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Question

Q1. Discuss the physiology of sleep

PHYSIOLOGY OF SLEEP

Sleep is a naturally recurring state of mind and body, characterized by altered consciousness, relatively inhibited sensory activity, reduced muscle activity and inhibition of nearly all voluntary muscles during rapid eye movement (REM) sleep, and reduced interactions with surroundings. It is distinguished from wakefulness by a decreased ability to react to stimuli, but more reactive than a coma or disorders of consciousness, with sleep displaying very different and active brain patterns.

Sleep occurs in repeating periods, in which the body alternates between two distinct modes: REM sleep and non-REM sleep. Although REM stands for "rapid eye movement", this mode of sleep has many other aspects, including virtual paralysis of the body. During sleep, most of the body's systems are in an anabolic state, helping to restore the immune, nervous, skeletal, and muscular systems; these are vital processes that maintain mood, memory, and cognitive function, and play a large role in the function of the endocrine and immune systems. The internal circadian clock promotes sleep daily at night.

The most pronounced physiological changes in sleep occur in the brain. The brain uses significantly less energy during sleep than it does when awake, especially during non-REM sleep. In areas with reduced activity, the brain restores its supply of adenosine triphosphate (ATP), the molecule used for short-term storage and transport of energy. In quiet waking, the brain is responsible for 20% of the body's energy use, thus this reduction has a noticeable effect on overall energy consumption.

Sleep increases the sensory threshold. In other words, sleeping persons perceive fewer stimuli, but can generally still respond to loud noises and other salient sensory events.

During slow-wave sleep, humans secrete bursts of growth hormone. All sleep, even during the day, is associated with secretion of prolactin.

There are other body system changes that occur during sleep. Generally, these changes are well tolerated in healthy individuals, but they may compromise the sometimes fragile balance of individuals with vulnerable systems, such as those with cardiovascular diseases. Physiological changes also occur in the following systems:

1. **-Cardiovascular:** Changes in blood pressure and heart rate occur during sleep and are primarily determined by autonomic nervous system activity. For instance,

brief increases in blood pressure and heart rate occur with K-complexes, arousals, and large body movements. Further, there is an increased risk of myocardial infarction in the morning due to the sharp increases in heart rate and blood pressure that accompany awakening.

2. **-Sympathetic-nerve activity:** Sympathetic-nerve activity decreases as NREM sleep deepens; however, there is a burst of sympathetic-nerve activity during NREM sleep due to the brief increase in blood pressure and heart rate that follows K-complexes. Compared to wakefulness, there is a rise in activity during REM sleep.

3. **-Respiratory:** Ventilation and respiratory flow change during sleep and become increasingly faster and more erratic, specifically during REM sleep. Ventilation data during REM sleep are somewhat unclear, but they suggest that hypoventilation (deficient ventilation of the lungs that results in reduction in the oxygen content or increase in the carbon dioxide content of the blood or both) occurs in a similar way as during NREM sleep. Several factors contribute to hypoventilation during NREM, and possibly REM, sleep such as reduced pharyngeal muscle tone. Further, during REM sleep, there is reduced rib cage movement and increased upper airway resistance due to the loss of tone in the intercostals and upper airway muscles. More generally, ventilation and respiratory flow show less effective adaptive responses during sleep. The cough reflex, which normally reacts to irritants in the airway, is suppressed during REM and NREM sleep. The hypoxic ventilatory response is also lower in NREM sleep than during wakefulness and decreases further during REM sleep. Similarly, the arousal response to respiratory resistance (for example, resistance in breathing in or out) is lowest in stage 3 and stage 4 sleep.

4. **-Cerebral blood flow:** NREM sleep is associated with significant reductions in blood flow and metabolism, while total blood flow and metabolism in REM sleep is comparable to wakefulness . However, metabolism and blood flow increase in certain brain regions during REM sleep, compared to wakefulness, such as the limbic system (which is involved with emotions), and visual association areas.

