



8. Arousal and sleep Physiology.

By

Prof. Sherif W. Mansour

Physiology dpt., Mutah school of Medicine.



Sleep

-It is state of loss of consciousness from which person can be aroused by **normal non harmful** stimuli.

-Normal person needs from **7 - 9** hours of sleep/ 24 hours, newly born need from 16-18 hours, while old persons need less hours of sleep.

Older Adults, shows earlier wake time and reduced sleep consolidation. one hypothesis may be an advanced circadian pacemaker that accompanies age. It is unclear if this is due to older adults experiencing an increased sensitivity to light.

In Younger adults SWS declines with age, older adults experience more frequent awakenings during a sleep episode.

Gender Differences

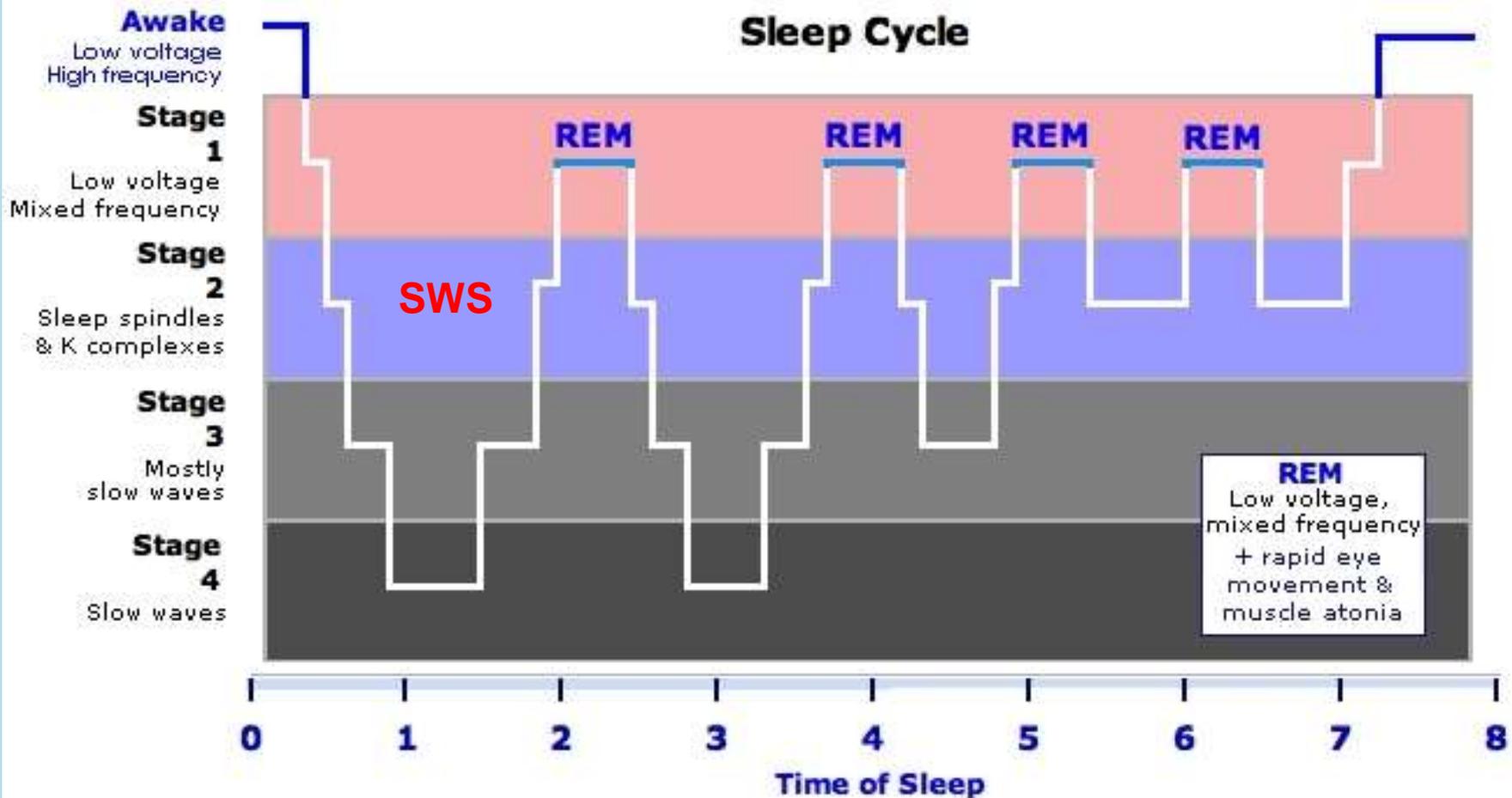
In adults, **men** spend greater time in stage 1 sleep and experience more awakenings. Although **women** maintain **SWS** longer than men, they complain more often of difficulty falling asleep and mid-sleep awakenings. In contrast, men are more likely to complain of daytime sleepiness.

