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ORIGINAL ARTICLE

A Study on Importance of Circadian Rhythm in Human

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ABSTRACT

The circadian rhythm serves as a biological clock inherent to all animals, plants, and certain microorganisms. It can be characterized as a 24-hour cycle that governs the sleep-wake pattern and plays a crucial role in the regulation of hormone production, among various other physiological processes. This rhythm is primarily controlled by the suprachiasmatic nucleus (SCN) located in the hypothalamus, which is situated centrally in the brain, just above the brainstem, and utilizes the neurotransmitter gamma-amino butyric acid (GABA). External factors, particularly environmental cues and sunlight, significantly influence the circadian rhythm, prompting the body to release specific hormones such as melatonin. This hormone induces feelings of drowsiness or sleep, followed by a decrease in melatonin levels and an increase in cortisol upon waking, thereby energizing the body. Maintaining a proper circadian rhythm is vital for an individual's overall health, as disruptions to this cycle can result in both physical and mental health issues.

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INTRODUCTION

The term circadian comes from the Latin circa, meaning "around", and dies, meaning "day". Processes with 24-hour cycles are more generally called diurnal rhythms; diurnal rhythms should not be called circadian rhythms unless they can be confirmed as endogenous, and not environmental. It is important to reserve the term "circadian rhythms" for those that can be verified as endogenous rather than influenced by environmental factors.

Franz Halberg introduced the term "circadian" in 1959. In his original definition, he noted that "circadian" combines "circa" (approximately) and "dies" (day), suggesting that certain physiological cycles are close to 24 hours, though not necessarily exact. Thus, "circadian" can be applied to all rhythms that span 24 hours, regardless of whether their individual or average durations deviate slightly from this timeframe.

Circadian rhythm encompasses the physical, mental, and behavioral changes that occur in most organisms over a 24-hour period, primarily influenced by the presence or absence of light. While distinct from the biological clock, the two concepts are interconnected, as the biological clock regulates the circadian rhythm and associated bodily processes. This natural cycle of changes affects various functions, including sleep, body temperature, hormone levels, and appetite. Disruptions in circadian rhythms have been associated with

conditions such as obesity, diabetes, depression, bipolar disorder, seasonal affective disorder, and sleep disorders like insomnia. Often referred to as the "body's clock," circadian rhythms are governed by a circadian clock that synchronizes biological processes to optimize an individual's fitness. These rhythms have been extensively documented across animals, plants, fungi, and cyanobacteria, indicating that they have evolved independently within each of these life kingdoms.

