

A Detailed Study of Different Stages of Sleep and Its Disorders – Medical Physics

M. Santhi & Dr. A. Mukunthan

Department of Physics, Bharath Institute of Higher Education And Research, Chennai – 600073, India

ABSTRACT: After laborious work in day or night, different parts of our body get tired and require a complete rest; just like the machines running continuously for long time are switched off to prevent overheating, which may cause firing also.

Sleeping is a process associated with closed eyes which gives a complete rest for our mental and physical activities except for the functioning of some vital organs like heart, lungs, and process like blood circulation, digestion etc. The duration of sleep is not a constant throughout the period. It depends on different factors like age group, type of hard work, diseases associated with human beings etc.

In the present study we have discussed in detail about the different stages of sleep, mechanism of sleep, diseases related to sleep disorders and remedial treatments.

KEYWORDS: Plasma volume, cardiovascular, respiratory, Gastrointestinal tract, excretory, sweat, lacrimal secretion, muscle tone, REM (Rapid Eye Movement), NREM (Non-Rapid Eye Movement), brain stem, cerebral cortex, EEG (Electroencephalograph), insomnia, hypersomnia, narcolepsy, cataplexy, sleep apnea syndrome, nightmare, night terror, somnambulism & sleep paralysis.

I.INTRODUCTION

Sleep is a process associated with closed eyes for some period which gives a complete rest for our mental and physical activities except for the functioning of some vital organs like heart, lungs, liver and process like blood circulation etc. The depth of sleep is not a constant throughout the sleeping period. It depends on factors like age factors, types of hard work performed and diseases associated with human beings, etc. A perfect sleep for a limited period gives freshness and fairness where as prolonged sleep gives drowsiness and laziness.

In this paper, we have discussed in detail about the different stages of sleep, changes in the activities of the organs of the body, types of sleep, mechanism of sleep, diseases caused by sleep disorders and related treatments or remedies, etc.

II.DISCUSSION

The relaxation (rest) given to mental and physical activities associated with closed eyes for definite time is known as sleep. The duration of sleep is not constant factor. It depends on different factors like age group, amount of hard work, diseases associated with persons, etc.

Duration of sleeping period:

Let us first discuss the age factor. Sleeping period for infants (new born) ranges from 16 to 20 hours per day, for growing children 12 to 14 hours, for adults 7 to 9 hours and for old persons 5 to 7 hours.

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Types of sleep:

There are mainly two types of sleep existing for human beings. They are

Rapid Eye Movement Sleep or **REM** Sleep

Non Rapid Eye Movement Sleep or Non-REM sleep or **NREM** Sleep

REM Sleep: (Active Sleep)

During this sleep period, eye ball move frequently. **Dreams occur** during this period. Through the eye balls move, the sleep is deep and hence is called *paradoxical sleep*. This **covers 25 %** of sleeping period. REM sleep is important since it plays a vital role in the **consolidation of memory**.

Secondly let us summarize the physiological changes taking place during this sleeping period.

Parameter	Activity
1. Plasma volume	decreases by 10%.
2. Heart beat	reduces and ranges from 45 to 60 beats/ min.
3. Blood pressure	decreases to 90-110 mm of Hg range.
4. Respiration	decreases – stroke type or breathing.
5. Secretion of saliva	decreases.
6. Stomach	contraction is more rapid.
7. Urine	formation decreases & specific gravity increases.
8. Secretion of sweat	increases.
9. Lacrimal	decreases.
10. Muscle tone & reflexes	Muscle tone reduces & threshold of most of reflexes increases.
11. Eye ball & pupil	Eye ball move up and down, pupils are constricted.
12. Sleep paralysis	may takes place during asleep or wake up.

NREM Sleep: (Quite Sleep)

During this sleeping period eye balls will not move. **Dreams will not occur** during this period. This sleep covers the remaining **75% of total sleeping period**. Usually REM follows NREM Sleep.