women often experience considerable daytime sleepiness during pregnancy and during the first few postpartum months

*There are two types of sleep:

Slow wave sleep (SWS) or Non-REM & Rapid eye movement sleep (REM)

Sleep Cycle



Slow wave sleep (SWS)

- 1) Most sleep during night, it lasts about 80-90 minutes.
- 2) Occupies 75% of sleep time.
- 3) It's period increases when person is very **tired** and vice versa.
- 4) No eye movements occur
- 5) There is 30% **reduction** in cardiovascular and metabolic activities.
- 6) **Dreams** occur but are not remembered.
- 7) Brain waves are very slow (delta wave).
- 8) Person is more easy to be aroused (awakened) .
- 9) Muscle tone are slightly inhibited
- 10) No abnormal muscle movements
- 11) Brain metabolism is decreased.
- 12) No penile erection in males.

Rapid eye movement sleep (REM)

- 1) Occurs in episodes during night lasts only 15 minute.
- 2) Occupies only 25% of sleep time
- 3) It's period increases when the person has no desire to sleep
- 4) Very characteristic rapid eye movements.
- 5) Heart rate, blood pressure and respiration become irregular and may increase.
- 6) **Active dreams** occur and are remembered.
- 7) Brain waves like wakefulness State.
- 8) Person difficult to be aroused.
- 9) Extreme inhibition of muscle tone .
- 10) Few irregular muscle movements.
- 11) Brain metabolism is highly active.
- 12) Erection in genital organs even in children and clitoris in females.

Note that :-

- Severe inhibition that occurs in muscle tone during REM sleep is due to increase activity of the **inhibitory supra-spinal centers**
- REM sleep is also called "paradoxical" sleep because the increased brain activities and brain metabolism during it.

Theories of sleep

A-The "passive" theory of sleep :

- States that reticular activating system receives visual, auditory and tactile impulses from surroundings, then activates cerebral cortex causing state of wakefulness. Fatigue of these neural circuits was thought to cause sleep until recovery occurs and so on.
- However transection in brain stem in mid-pontine region leads to a brain that never goes to sleep, which indicates presence of other centers below mid pons that send impulses to higher center causing sleep.

B- Active theory of sleep:

- Stimulation of "**middle raph nuclei**" in lower pons and medulla produce sleep. These nuclei send wide neural connection to cortex, limbic system, diencephalon and also to the spinal cord which can inhibit pain sensations
- Stimulation of other areas like nucleus of **tractus solitarius**, rostral part of the hypothalamus and some diffuse nuclei in thalamus has the same effect
 - the "**locus ceruleus**" in the brain stem is considered as a center for REM sleep. The neurons of this nucleus secrete norepinephrine.

C- Metabolic theory of sleep:

- This theory states that prolonged wakefulness causes progressive accumulation of many chemical substances in brain stem and C.S.F that when reach a certain concentration it produces sleep.
- Of these factors "**muramyl peptide**". Another substance which is a non peptide called "**Sleep factor -serotonin**" was separated from brain stem of animal that were kept awake for days, when injected into third ventricle of normal animals caused immediate sleep.

D- Positive feed back theory:

This feedback between reticular formation and cerebral cortex. This theory explains in fact the periodicity between sleep and wakefulness.

When the sleeping centers are not active, the reticular activating system stimulate the cerebral cortex, which in turn activate the reticular formation, which in turn reactivate the cerebral cortex and so...on. This circuit keeps the state of wakefulness till it becomes **fatigued** or the sleeping centers become active.

