Brain Waves and Sleep Science

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Abstract: **Human brain is the most complex living structure of the universe. Brain radiates a number of waves that are classified based on frequency and are named as gamma, alpha, beta, theta & delta. We spend nearly one-third of our lives asleep. Sleep is crucial for concentration, memory, coordination and even emotional health. Without enough sleep, people have trouble focusing and responding quickly. In fact, sleep lose can have a similar effect on performance as drinking alcohol. And evidences suggest that a lack of sleep increases the variety of risks including diabetes, cardiovascular disease and heart attacks, stroke, depression, high blood pressure. Scientists now recognize that sleep consists of several different stages that involve the replay of these stages in a specific pattern, a process that depends on the switching mechanisms between sleep wake states. These helps to reduce various sleep disorders.**

I. INTRODUCTION

The invention of the techniques and instruments that can trace the waves emitted out of the human brain, have been proved very useful in curing the disorders caused in people.

The brain's electrical activity creates a changing electrical field, which can be picked up by the sensitive electrodes placed on head. The technique is called "*electroencephalography"* or EEG and changing electrical signals are what commonly referred as brain waves.

Although sleep appears to be a passive activity, it actually involves a highly active and well-scripted mechanism of brain circuits, resulting in sleep's various stages. During sleep, the brain cells scramble to progress through a series is called *sleep cycle.* The average person should ideally go through about five of these each night.

A sleep cycle consists of five stages which are divided into two categories: REM sleep and Non-REM sleep. Another cycle that includes sleep cycle is *sleep-wakefulness cycle*, which explains the complete process from falling asleep to the arousal of a person.

There are pressing reasons why understandings of the mechanisms behind sleep are so important. Sleep disorders are among the nation's most common health problems, affecting up to 70 million people, most of whom are undiagnosed and untreated. These disorders are one of the least recognized sources of disease, disability, and even death. Research holds promise for devising new treatments to allow millions of people to get a good night's sleep.

II. TYPES OF BRAIN WAVES

There are five different types of waves that our brain emits (Figure 1). All these waves lie in specific frequency bands and are radiated in different states of brain.

- Gamma Waves

These are involved in higher processing tasks as well as cognitive functioning. Gamma waves are important for learning, memory and information processing. It is found that the 40 Hz gamma waves are important for binding our senses in regards to perception and it involves a state of meditation.
Frequency range: 40 Hz to 100 Hz (Highest)

- Beta Waves

These are known as high frequency low amplitude brain waves that are commonly observed while we are awake. They are involved in conscious thought, logical thinking, and tend to have a stimulating affect. Having too much beta may lead to us experiencing excessive stress and/or anxiety. When you drink caffeine or have another stimulant, your beta activity will naturally increase.
Frequency range: 12 Hz to 40 Hz (High)

- Alpha Waves

This frequency range bridges the gap between our conscious thinking and subconscious mind. In other words, alpha is the frequency range between beta and theta. It helps us calm down when necessary and promotes feelings of deep relaxation. If we become stressed, a phenomenon called "alpha blocking" may occur which involves excessive beta activity and very little alpha.
Frequency range: 8 Hz to 12 Hz (Moderate)

- Theta waves

This particular frequency range is involved in daydreaming and sleep. Theta waves are connected to us experiencing and feeling deep and raw emotions. Too much theta activity may make people prone to bouts of depression and may make them "highly suggestible" based on the fact that they are in a deeply relaxed, semi-hypnotic state. It is also involved in restorative sleep.
Frequency range: 4 Hz to 8 Hz (Slow)

- Delta Waves

These are the slowest recorded brain waves in human beings. They are found most often in infants as well as young children. They are associated with the deepest levels of relaxation and

restorative, healing sleep. They have also been found to be involved in unconscious bodily functions such as regulating heart beat and digestion. Adequate production of delta waves helps us feel completely rejuvenated after we wake up from a good night's sleep.
Frequency range: 0 Hz to 4 Hz (Slowest).