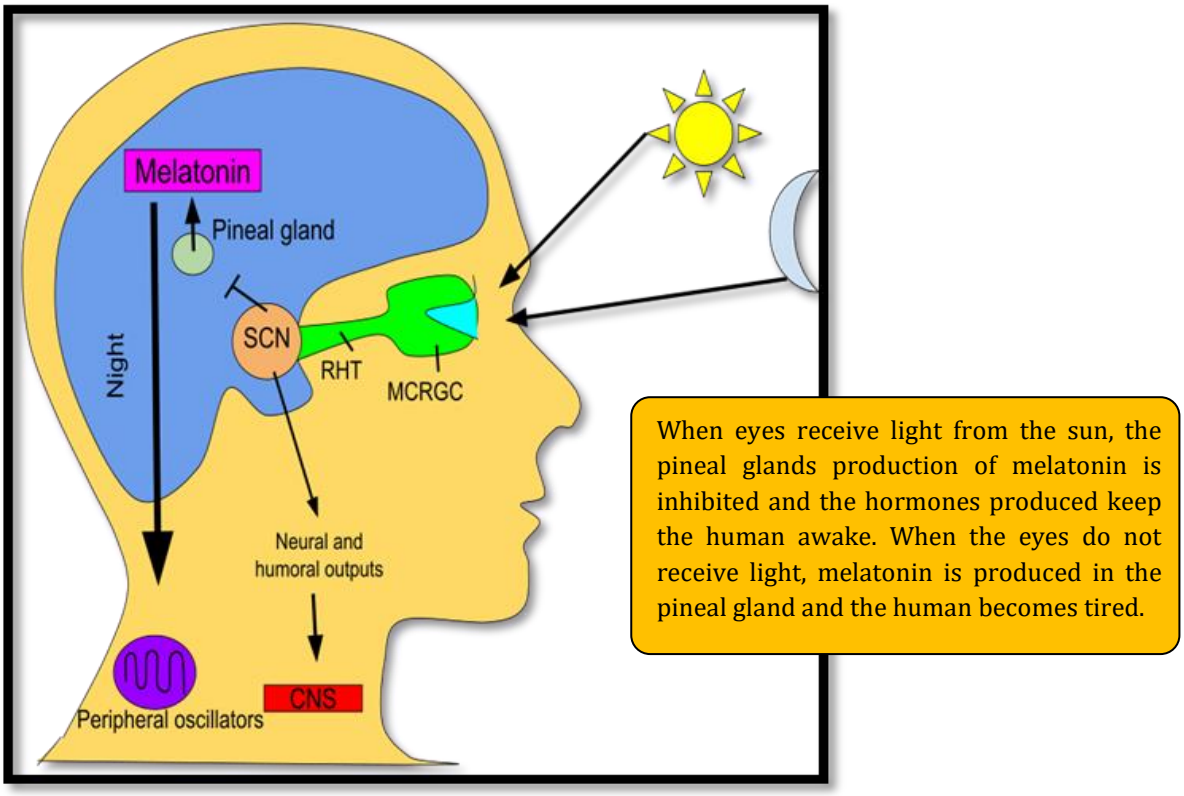


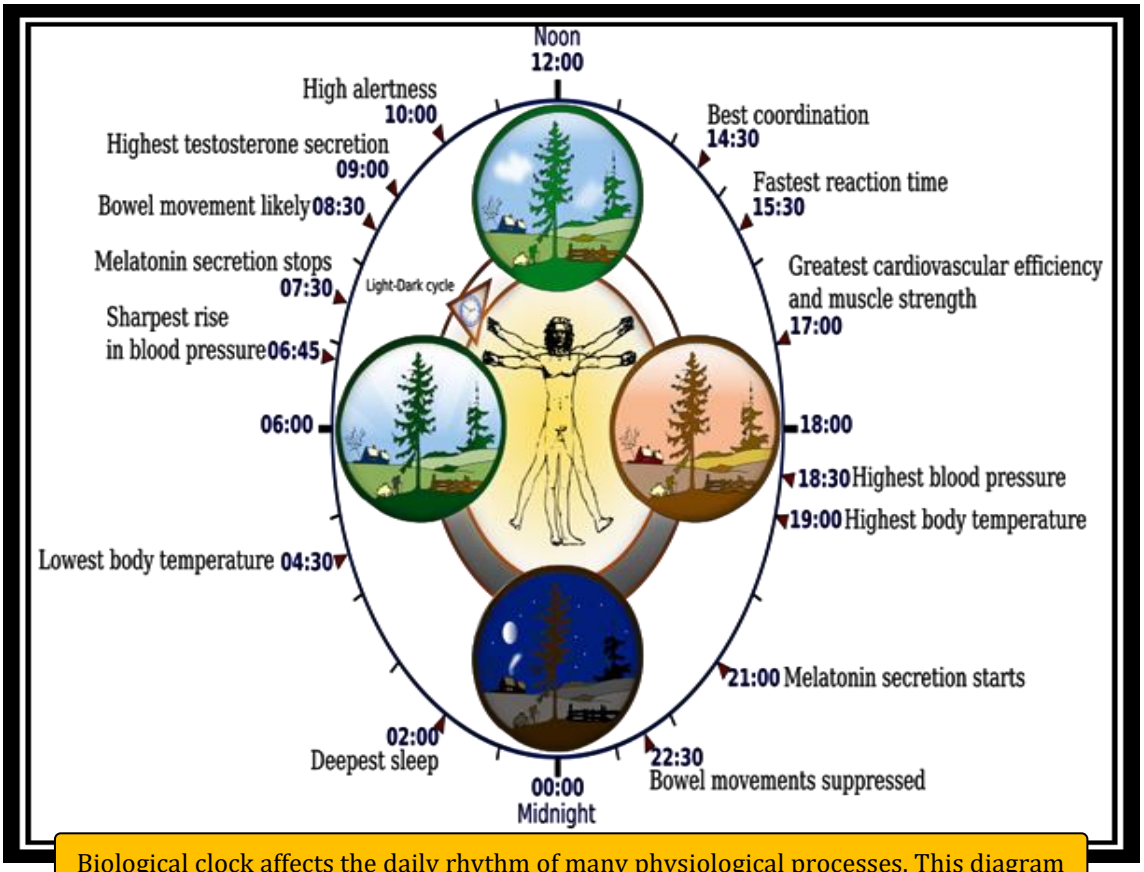
Fig. 1: Circadian Rhythm Mechanism in Human