The physiological importance of sleep

- 1- Sleep restores both normal levels of activity and balance among the different parts of the neurons in the C.N.S
- 2- Loss of sleep makes C.N.S neurons to lose their base line of physiological operations. Lack of sleep also causes malfunction of the mind and abnormal behavioral activities. The person becomes irritable and even psychotic, with great loss of concentration and extreme fatigability
- 3- Marked increase in sympathetic activities all over the body in sleep deprivation.
- 4- Disturbance in other body functions secondary to disturbance in their nervous control as digestion, absorption, hormone secretions, vasomotor and cardiovascular regulation.

-Positive feed back mechanisms in the body:

- 1- Positive feed back mechanism between estrogen and LH hormone which causes LH surge and ovulation.
- 2- Hyperthermia increases metabolism and increased metabolism causes hyperthermia and so on.
- 3- In labour, uterine contraction push head of baby to dilate the cervix, dilation of cervix send afferent impulses to sacral region causing more uterine contraction and so on.
- 4- Positive feed back mechanism between cerebral cortex and the reticular formation which cause wakefulness state.

Reticular Formation

- The reticular formation consists of millions of neurons which spreads along the mid-ventral part of the whole brain stem.
- It is corresponding to the interneurons of the spinal cord being continuous with them in the upper cervical segments then extending upward to the level of the intra-laminal and non-specific thalamic nuclei anastomosing with them, then diffusing nearly to all areas of the cerebral cortex .

- Types of cells (neurons) that are found in the R.F:

1- Sensory neurons :

- They are the largest in number but the smaller in size having short axons and make many interconnections with each others.
- These neurons are the site of convergence, divergence and formation of the reverberating circuits which enable R.F to act as a **link** between lower and higher centers in the brain.
- These neurons receive impulses from :-
- All ascending tracts including auditory, olfactory, and visual pathways .
- Many higher centers including cerebral cortex, hypothalamus basal ganglia, cerebellum and vestibular apparatus.

2- Motor neurons :

- These are **lesser** in number but **larger** in size having longer axons which form two distinct types of fibers:

-Ascending fibers which connect first with non specific thalamic nuclei, then diffuse nearly to all areas of cerebral cortex. This system is called the **reticular activating system (R.A.S)**

-Descending fibers which reach to the AHC (both alpha cells and gamma cells) at all levels of the spinal cord forming the **reticulo-spinal** tracts which regulate muscle tone.

3- Specific centers :

Many neurons in the reticular formation collect and form specific " centers", which has certain function as Red nucleus, olivary nuclei, vestibular nuclei, respiratory centers, vasomotor and cardiac centers, deglutition and vomiting centers.

4-Neuro-transmitter secreting neurons:

The reticular formation contains many neurons and their nerve fibers which secrete and form many chemical transmitters that regulate the chemistry of the brain as serotonergic, noradrenergic, adrenergic, dopaminergic and the opioid secreting neurons and fibers .

***Functions of the reticular formation:**

- 1- The R.F is the link between higher centers in the brain and the lower centers in the spinal cord.
- 2- Many vital centers as respiratory , cardiovascular and vasomotor centers are parts of the R.F, thus regulating most of autonomic functions
- 3- Arousal state, via the reticular activating system..
- 4- Pain perception and control : as the R.F contain many opiate receptor and many neuron that secrete endogenous enkephalins and endorphins.
- 5- Regulation of brain chemistry:- R.F contain many neurons that secrete many chemical transmitters which regulate brain functions.
- 6- Regulation of muscle tone through:

Facilitatory R.F.	Inhibitory R.F.
<ul style="list-style-type: none">-Dorso-lateral R.F in the pons-Has its own intrinsic activity.-Stimulated by area 4, neo-cerebellum and vestibular nucleus but inhibited by suppressor cortical centers.-It sends ventral reticulo-spinal tract → ↑ ms. tone.	<ul style="list-style-type: none">-Ventromedial RF in medulla.-No intrinsic activity.-Stimulated by the suppressor cortical areas, basal ganglia and paleocerebellum.-It sends lateral reticulo-spinal tract → ↓ ms. tone.

Thank You