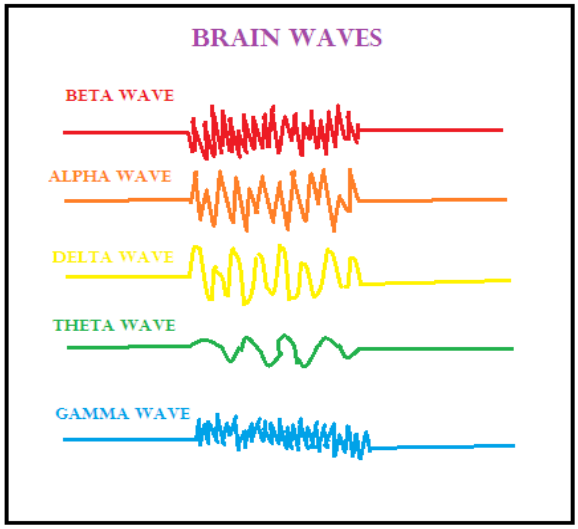

Figure1. Brain Waves

III. SLEEP CYCLE

Researchers found that each night, over the course of the first hour or so of sleep, the brain progresses through a series of stages during which brain waves slow down. This period of slow wave sleep is accompanied by relaxation of the muscles and the eyes. Heart rate, blood pressure, and body temperature all fall. If awakened during this time, most people recall only fragmented thoughts, not active dreams.
Over the next half hour or so, brain activity alters drastically, from deep slow wave sleep to *rapid eye movement(REM)* sleep (Figure 2), which are similar to those observed during waking. Paradoxically, the fast waking like EEG activity is accompanied by *atonia*, or paralysis of the body's muscles. Only the muscles that allow breathing and control eye movements remain active.

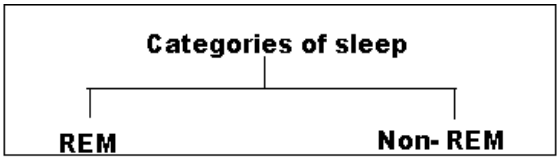

Figure 2. Categories of sleep

REM sleep**:** Rapid eye movement sleep (REM sleep, REMS) is a unique phase of mammalian sleep characterized by random movement of the eyes, low muscle tone throughout the body, and the propensity of the sleeper to dream vividly. This phase is also known as paradoxical sleep (PS) and sometimes-desynchronized sleep because of physiological similarities to waking states, including rapid, low-voltage desynchronized brain waves.

Non-REM sleep: Non-rapid eye movement sleep, or NREM, is, collectively, sleep stages 1–3, previously known as stages 1–4. Rapid eye movement sleep (REM) is not included. There are distinct electroencephalographic and other characteristics seen in each stage. Unlike REM sleep, there is usually little or no eye movement during these stages. Dreaming is rare during NREM sleep, and muscles are not paralyzed as in REM sleep.

REM Dreams and Non-REM dreams are very different from each other in a few major ways. The first difference between the two is Non-REM dreams consist of brief, fragmentary impressions. They are also less likely to involve visual images compared to REM sleep, and are more frequently forgotten. Non-REM dreams are like thinking about something during the day for a brief period while REM dreams are comparable to thinking deeply about something. REM sleep consists of about two hours a night while Non-REM sleep lasts about four to six hours.

Sleep with age: There is a measure of how much sleep an individual needs as The sleep changes with age group (Figure 3).

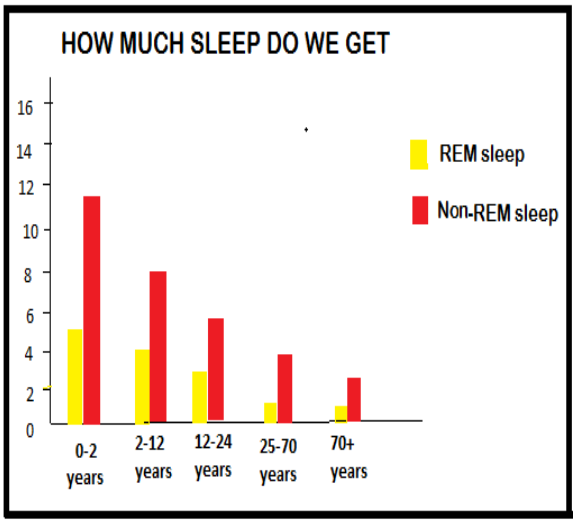

Figure 3. Sleep variation along with age

IV. STAGES OF SLEEP

A sleep cycle consists of five stages, which are further divided into two categories: REM sleep and non-REM sleep. REM sleep, or rapid eye movement sleep, occurs toward the end of each cycle. As people sleep they go through five different stages. These stages are broken down separately because there are changes in your brain waves. About every 90-100 minutes people pass through all 5 stages.