THE IMPORTANCE OF CIRCADIAN RHYTHM

The circadian rhythm is extremely important because it regulates the sleep-wake cycle which is responsible for the fulfillment of multiple biological needs in the brain and the body like memory consolidation, the ability to maintain focus, attention spans, and alertness, things like sluggish response times may be observed in individuals with a disturbed circadian rhythm. Another function consists of replenishing energy by sleeping, a disturbed circadian rhythm can lead to changes in the inferior parietal cortex, occipital cortex, prefrontal cortex, and thalamus region of the brain resulting in them having delayed or disoriented sensory information. A newly found key function of sleep is that good sleep is responsible for the removal of toxins from the human brain, these toxins are metabolic byproducts (like amyloid beta) and are referred to as the debris of the brain they are harmful to the neurons and are directly associated with Alzheimer's Disease. The cardiovascular system is also greatly dependent on the circadian rhythm, during the state of rest the heart can recover lower blood pressure and lower heart rates which initiates repairs.

On the other hand people with a disoriented sleep cycle have blood pressure and cardiovascular issues and may exhibit hypertension. The immune system also shows a direct correlation with the circadian rhythm, people with sleep deprivation may even exhibit half the antibody response in comparison to that of people with a good quality of sleep. Furthermore, people with sleep deprivation can be 2% to 300% more vulnerable to the rhinovirus than people with satiated sleep. Circadian rhythm is also responsible for

the regulation of appetite in individuals and people with a disturbed sleep cycle may show unhealthy eating habits which leads to gastrointestinal issues or issues like indigestion or constipation, individuals may gain weight which can lead to obesity after a while. The response of metabolic systems to food also gets disoriented and impaired leading to diabetes due to sudden metabolic changes. A disoriented sleep cycle is responsible for increased suicidal ideation, increased hostility and increased risk of depressive disorders, high anxiety levels and emotional vulnerability.



Biological clock affects the daily rhythm of many physiological processes. This diagram depicts the circadian patterns typical of someone who rises early in morning, eats lunch around noon and sleeps at night (10p.m.). Although circadian rhythms tend to be synchronized with cycles of light and dark, other factors– such as ambient temperature, meal times, stress and exercise - can influence the timing as well.

Fig. 2: Characters of the human circadian biological clock

HUMAN CIRCADIAN RHYTHMS

Circadian rhythms in humans can be investigated by measuring the rhythms of peak performance for physiological and behavioral processes. Figure 2 shows examples of processes in humans that display these rhythms. Notice that, in most cases, there is a period of peak activity or peak performance during the 24-hour cycle. Look at the example of skin cell division (mitosis) which peaks after midnight for about a two hour period. The time that it takes for a circadian rhythm to run one cycle is called the period of the rhythm. In most organisms the natural or innate period of the circadian rhythm is not exactly 24-hours, however, the regular changes in light and temperature that we experience in our environment help us to adjust our biological clock to a 24-hour day. This called entrainment.

