestivation. Circadian rhythm, originating from the Latin words "circa" (approximate) and "dies" (day), is a circadian rhythm or circadian cycle, is a natural oscillation that repeats roughly every 24 hours. Circadian rhythms can refer to any process that originates within an organism (i.e., endogenous) and responds to the environment (is entrained by the environment). Circadian rhythms are regulated by a circadian clock whose primary function is to rhythmically co-ordinate biological processes so they occur at the correct time to maximize the fitness of an individual [5]. Circadian rhythms play a crucial role in medicine, coordinating with daily physiological cycles like sleep-wake patterns, digestion, temperature regulation, and hormone secretion.

In the medical domain, three disciplines consider the influence of time: Chronophysiology, Chrono pathology and Chrono pharmacology. Each of these disciplines explores the intricate relationship between temporal factors and various aspects of human physiology, pathology, and pharmacology.[6]

AIM OF THE STUDY

To explore chronobiological insights in Ayurvedic literature and to re-establish the significance of *Kaala* in life regulation.

METHODOLOGY

This study involved a comprehensive examination of the *Ayurvedic Samhitas* and related commentaries. Additionally, relevant insights were sought from contemporary medical science literature, including articles, journals, and other published works, contributing to a thorough and multidimensional review process. The gathered materials underwent thorough scrutiny, and a systematic content analysis was conducted. This analytical approach aimed to

elucidate the concept of chronobiology within the context of Ayurveda, particularly its understanding related to the fundamental concept of *Kaala*.

History of Chronobiology in Ayurveda

Ayurveda has meticulously examined the chronobiological shifts in human physiology and the manifestation of diseases in a comprehensive manner. However, in the historical context of chronobiology, the contributions of ancient Ayurvedic scholars have often been overlooked. The foundations of the concept of chronobiology can be discerned within Ayurvedic literature itself. Early authoritative texts in Ayurveda, such as the *Susruta Samhita*, believed to have been authored around 500 B.C., have expounded upon the influence of *Kaala* on health, the emergence of diseases, and the corresponding preventive measures.

Even predating the era of Ayurveda, there is evidence of the veneration of *Kaala* as a significant entity in the *Vedas*. The *Atharva Veda*, for instance, contains hymns that extol the virtues of *Kaala*, *Surya*, and others. This attests to the awareness of our ancestors regarding the pivotal role of these factors in sustaining life.

Importance of Lokapurusha Samya Vada

Our *Acharyas* have astutely observed and comprehended that environmental factors exert influence on all living organisms, considering them as microcosms of the universe. They coined the theory known as *Lokapurusha Samya Vada*, positing that man is a miniature replica of the universe. Accordingly, all changes in the environment affect human beings, given that everything originates from *Panchamahabhutha* [7].

Chronophysiology in Ayurveda

Physiological functions influenced by *Kaala* are dispersed throughout our *Samhita*, and these can be expounded upon within the framework of the concept of chronophysiology.

Doshik Rhythm:[8] Physiological variations of *Dosha* based on factors such as age, diurnal cycles, and stages of digestion are systematically presented in the table below. The *Tridosha* system adheres to a biological rhythm in its functional patterns, aligning with age, diurnal fluctuations, and distinct stages of digestion.

Table 1: Doshik rhythm [9]

S.No	Variables	Vata	Pitta	Kapha	Rhythm
1	Age	Vridha	Youvana	Balya	
2	Day	Aparahna	Madhyahna	Purvahna	Ultradian
3	Night	Apararathri	Madyarathri	Purvarathri	Ultradian
4	Stage of digestion	End of digestion	During digestion	Beginning of digestion	Ultradian

Rithubhavas in a day:[10] *Acharya Susrutha* systematically correlated six seasons with distinct phases of the day and night. The characteristics of

Vasantha, *Greeshma*, and *Pravrit* are manifested in the body during the forenoon, midnoon, and afternoon, respectively. Similarly, the features of *Varsha*, *Sarath*,

and *Hemantha* are observed during the evening, midnight, and early morning, respectively. In this manner, *Acharya Susruta* eloquently conceptualized a year as analogous to a day, effectively aligning the circannual rhythm with the circadian rhythm.