Stage 1: In this stage of sleep cycle brain waves are referred to as theta waves. They consist of a 4-7 cycle per second rhythm. (*Non-REM Sleep*)

Stage 2: In stage 2 of sleep, the brain generates sleep spindles. Spindles are a 12-14 rhythm that lasts a half of a second. Sleep talking usually occurs during stages 1 and 2 of sleep. Sleep talking is mumbled and usually not understandable. (*Non-REM Sleep*)

Stage 3: Delta waves are produced from the brain in the third stage of sleep. These brain waves become slower when the sleep cycle begins. During this cycle your heart rate, blood pressure, and arousal decline. (*Non-REM Sleep*)

Stage 4: Stage four is very similar to stage 3 because Delta waves continue in the brain. During this stage of sleep most dreams and nightmares occur. (*Non-REM Sleep*)

Stage 5: In stage five your breathing becomes irregular and more rapid. Your heartbeat rises and your eyes dart around in a momentary burst of activity while your eyelids are closed. This is called REM sleep (*REM Sleep*)

V. SLEEP –WAKEFULNESS CYCLE

A question arises why we feel sleepy? There are two main determining factors: the *circadian system* (time of day or night) and how long we have been awake. There is a natural clock in our brain i.e. the circadian timing system, regulated by the *suprachiasmatic nucleus*, a small group of nerve cells in the hypothalamus that acts as a master clock. These cells express clock proteins, which go through a biochemical cycle of about 24 hours, setting the pace for daily cycles of activity, sleep, hormone release, and other bodily functions.

The suprachiasmatic nucleus also receives input directly from the retina, and the clock can be reset by light so that it remains linked to the outside world's day-night cycle. Orexin neuronsin the lateral hypothalamus directly regulate sleep and arousal. Orexin activation plays a critical role in preventing abnormal transitions into REM sleep during the day, as occurs in narcolepsy.

The second system regulating sleepiness is the homeostatic system, which responds to progressively longer wake periods by increasing the urge to sleep. The subjective sense of the increasing need to sleep coinciding with increasing wakefulness suggests that there might be a brain physiological parallel; that is, the longer a person is awake, the greater the likelihood of an increase in sleep-inducing factor (s).

Evidence now suggests that one important sleep factor is the inhibitory neurochemical *adenosine*. With prolonged wakefulness, increasing levels of adenosine are evident in the brain.

The increased levels of adenosine serve the purpose of slowing down cellular activity and diminishing arousal. Adenosine levels then decrease during sleep. Brain adenosine may be produced by breakdown of ATP (adenosine triphosphate) which is the cellular energy source of the brain nerve cell in the course of the high brain activity that takes place during wakefulness. Since nerve cell activity decreases and adenosine levels decline in non-REM sleep, the logical assumption is that ATP increases during sleep.

Because ATP is needed to produce adenosine, which is essential for wakefulness, it makes sense that ATP is produced during sleep. This finding also supports the commonly held notion that sleep is necessary for providing restorative energy.

VI. SLEEP DISORDERS

The most common sleep disorder, and the one most people are familiar with, is insomnia. People suffering from insomnia have difficulty falling asleep initially, but others fall asleep and then awaken partway through the night and cannot fall asleep again. Many of the most common disorders, listed below, disrupt sleep and result in inadequate amounts of sleep, particularly of the deeper stages:

• Excessive daytime sleepiness.

• Obstructive sleep apnea occurs as sleep deepens and the airway muscles in the throat relax to the point of collapse, closing the airway. The individual has difficulty breathing and wakes up without entering the deeper stages of slow wave sleep. This increases the blood pressure and also raises the chances of heart attacks.

• Periodic limb movements of sleep are intermittent jerks of the legs or arms that occur as the individual enters slow wave sleep. These movements can cause arousal from sleep. A related disorder, called REM behavior disorder, occurs when muscles fail to become paralyzed during REM sleep; as a result, people literally act out their dreams by getting up and moving around.

• Narcolepsy is a relatively uncommon condition in which the switching mechanisms controlling the transitions into sleep, particularly REM sleep, do not work properly. This problem is due to the loss of nerve cells in the lateral hypothalamus that contain the neurotransmitter orexin. People with narcolepsy have sleep attacks during the day, in which they suddenly fall asleep.

People with narcolepsy tend to enter REM sleep very quickly as well and may even enter a dreaming state while still partially awake, a condition known as hypnagogic hallucination.

VII. CONCLUSION

The importance of the researches made in the field of neuroscience cannot be overstated. More than 1000 disorders in the brain and the nervous system results in more hospitalization than any other group of disease.

Neurological illnesses affect a number of people and this rate is on proliferation. There are about 6-6.5 lakh doctors available but India will need around 4 lakh more by 2020 to maintain the required ratio of 1 doctor per 1,000 persons.

There is a proliferation in the use of computers and internet now-a-days that leads to sleep lose. Increased hours on the work places have led to disturbances in the proper sleep. These disturbances lead to increased stress & mental fatigue thus resulting in poor performance and unbalanced life. Disorders like insomnia and narcolepsy have become considerable causes of accidents in case of adults.

Knowledge and proper treatment of these disorders at right time can prevent from mental disability and can lead to a healthy life.

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