



21st Lecture

Physiology of Sleep

PHYSIOLOGY TEAM – 430

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Sleep Physiology

- Sleep is temporary physiological state of unconsciousness from which the person can be aroused (awaken) by sensory stimuli
- If we do an EEG in a sleeping person, it shows various types of transients (waves) that are characteristic of different sleep stage
- It Differs from Coma, that the Coma is a state of loss of consciousness (LOC) from which the person cannot be aroused
- The EEG in coma is generally unreactive, and there are several EEG patterns of coma
- The commonest EEG pattern of coma is Continuous Slow Waves

• Types of sleep:

Depending on EEG criteria, every night we go through two alternative types of sleep:

1) SWS (Slow-Wave Sleep):

- Low frequency waves in EEG
- No rapid eye movement (it is also called "Non-Rapid Eye Movement")

2) REM sleep (Rapid Eye Movement):

- The person moves his eyes rapidly while sleeping

• Sleep Classification (Based on EEG features):

✓ NREM sleep (SWS): 4 Stages:

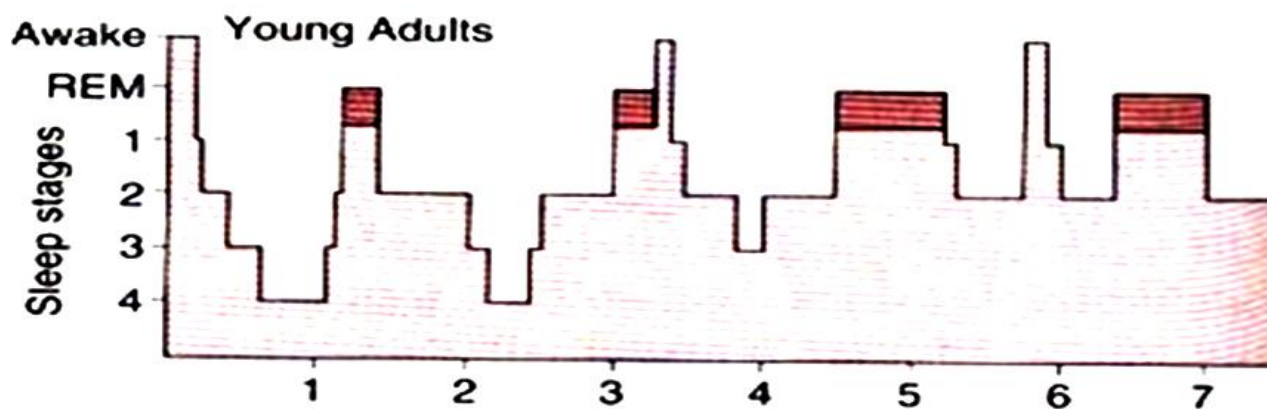
- Stage 1 NREM:
When a person is initially falling asleep, low amplitude, fast activity (**alpha waves**)
- Stage 2 NREM:
Appearance of **sleep spindles**: Bursts of alpha-like 10-14 Hz, 50 uV waves
- Stage 3 NREM:
Lower frequency (**Mainly theta**), high amplitude EEG waves
- Stage 4 NREM:
Slower frequency (**Mainly delta**), higher amplitude EEG waves

✓ REM sleep:

- Low-voltage, fast activity (**Beta waves**)

- **Distribution of Sleep Stages:**

- While sleeping the person goes through Sleep Cycles (about 4-6 Cycles per a night sleep), these cycles are formed of NREM sleep with all of its stages, and REM sleep which appears after about 90 minutes of sleeping
- As the night goes on there is a progressive reduction in stages 3 and 4 with a progressive increase in REM sleep



- REM sleep is shown in red
- Notice the reduction in stages 3 and 4

Notes:

- In adulthood: NREM occupies 75% - 80% while the REM takes 20% - 25%
- In Premature infants: REM Occupies 80% of total sleep
- In Full-Term Neonates: REM occupies 50% of total sleep
- REM sleep when you were just born is at its highest level and it rapidly falls down to remain at about 25% of total sleep for a long time (Plateau phase), then finally it goes under that percentage in old age

- **SWS (NREM) Sleep:**

- The restful type of sleep
- Exemplified in the first hour of sleep
- **Characteristics of SWS sleep:**
 - ✓ Decrease in peripheral vascular resistance
 - ✓ Decrease up to 10 - 30 % in blood pressure
 - ✓ Decrease in respiratory rate
 - ✓ Decrease in basal metabolic rate
 - ✓ Dreams and nightmares sometimes occur in this type of sleep (But dreams mainly a characteristic of REM sleep)