The difference between REM & NREM can be tabulated as follows:

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Body parameters	REM Sleep	NREM Sleep
1. Eye balls movement	Rapid	Absent
2. Dreams	Occur	Absent
3. Muscle twitching	Occur	Absent
4. Blood pressure	Fluctuate	Stable
5. Heart beat	Fluctuate	Stable
6. Respiration	Fluctuate	Stable
7. Body temperature	Fluctuate	Stable

Stages of sleep:

Normally there are five stages of sleep for human beings. One stage is for REM sleep and four stages are for NREM sleep. **Electroencephalograph (EEG)** is mainly used as a tool to discover REM sleep first, and further studies demonstrated that it can be employed successively to study the different stages of sleep in NREM also by displaying different patterns of brain wave.

Polysomnography (PSG) is a multi-parametric test used in the study of sleep and as a diagnostic tool and the test result is known as *polysomnogram*.

There are five phases of sleep: stages 1, 2, 3, 4 for Non-REM sleep and 5th one for REM (rapid eye movement). When we sleep, the body cycles between NREM and REM sleep. Sleep starts from stage 1 of NREM and ends with stage 5 of REM, and begin the cycle again. A normal person spends about 25% REM sleep and 75% NREM sleep. The period of NREM sleep is made up of 4 stages and each stage can last about 5 to 15 minutes.

Stage 1:

This represents the light stage of sleep. During this stage eyes are closed and it is considered as transition period between wakefulness and sleep. During this stage one can awake easily without difficulty. The eye movement and body movements slow down. One can experience a sudden jerky movement of your legs or other muscles. These are known as *hypnic myoclonia or myoclonic jerks*. These can give a sensation of falling. This stage lasts about 10 to 15 minutes. This stage is also known as *stage of drowsiness*. In this stage EEG shows *diminished alpha waves* first and then low voltage fluctuations with *infrequent delta waves*.

Stage 2: (Stage of light sleep)

This stage lasts about 20 minutes. During this stage eye movement stops and brain waves (activity of brain) becomes slower. The brain begins to bursts of rapid, rhythmic brain activity known as *sleep spindles*. During this period EEG shows *intermittent peaks* and valleys at a frequency of 14 per second (superimposed by *low voltage delta waves*). This represents the periods of muscles relaxation. In this stage body temperature decreases and heart beats begin to slow. At this point body enters into deep sleep.

Stage 3:

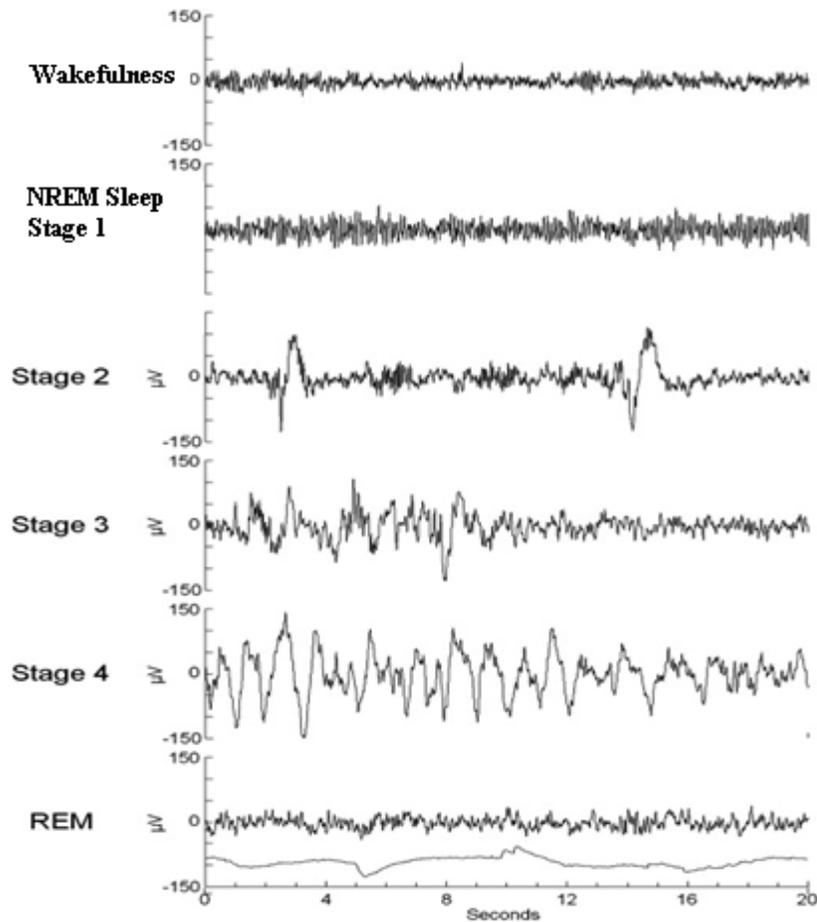
This represents the *second stage of deep sleep*. In this period brain gives rise to slow delta waves with low frequency and high amplitude. In this stage it is very difficult to wake someone up. Stage 3 and stage 4 are important for