5. **-Renal:** There is a decreased excretion of sodium, potassium, chloride, and calcium during sleep that allows for more concentrated and reduced urine flow. The changes that occur during sleep in renal function are complex and include changes in renal blood flow, glomerular filtration, hormone secretion, and sympathetic neural stimulation .

6. **-Endocrine:** Endocrine functions such as growth hormone, thyroid hormone, and

melatonin secretion are influenced by sleep. Growth hormone secretion typically takes place during the first few hours after sleep onset, while thyroid hormone secretion takes place in the late evening. Melatonin, which induces sleepiness, likely by reducing an alerting effect from the suprachiasmatic nucleus, is influenced by the light-dark cycle and is suppressed by light

Key physiological methods for monitoring and measuring changes during sleep include electroencephalography (EEG) of brain waves, electrooculography (EOG) of eye movements, and electromyography (EMG) of skeletal muscle activity. Simultaneous collection of these measurements is called polysomnography, and can be performed in a specialized sleep laboratory. Sleep researchers also use simplified electrocardiography (EKG) for cardiac activity and actigraphy for motor movements.

Non-REM and REM sleep

Sleep is divided into two broad types: non-rapid eye movement (non-REM or NREM) sleep and rapid eye movement (REM) sleep. Non-REM and REM sleep are so different that physiologists identify them as distinct behavioral states. Non-REM sleep occurs first and after a transitional period is called slow-wave sleep or deep sleep. During this phase, body temperature and heart rate fall, and the brain uses less energy. REM sleep, also known as paradoxical sleep, represents a smaller portion of total sleep time. It is the main occasion for dreams (or nightmares), and is associated with desynchronized and fast brain waves, eye movements, loss of muscle tone, and suspension of homeostasis.

The sleep cycle of alternate NREM and REM sleep takes an average of 90 minutes, occurring 4–6 times in a good night's sleep. The American Academy of Sleep Medicine (AASM) divides NREM into three stages: N1, N2, and N3, the last of which is also called delta sleep or slow-wave sleep. The whole period normally proceeds in the order: N1 → N2 → N3 → N2 → REM. REM sleep occurs as a person returns to stage 2 or 1 from a deep sleep. There is a greater amount of deep sleep (stage N3) earlier in the night, while the proportion of REM sleep increases in the two cycles just before natural awakening.

NREM SLEEP AND REM SLEEP DIFFERENCES

Physiological Process	NREM	REM
Brain activity	Decreases from wakefulness	Increases in motor and sensory areas, while other areas are similar to NREM
Heart rate	Slows from wakefulness	Increases and varies compared to NREM
Blood pressure	Decreases from wakefulness	Increases (up to 30 percent) and varies from NREM
Sympathetic nerve activity	Decreases from wakefulness	Increases significantly from wakefulness
Muscle tone	Similar to wakefulness	Absent
Respiration	Decreases from wakefulness	Increases and varies from NREM, but may show brief stoppages; coughing suppressed
Body temperature	Is regulated at lower set point than wakefulness; shivering initiated at lower temperature than during wakefulness	Is not regulated; no shivering or sweating; temperature drifts toward that of the local environment
Sexual arousal	Occurs infrequently	Greater than NREM

Awakening can mean the end of sleep, or simply a moment to survey the environment and readjust body position before falling back asleep. Sleepers typically awaken soon after the end of a REM phase or sometimes in the middle of REM. Internal circadian indicators, along with successful reduction of homeostatic sleep need, typically bring about awakening and the end of the sleep cycle. Awakening involves heightened electrical activation in the brain, beginning with the thalamus and spreading throughout the cortex.