Experiments have clearly demonstrated that the human biological clock ticks with an innate period of 24.3 hours, slightly longer than the 24-hour day. This was measured by

putting people into constant environmental conditions where light and temperature did not change at all over a period of several months, allowing their biological clocks to 'free-run'. Scientists measured when activity started and stopped in the people taking part in the experiment. These measurements are graphed to show when the subjects are active.
The graphs of the activity patterns are called actograms. A typical set of results is shown in the actogram in Figure 4.
The actogram in Figure 4 shows the results of activity measurements for one human subject over a period of 87 days (almost 3 months). Look carefully at the X-axis. It covers a period of 48 hours. Each day is shown side by side with the next day so that you can see clearly when the activity patterns start and end.
The human biological clock is adjusted (or entrained) to the 24-hour day on a daily basis by light sensed through the eyes. Morning light 'phase advances' the clock to shift it to an earlier time zone, whereas evening light 'phase delays' the clock to shift it to a later time zone. As our clock ticks with a period slightly longer than 24 hours, it is the morning light that is essential to keep our daily rhythms adjusted to the 24-hour day.

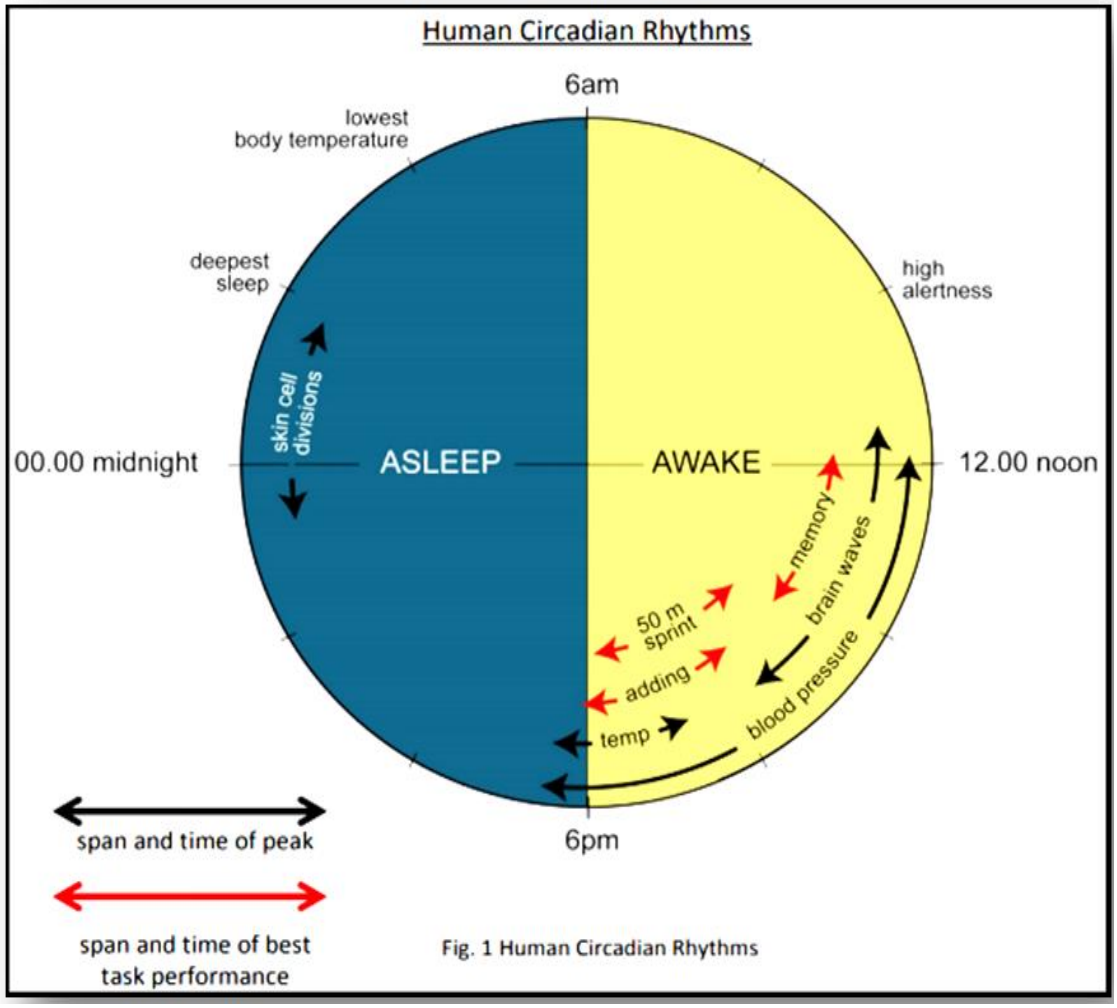


Fig. 3: Human Circadian Rhythm

FIXING THE PROBLEM

Not having a proper sleep cycle is linked to sleep disruption, mood disorders, obesity, diabetes, and mental health problems along with other issues like insomnia. Researchers firmly believe that not having a proper sleep cycle shows a direct correlation with poor mental and physical health. An already disrupted circadian rhythm can only be fixed by healthy behavioral patterns including proper sleep schedules or else a disturbed

circadian rhythm may lead to clinical diseases and disorders which are very tough to cure (like insomnia).

People with unhealthy sleeping habits are advised to take measures like dimming the light and avoiding blue light exposures while individuals with unhealthy sleeping schedules are brought to a consistent sleeping time with minute differences in their sleep schedule by tweaking 10-15 minutes till they get to a regulated and healthy sleep schedule. Exercise may also be advised to someone with an inconsistent sleep cycle as it is a great contributor to the regulation of the circadian rhythm because circadian rhythm is based on multiple biological clocks like the hormonal and body temperature clocks which are operating in tandem and show great improvement on exercising. Avoiding the consumption of alcohol and caffeine (especially in the later hours of the day) is suggested for patients who suffer from a disoriented sleep cycle or a disoriented circadian rhythm over prolonged periods. Alcohol is strongly advised against as the body cannot enter deep REM sleep under the influence of alcohol while REM sleep is extremely important to the body for the rest of the circadian rhythm along with things like muscle recovery. In older people, irritability might be caused due to a disturbed circadian rhythm and a disrupted sleep cycle especially under the influence of alcohol due to the inability to fall asleep due to a sugar spike. Melatonin pills may be advised by a qualified physician to transition the sleep cycle depending on the sleep debt of the patient.