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feeling refreshed in the morning. If these stages are short, sleep will not feel satisfying. Some sleep disorders like *bed-wetting and sleep walking* are more likely to occur at the end of *stage 4* of sleep.



EEG curves of brain signals

III.MECHANISM

Sleep occurs due to the activity of some sleep inducing center in brain. Stimulation of these centers induces sleep. Damage of these sleep centers results in *sleeplessness* or *persistent wakefulness* called *insomnia*.

Sleep Centers:

Complex pathways between the reticular formation of *brainstem*, *diencephalons* and *cerebral cortex* are involved in the onset and maintenance of sleep. However, 2 centers are located in brainstem, which induce sleep. Recently, many more areas are identified in the brain of animals, which induce sleep. Inhibition of ascending reticular activating system also results in sleep.

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Role of Raphe Nucleus:

This is situated *in lower pons and medulla*. Activation of this results in NREM sleep. This is due to release of *serotonin* by the nerve fibers arising from this nucleus. *Serotonin* induces NREM sleep.

Role of Locus Ceruleus of Pones:

Activation of this produces REM sleep. *Noradrenaline* released by the nerve fibers arising from locus ceruleus induces REM sleep.

Inhibition of Ascending Reticular Activating System (ARAS):

The ARAS is responsible for wakefulness because of its afferent and efferent connections with cerebral cortex. The inhibition of *ARAS induce* sleep. The lesion of ARAS leads to *permanent somnolence, i.e.coma*.

Sleep Disorders:

Insomnia:

It's the *inability to sleep or abnormal wakefulness*. This is the most common sleep disorder. It occurs due to systemic illness or mental conditions such as psychiatric problems, alcoholic addiction and drug addiction.

Acute vs. Chronic Insomnia:

Insomnia also varies in how long it lasts and how often it occurs. It can be *short-term (acute insomnia)* or can last a *long time (chronic insomnia)*. It can also come and go with periods of time when a person has no sleep problems. Acute insomnia can last from *one night to a few weeks*. *Insomnia is called chronic* when a person has insomnia at least three nights a week for a month or longer.

How is insomnia treated?

Acute insomnia may not require any treatment. Mild insomnia often *can be prevented or cured by practicing good sleep habits*. If insomnia makes us hard to function during the day because of our sleepiness and tiredness, the doctor may prescribe *sleeping pills* for a limited time. Rapid onset, *short-acting medications can help in avoiding the effects such as drowsiness*. *It's better to avoid* using over-the-counter *sleeping pills* for insomnia since they may have undesired side effects and tend to lose their effectiveness over time.

Treatment for chronic insomnia includes first treating any underlying conditions or health problems that are causing the insomnia. If insomnia continues, your *sleep specialist* may suggest cognitive *behavioral therapy*. Behavioral approaches help you to change habits that may worsen insomnia and to learn *new behaviors* to help promote sleep. *Techniques such as relaxation, exercise, sleep restriction therapy, stimulus control and reconditioning may be useful*.

Hypersomnia:

Excessive sleep or excessive need to sleep is called hypersomnia. It occurs because of *lesion in the floor of third ventricle*, brain tumors, *encephalitis*, chronic *bronchitis* and disease of muscle. It occurs in *endocrine disorders* such as *myxedema* and *diabetes insipidus*.

Sleep Apnea Syndrome:

It is the *temporary stoppage of breathing during sleep*. It is the disorder involving fluctuations in the rate and force of respiration during REM sleep with short apneic episode. The apnea may be due to reduced stimulation of respiratory centers, arrest of diaphragmatic movements, airway obstruction or the combination of these. When breathing stops, the resultant hypercapnia and hypoxia stimulate respiration.