Table 2: Rithubhavas in a day

Rithu	Day
<i>Vasantha</i>	Forenoon
<i>Greeshma</i>	Midnoon
<i>Pravrit</i>	Afternoon
<i>Varsha</i>	Evening
<i>Sarath</i>	Midnight
<i>Hemantha</i>	Early morning

Physiological status of *Agni* according to season^[11]

Teekshnagni is observed during the seasons of *Sisira* and *Hemantha*, while *Madhyamagni* is evident in *Vasantha* and *Sarath*. Contrarily, during the seasons of *Greeshma* and *Varsha*, *Mandagni* prevails.

Table 3: Agni according to Season

Rithu	Agni
<i>Sisira</i>	<i>Teekshnagni</i>
<i>Vasantha</i>	<i>Madhyamagni</i>
<i>Greeshma</i>	<i>Mandagni</i>
<i>Varsha</i>	<i>Mandagni</i>
<i>Sarath</i>	<i>Madhyamagni</i>
<i>Hemantha</i>	<i>Teekshnagni</i>

Seasonal variation in *Sharira bala*^[12]

The physiological strength of an individual exhibit variations with the changing seasons. During the seasons of *Greeshma* and *Varsha* rithu, the physical strength tends to be diminished. In contrast, during *Vasanta* and *Sarat* rithu, the body demonstrates a moderate level of strength, while the peak of physical strength is achieved during *Sisira* and *Hemanta* rithu.

Table 4: Rithu and Sharira bala

Rithu	Sharira Bala
<i>Sisira</i>	<i>Pravara</i>
<i>Vasantha</i>	<i>Madhyama</i>
<i>Greeshma</i>	<i>Avara</i>
<i>Varsha</i>	<i>Avara</i>
<i>Sarath</i>	<i>Madhyama</i>
<i>Hemantha</i>	<i>Pravara</i>

Artava^[13]

Artava exemplifies an infradian rhythm, constituting a cyclic pattern of 28 days within the female reproductive system.

Garbhakaala^[14]

The gestational period in humans, known as *Garbhakaala*, spans duration of 10 months and is aligned with the circannual rhythm.

Chronopathology in Ayurveda

Various diseases exhibit aggravation based on temporal characteristics. Similarly, in Ayurveda, numerous pathological conditions are noted to be significantly influenced by the concept of *Kaala*. Disruptions in the circadian rhythm of human physiology have emerged as prominent contributors to the manifestation of diseases. According to Ayurvedic principles, the primary etiological factors responsible for all diseases encompass *Hina*, *Mithya*, and *Atiyoga* of *Kaala*, *Artha*, and *Karma*.^[15]

In the 13th chapter of the *Sootrasthana* in the *Ashtanga Hridaya*, *Acharya Vagbhata* elucidates that *Doshas* remain in a latent state in their respective locations, awaiting the triggering causes for their vitiation. When favourable conditions, including *Kaala*, arise, these *Doshas* undergo exacerbation within the domains of other *Doshas*. These insights underscore the significance of *Kaala* in the context of pathology.^[16]

This concept is aptly illustrated in the context of *Vishama Jwara*. *Doshas*, initially in a latent state within the *Dhatus*, become active when stimulated by the influences of *Rithu*, *Ahorathra*, *Dosha*, *Kaala*, *Artha* and *Manas* giving rise to the manifestation of *Jwara*^[17]. Conversely, when these influencing factors are unfavourable, the *Doshas* revert to a dormant state, thereby contributing to a period free from disease.