CLINICAL CORRELATES

1. **-Insomnia:** Insomnia is a general term for difficulty falling asleep and/or staying asleep. Insomnia is the most common sleep problem, with many adults reporting occasional insomnia, and 10–15% reporting a chronic condition. Insomnia can have many different causes, including psychological stress, a poor sleep environment, an inconsistent sleep schedule, or excessive mental or physical stimulation in the hours before bedtime. Insomnia is often treated through behavioral changes like keeping a regular sleep schedule, avoiding stimulating or stressful activities before bedtime, and cutting down on stimulants such as caffeine. The sleep environment may be improved by installing heavy drapes to shut out all sunlight, and keeping computers, televisions and work materials out of the sleeping area.
2. **-Obstructive sleep apnea:** Obstructive sleep apnea is a condition in which major pauses in breathing occur during sleep, disrupting the normal progression of sleep and often causing other more severe health problems. Apneas occur when the muscles around the patient's airway relax during sleep, causing the airway to collapse and block the intake of oxygen.Obstructive sleep apnea is more common than central sleep apnea. As oxygen levels in the blood drop, the patient then comes out of deep sleep in order to resume breathing. When several of these episodes occur per hour, sleep apnea rises to a level of seriousness that may require treatment. Major risk factors for sleep apnea include chronic fatigue, old age, obesity and snoring.
3. **-Aging and sleep:** People over age 60 with prolonged sleep (8-10 hours or more; average sleep duration of 7-8 hours in the elderly) have a 33% increased risk of all-cause mortality and 43% increased risk of cardiovascular diseases, while those with short sleep (less than 7 hours) have a 6% increased risk of all-cause mortality.

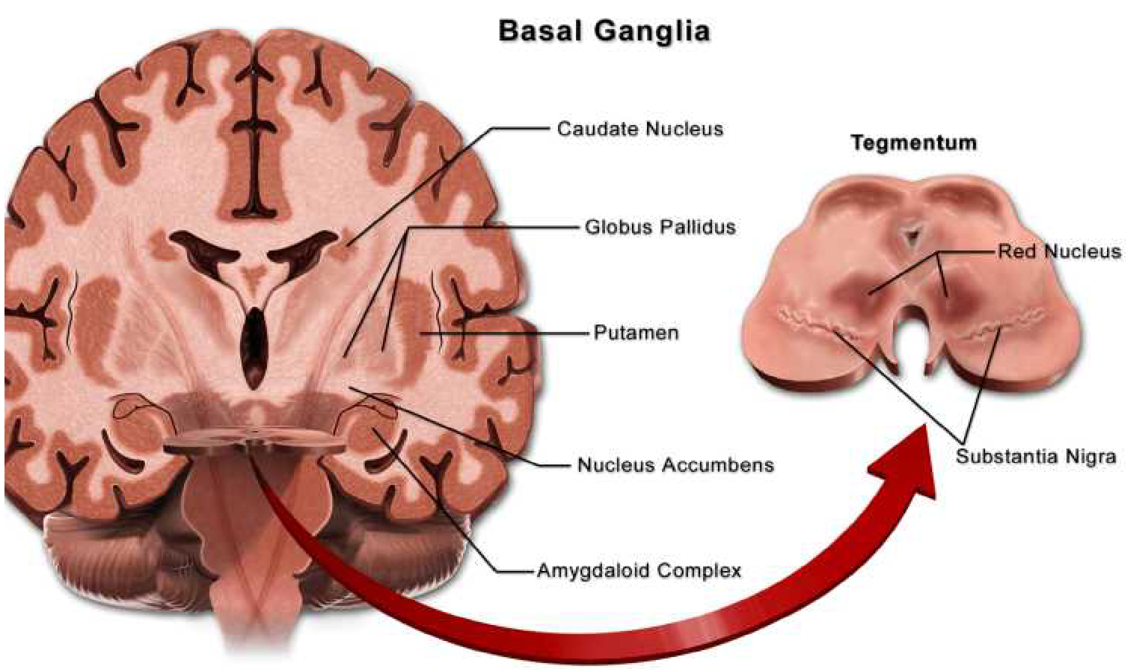
Q2. Discuss the role of basal ganglia in coordinating movement