It occurs in *overweight*, myxedema, enlargement of tonsil and lesion in brainstem. The common features of this syndrome are *loud snoring*, restless movements, nocturnal insomnia, daytime sleepiness, morning headache and fatigue. In severe conditions, hypertension and right heart failure occur.

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How is Sleep Apnea treated?

The persons, who have mild sleep apnea, may be able to treat it on their own *by losing weight, developing good sleep habits, and avoiding alcohol and certain medicines before bed.*

The persons who have moderate to *severe sleep apnea*, they may need to use a breathing device called a *CPAP* (continuous positive airway pressure) that *prevents the airway from closing during sleep. Removing tonsils and adenoids* is often *a curative procedure for children with OSA*. However, this rarely helps adults. There is a more *radical surgery* whereby all or part of soft palate is removed. This entails a lengthy, painful recovery period and less than 40% of patients will have their sleep apnea cured by these *throat surgeries*.

Narcolepsy and cataplexy:

Narcolepsy is the *sudden of uncontrollable sleep*. Cataplexy is sudden outburst of emotion. Both these diseases are due to *hypothalamic* disorders.

How is it treated?

There are *medications* that can be *quite effective* and can help people with *narcolepsy* lead normal lives. Stimulants such as *Modafanil (Provigil)* are used to improve day time alertness and hypnotics such as *sodium oxybate (Xyrem)* are used to consolidate sleep. *Sodium Oxybate* is also effective at treating *Cataplexy*. Other medications useful for treating *Cataplexy* are anti-depressants such as *SSRIs* (Serotonin selective re-uptake inhibitors).

Somnambulism (Sleep Walking):

Rising out of bed and *walking in the state of sleep* is called *Somnambulism* or *Sleep Walking* (somnus = sleep; ambulare = to walk). It varies from just sitting up in the bed to walking around with eyes open and performing some major complex tasks. The episode lasts for few minutes to half an hour. It occurs during NREM sleep. In children, it is associated with bed-wetting or night terror without any psychological disturbance. However, in adults it is associated with *psychoneurosis*.

Nocturnal Enuresis (Bed-Wetting):

The involuntary passage of urine at bed is called Nocturnal Enuresis (Bed-Wetting). It is *common in children*.



Sleep Walking

Prevention:

Avoiding the use of alcohol or central nervous system depressants. *Avoiding getting too tired and to prevent insomnia, because this can trigger a sleepwalking episode. Avoiding or minimizing stress, anxiety, and conflict, which can worsen the condition.*

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Sleep Paralysis:

People with sleep paralysis are *not able to move their body or limbs*. It can occur either when falling asleep or waking up. Brief episodes of partial or complete skeletal muscle paralysis can occur during sleep paralysis. Sometimes sleep paralysis runs in families, but the cause of sleep paralysis is not known. This disorder is not harmful, but people experiencing sleep paralysis often are fearful because they do not know what is happening. An episode of sleep paralysis often is terminated by sound or touch. Within minutes, the person with sleep paralysis is able to move again. It may occur only once in a lifetime or can be a recurrent phenomenon. It is seen most commonly in people with narcolepsy.

Sleep paralysis occurs when the brain is awakened from an REM state into essentially a normal fully awake state, but the bodily paralysis is still occurring. This causes the person to be fully aware, but unable to move.

Nightmare:

It is a condition during sleep characterized by a *sense of extreme uneasiness or discomfort or by frightful dreams*. The discomfort is felt as of some heavy weight on the stomach or chest or as uncontrolled movement of the body. After a period of extreme anxiety, the subject wakes with a trouble state of mind. This occurs *due to improper food intake, digestive disorders or nervous disorders*. It also occurs during *drug or alcohol withdrawal*.

Night Terror:

It is a disorder similar to nightmare. It is common in children. It is also called *pavor nocturnes or sleep terror*. The child awakes *screaming* in a state of fright and *semi consciousness*. The child cannot recollect the attack in the morning. Nightmare occurs shortly after falling asleep and during NREM sleep. There is no psychological disturbance.