Each instance of *Vishama Jwara* follows a periodic pattern with consistent disease-free intervals. For instance, *Satata Jwara* presents itself twice within a single *Ahorathra*, *Anyedhushka* manifests once in an *Ahorathra*, *Triteeyaka* occurs every third day, and *Chathurthaka* recurs every fourth day.^[18]

Various disorders mentioned in Ayurveda exhibit rhythmicity in their presentation, including *Vataja sophra*, *Kaphaja sophra*, *Sangrahani*, *Suryavarta*, *Kaphaja sula*, *Pithaja sula*, *Vataja sula*, and others. The chronopathological behavior of diseases, as per the season, encompasses *Vatika roga*, *Paithika roga*, *Kaphaja roga*, and *Rakthaja roga*, occurring specifically in *Varsha*, *Sarath*, *Vasantha*, and *Sarath* rithu, respectively. Similarly, conditions such as *Udarda*, *Tamaka swasa*, and *Arsas* develop in specific seasons, indicating a seasonal influence on their occurrence. Ayurveda provides examples of episodic diseases, including *Ardita*, *Bahyayama*, *Apasmara*, *Dandaka*, *Hanusthamba*, *Akshepaka*, *Aganthuja Unmada*, and others.

Bridging in Chronobiology

Physiology and pathology are interconnected aspects rather than distinct entities. Physiology can transform into pathology when it surpasses established limits. This phenomenon is elucidated through the concept of *Kriyakaala*. Within the framework of this concept, *Greeshma* marks the progression of *Vata* through *Chaya*, *Prakopa*, and *Prasama* across three seasons, while *Varsha* onward represents the corresponding phases for *Pitta*. In the case of *Kapha*, these transitions transpire during the three seasons from *Sisira* onward. This framework provides insights into the regular physiological variations of *Dosha* in relation to seasonal changes. [19]

Susruta's shat Kriyakaala expounds upon the six distinct stages of *Dosha* accumulation that progressively culminate in the onset of diseases. The natural occurrences of *Chaya* and *Prakopa* of *Doshas* within the body are intrinsic to each season but can evolve into pathological states when proper adherence to *Rithucharya* and *Rithushodana* is lacking. The significance of *Kriyakaala* lies in its potential for timely intervention [20], thereby establishing a connection with pharmacology. Consequently, *Kriyakaala* can be regarded as the intermediary between chronophysiology, chronopathology, and chronopharmacology.

Chronopharmacology in Ayurveda

The temporal dimension holds significant importance in the pharmacological context of Ayurveda. Concerning treatment, time is categorized into two types: *Kshanadi kaala* and *Vyadhi avastha kaala*. *Kshanadi kaala* involves the measurement of time in units such as *Kshana*, *Kaashta* etc establishing the timing for medication, administering procedures, and describing the correlation with seasonal and daily patterns. *Vyadhi avastha kaala* pertains to different stages of a disease, encompassing *Aama*, *Pachyamaana*, and *Pakwavastha*.

Time plays a crucial role in determining the efficacy of medicine, as the same treatment administered at different times can yield varied effects. *Acharya Vagbhata* emphasizes the concept of *Kalobheshajayogakrit*, [21] asserting that a medicine exerts its optimal action when administered at the proper time. To mitigate variations, *Acharyas* elucidate specific times for medication, known as *Aushadha sevana kaala*. The concept of chronopharmacology can be likened to *Aushadha sevana kaala* [22]. While *Charaka Samhita*, *Susruta Samhita*, and *Ashtanga Hridaya* outline 10 *Aushadha sevana kaala*, *Ashtanga Sangraha* introduces 11 distinct timings for medication.

Regulators of Biological Rhythm

Optimal health can be attained by adhering to a consistent physiological rhythm within the body. This can be accomplished through the practice of

Dinacharya, *Rithucharya*, *Rithu sodhanas*, *Aaharavidhi vidhana*, *Sadvritha palana*, and *Aachara rasayana*.