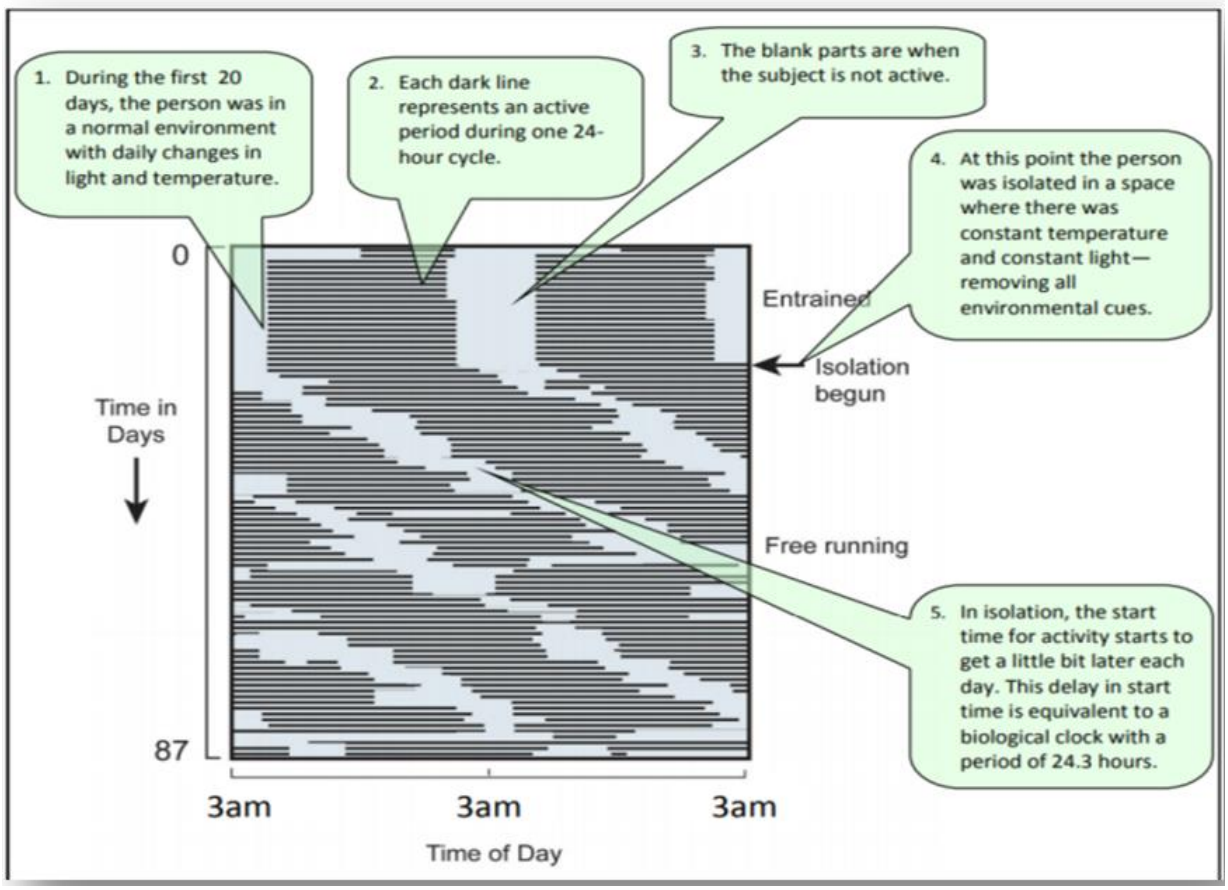


Fig. 4: Activity/ Time Graph for a Human

CONCLUSION

Individuals with an irregular circadian rhythm face an increased risk of various health issues, including cardiovascular diseases, mental health disorders, sleep disturbances, obesity, diabetes, and heightened levels of anxiety. It is crucial to recognize that the consumption of sleep suppressants, such as caffeine, may initially appear innocuous; however, excessive intake can lead to a significant sleep deficit that becomes irreparable,

ultimately disrupting the circadian rhythm and adversely affecting both health and mood. Additionally, it is advisable to limit alcohol consumption due to its detrimental effects on sleep quality and the reduction of REM sleep duration. In the contemporary world, managing screen time poses a challenge, yet individuals should strive to minimize their exposure, as screens emit blue light that adversely impacts the sleep cycle and disrupts the circadian rhythm. Engaging in healthy activities, such as regular exercise, is highly recommended due to its beneficial effects on hormonal balance and circadian regulation.
Furthermore, caution is advised against the excessive use of melatonin supplements, as they do not serve as compensatory measures for sleep deficits but rather provide a temporary solution. Such supplements should only be taken under a physician's guidance, as over-the-counter use can lead to significant disruptions in the circadian rhythm, potentially resulting in insomnia and other disorders, including sleep apnea. Individuals experiencing sudden onset diabetes or unexplained weight gain without prior medical history should consult a qualified sleep specialist, as these symptoms may indicate a disrupted circadian rhythm that requires intervention. Lastly, maintaining a balanced diet and adhering to a well-structured eating schedule can greatly enhance an individual's circadian rhythm and overall health.

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