REM Sleep Cardiac Arrhythmias

A cardiac arrhythmia is a change from the normal rate or rhythm of the heart's contractions. People who have *coronary artery disease* and whose *blood oxygen is lowered* by sleep-disordered breathing may be at risk for arrhythmias, which often take place during REM sleep. Continuous *positive airway pressure (CPAP) treatment* may reduce this risk.

Restless Leg Syndrome (RLS):

It is a *disorder* of the part of the *nervous system* that *affects movements of the legs*. Because it usually interferes with sleep, it also is considered as a sleep disorder. People with RLS have strange sensations in their legs (and sometimes arms) and an irresistible urge to move their legs to relieve the sensations. The sensations are difficult to describe: they are usually not painful, but are reported to be uncomfortable, *"itchy," "pins and needles," or "creepy crawlly"* feeling deep in the legs. The sensations are usually worse at rest, especially when lying in bed. Having *low iron storage in the brain is the cause of RLS*. We know *iron is necessary* for the *proper synthesis* and functioning of *Dopamine* which is an important neurotransmitter.

How is RLS treated?

RLS can often be treated successfully with *medications*. Sometimes people with RLS have *low iron*, therefore, *iron supplements* can help relieve the symptoms. If iron is not the problem or iron therapy is not effective or symptoms are causing great sleep disruption, then there are 4 classes of medication that are used: *Dopamine agonists*, e.g. *pramipexole* (Mirapex), *ropinirole* (Requip), *Anti-epileptics*, e.g. *gabapentin* (Neurontin), *Benzodiazepines*, e.g. *clonazepam* (Klonopin), *Opioids*, e.g. *Methadone*.

Movement disorders during sleep:

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Movement disorders occur immediately after falling asleep. *Sleep start or hypnic jerk* is the common movement disorder during sleep. It is characterized by sudden jerks of arms or legs. The sleep start is a physiological forms of *clonus*.

The other movement disorders are *teeth grinding (bruxism)*, *banging the head and restless moment of arms or legs*.

IV. CONCLUSION

So far we have discussed briefly about different stages of sleep, its types, mechanism, sleep disorders and their associated diseases and corresponding precautions and treatment to be followed. Even though sleep is must for giving rest for our mental and physical activities, there should be some minimum time limit for sleep depending on age groups, work performed and diseases associated with human beings. Deficiency in sleeping period causes diseases related to sleep disorders and excess of sleep causes laziness and drowsiness. Here we want to quote one proverb related to sleep, "6 hours sleep is a must, 7 hours sleep is luxury and 8 hours of sleep causes laziness." Hence everyone should have a nice sleep for limited time which gives freshness and fairness required for our next day's work.

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REFERENCES

1. Biller J, Love BB, Schneck MJ. Sleep and its disorders. In: Bradley WG, Daroff RB, Fenichel GM, Jankovic J, eds. *Neurology in Clinical Practice*. 5th ed. Philadelphia, Pa: Butterworth-Heinemann Elsevier; 2008:chap 72.
2. Mahowald MW. Disorders of sleep. In: Goldman L, Schafer AI, eds. *Cecil Medicine*. 24th ed. Philadelphia, Pa: Saunders Elsevier; 2011:chap 412.
3. Medication for the treatment of sleep disorders by J.F. Pagel, M.D., and Bennett L.Parnes, M.D.
4. Essentials of medical physiology – Dr.K. Sembulingam and PremaSembulingam and Jaypee Press – New Delhi
5. Concise Medical Physiology by Dr. Chaudhuri, New Central Book Agency (P) LTD, Pune 1993 Edition.
6. <http://www.sleepeducation.com/>
7. <http://ebooks.cambridge.org/chapter.jsf?bid=CBO9780511544514&cid=CBO9780511544514A026>
8. <http://www.webmd.com/sleep-disorders/excessive-sleepiness-10/sleep-101?page=2>
9. <http://www.anxietycare.org.uk/docs/sleep.asp>
10. http://www.sciencedaily.com/news/mind_brain/sleep_disorders/
11. <http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001805/>
12. <http://slu.adam.com/content.aspx?productId=117&pid=1&gid=000802>
13. http://www.helpguide.org/life/sleep_disorders.htm
14. <http://www.soundsleeping.org/sleeping/sleep-stages.htm>