DISCUSSION

Living organisms undergo continuous influence from external stimuli, many of which manifest cyclic patterns. Predictable daily and seasonal environmental changes enable animals, including humans, to anticipate these cyclic events through periodic and predictable adjustments in internal conditions. Biological rhythms are those rhythms that arise in organisms to match external geophysical rhythms with comparable period. The field of chronobiology studies these rhythms in living organisms and how they are tuned by cues from the outside world. The study of this phenomenon falls within the domain of chronobiology, which encompasses chronophysiology, chronopathology and chronopharmacology. Despite chronobiology being a relatively recent scientific discipline, our ancient *Acharyas* recognized the rhythmicity of life with respect to *Kaala* centuries ago. In Ayurveda, *Kaala* is considered a significant factor influencing health. Ayurveda extensively explores the profound relationship between living beings and their environment, elucidating how environmental changes significantly impact human biology. According to Ayurveda, everything on earth is derived from *Panchamahabhutha*. The human body is considered a micro part of the infinite macrocosm, sharing elements with nature. There are substantial similarities between the human body and nature at both anatomical and physiological levels. The balance of universal activities such as *Visarga*, *Aadana*, and *Vikshepa* is maintained by the moon, sun, and air, and analogous functions are carried out in the human body by *Tridosha*, namely *Vata*, *Pitta* and *Kapha*.

Ashtanga Hrudaya explicates the concept of circadian and ultradian rhythms succinctly with the *Shloka*: "*Vayo Ahoratribhuktanam te Antamadhyaadigaha Kramath*," [8] signifying that *Vata*, *Pitta*, and *Kapha* distinctly manifest their presence at the end, middle, and beginning of life, day-night cycles, and digestion processes. Each *Dosha* demonstrates diurnal variations, which further fluctuate based on digestion phases and age. *Acharya Susrutha* has analogized the six seasons with distinct phases of day and night. In doing so, he has succinctly summarized a year as a day, thereby equating the circannual rhythm to the circadian rhythm. Likewise, Ayurveda comprehensively explores the rhythmic variations in *Agni* and *Sharira bala* corresponding to different seasons. *Artava* and *Garbha Kaala* serve as examples of infradian and circannual rhythms, respectively.

Numerous diseases exhibit exacerbation in accordance with temporal characteristics. Similarly, the pathologies of many diseases are noted to be significantly influenced by *Kaala*, Ayurvedic principles

assert that the improper application or misalignment of *Kaala*, categorized as *Hinayoga*, *Mithyayoga* and *Atiyoga* is regarded as a primary etiological factor for various ailments. [15]

In the realm of chronobiology, the connection can be established through the concept of *Kriyakaala*. Physiology and pathology are interconnected aspects, with physiology transitioning into pathology when it surpasses established limits. The concept of *Kriyakaala* serves to illustrate this phenomenon. One significant aspect of *Kriyakaala* is its role as a critical time for intervention, creating a link with pharmacology. Consequently, *Kriyakaala* can be viewed as a pivotal bridge between chronophysiology, chrono pathology, and chrono pharmacology. Timing plays a crucial role in determining the efficacy of medication. The same medicine, when administered at different times, yields varying effects. The proper action of a medicine is realized only when it is administered at the right time. To mitigate variations in effectiveness, specific timings have been elucidated by ancient scholars, referred to as *Aushadha sevana kaala*. This concept aligns with the principles of chrono pharmacology.

Achieving optimal health is possible through the maintenance of a consistent physiological rhythm within the body. This objective can be realized by incorporating disciplined practices such as *Dinacharya*, *Rithucharya*, *Rithu sodhanas*, *Aaharavidhi vidhana*, *Sadvritha palana*, and *Aachara rasayana* into one's routine. It is recommended that individuals diligently follow these practices to effectively regulate their lives.

CONCLUSION

Chronobiology, which provides insights into human biological rhythms and those of other organisms, has been a concept prevalently utilized by the ancestors of Ayurveda for centuries, well before its emergence as a separate scientific discipline. The ancient *Acharyas* must have possessed awareness of biological rhythms, evident in the significance accorded to *Kaala* in Ayurveda. The study of chronobiology has played a crucial role in re-establishing the Ayurvedic understanding of the relationship between *Kaala* and health, bridging the traditional wisdom with contemporary scientific insights.

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