- **REM Sleep (Paradoxical sleep):**

- In a normal night of sleep, episodes of REM occurs every 90 minutes and lasts for 5 – 30 minutes
- Not as restful as SWS
- If the person is extremely sleepy, REM sleep becomes short and may be absent
- If the person becomes more rested, REM episodes increase
- **Characteristics of REM sleep:**
 - ✓ Rapid eye movement
 - ✓ Decrease in muscle tone (Except in eye + respiratory muscles)
 - ✓ Inhibition of peripheral muscles but active bodily muscle movement occurs
 - ✓ Heart rate + Respiratory rate become irregular
 - ✓ Fluctuation of blood pressure occurs (Characteristic of dream state)
 - ✓ More difficult to awake person in REM episode (But mostly we wake up in the morning in REM episode)
 - ✓ Increase up to 20 % of brain metabolism
 - ✓ Erection of penis + Engorgement of clitoris
 - ✓ EEG shows brain waves similar to those during wakefulness
- The REM sleep is also called paradoxical because the person is asleep but may seem awake (because of the rapid eye movement)
- In conclusion, in REM sleep the brain is active but this brain isn't aware of the external world and its activity isn't for purposeful external motor activity

Importance of REM sleep:

- 1) Expression of concerns in the sub-consciousness (Through dreams)
- 2) Long-term chemical and structural changes that the brain need to make learning & memory possible.

- **Difference between dreams in SWS and REM:**

- 1) REM dreams are vivid dreams
- 2) REM dreams are associated with more bodily muscle activity
- 3) SWS dreams are usually not remembered when waking up

- **Theories of sleep:**

- **Serotonin** (produced by raphe nuclei) induces SWS
- REM sleep is triggered by Pontine Reticular Formation & Ponto-Geniculo-Occipital circuit
- **Melatonin** (produced by pineal gland) plays an important role in day-night entrainment of sleep

- **Role of Serotonin and Melatonin in SWS sleep:**

- Serotonin is produced by raphe nuclei and it plays an important role in SWS sleep
- Drugs that block serotonin formation make the animal sleepless for days
- Transecting the brain at the level of midpons, will cause wakefulness for several days

Note:

There is an area called (Bulboreticular Facilitory Area) and located in RAS, which is responsible for alertness, to produce sleep this area should be inhibited by Serotonin, so if we did the transaction there will be no serotonin going to that area and that is the cause of the sleepless several days

- Injections of melatonin induce sleep
- If Light falls on the retina → Stimulation of Suprachiasmatic Nucleus of Hypothalamus → Inhibition of Melatonin release from Pineal Gland → Wakefulness is produced

- **Circadian control of Sleep-Wake Cycles:**

- Circadian control/rhythm: Regulation of a biological rhythm by day-night cycles
- The circadian controller is Melatonin
- Darkness (Night) → Stimulation of Pineal Gland → Secretion of Melatonin → SWS sleep
- Light (Day) → Falls on retina → Stimulation of Suprachiasmatic Nucleus of Hypothalamus → Inhibition of Melatonin → Wakefulness

- **Mechanism of sleep-wake cycles:**

- **Morning:**

- ✓ Maximum activity of Bulboreticular Facilitory Area (resist any inhibition from Raphe Nuclie)
 - ✓ Melanin in low levels
 - These two will cause:
 - ✓ Activation of cerebral cortex to increase vigilance
 - ✓ Excitation of PNS to become more receptive to sensory stimuli and ready to respond by increasing muscle tone
 - Then, a Positive Feedback Signals are sent back to the Bulboreticular Facilitory Area for further activation for numerous hours

- **Night:**

- After the brain remains activated for many hours:
 - ✓ Activation of Bulboreticular Facilitory Area becomes less
 - ✓ Positive Feedback Signals stop
 - This will cause:
 - ✓ Raphe Nuclie is Activated (Serotonin secretion)
 - ✓ Melatonin levels are high

- **Mechanism of REM sleep generation:**

- It is believed that Cholinergic Neurons located in the Pons that generates REM sleep
 - Animal experiments showed that large group of spikes originate from Pontine Reticular Formation in REM sleep
 - The spikes are spread to Lateral Geniculate Nucleus then to the Occipital cortex, that's why they are also known as (Ponto-Geniculo-Occipital spikes)

- **Physiologic Functions of Sleep:**

- Forced lack of sleep in humans showed that the person:
 - ✓ Will experience progressive sluggishness in thoughts
 - ✓ Irritable
 - ✓ Develops mental confusion & psychosis-like features
 - It is noticed that sleep restores both normal levels of brain activity and normal balance among the different hormones, neurotransmitters and functions of CNS