THE ROLE OF BASAL GANGLIA IN COORDINATING MOVEMENT

The basal ganglia or basal nuclei are large masses of grey matter located within the central core of white matter of the cerebral hemispheres. They are interconneted and play roles in movement and cognitive functions. The basal ganglia is composed of the following grey nuclei:

1. Caudate nucleus
2. Lentiform nucleus (made up of putamen and globus pallidus)
3. Amygdaloid nuclear complex (or Amygdala)
4. Substantia nigra (within the midbrain)
5. Subthalamic nucleus

The lentiform nucleus is composed of two groups of neuronal soma (grey matter) known as the putamen and globus pallidus. The lentiform and caudate nuclei together constitutes a mass of grey matter, the corpus striatum.



We can classify these nuclei into the following groups:

i. Input nuclei: corpus striatum (caudate nucleus, putamen),

ii. Intermediary nuclei: Globus Pallidus Externa, Substantia nigra, and Subthalamic Nucleus

iii. .Output nuclei: Substantia Nigra and Globus Pallidus

In order to understand the functions of the basal ganglia, we must mention the extrapyramidal system. This system is the part of the brain and brain stem that participates in motor control except for the corticospinal (pyramid) system. It includes:

1. Basal ganglia and their pathways
2. Portions of the cerebral cortex that give projections to the basal ganglia
3. Parts of the cerebellum that give projections to the basal ganglia
4. Parts of the reticular formation that are connected to the basal ganglia and cerebral cortex
5. Thalamus nuclei associated with the basal ganglia and reticular formation.

The role of the extrapyramidal system is to control automatic movements, skeletal muscle tone, and maintenance of postural reflexes.

The basal ganglia exert their role in motor control through constant interaction with the cerebral cortex and the corticospinal pathway. They get information mainly from the cerebral cortex and send out information.

Almost all the motor and sensory nerve fibers that connect the cerebral cortex to the spinal cord pass between the major masses of the basal ganglia (nucleus caudatus and putamen) and are called the internal brain capsule.

The connections of the motor cortex, the thalamus and the joint circuits of the brain stem and cerebellum are very important. Namely, the main circuit of the basal ganglia system involves a huge number of connections between the basal ganglia themselves, as well as numerous entry and exit pathways between the motor regions of the brain and the basal ganglia.

The most prominent functions of the basal ganglia include:

1. Represents the accessory motor system.
2. Mediates between neocortical motor centers and the "elderly" motor areas of the brainstem
3. Selects the purposeful and desired motor activity and suppresses unwanted movements.
4. Acts by modifying ongoing neural activity in motor projections
5. Delivers an inhibitory role in motor control
6. Inhibits muscle tone (balance of excitatory and inbound input signals according terminating on skeletal muscle)
7. Monitor and adjust slow and continuous contractions (equilibrium, body position, etc.)
8. Regulates attention and individual cognitive processes
9. Participates in motor planning and learning
10. Assisting the cerebral cortex in making subconscious, learned movements
11. Temporal pattern of movement and gradation of the intensity of movement

Cognitive control of motor activity in which the nucleus caudatus plays a major role is another important function of the basal ganglia. Likewise, planning which movement patterns will be used together, or in what order in order to achieve a complex goal, is another role of the basal ganglia.

CLINICAL CORRELATES

Degeneration of the basal ganglia and consequently, its dysfunction can lead to several neurological conditions including the following:

1. **Parkinson's disease:** Parkinson's disease results from loss of dopaminergic innervation (loss of the nigrostriatal connection) to the striatum and other basal ganglia structures. It is also referred to as Parkinsonism or Paralysis agitans (shaking palsy). The condition is characterized by rigidity (increased muscle tone), which leads to a stooped posture, a slow shuffling gait, difficulty in speech and a mask like face. Parkinsonism is believed to be due to degenerative changes in the striatum and the substantia nigra. Patients with this disease lack the nigrostriatal afferents to the striatum, and are also deficit of the neurotransmitter, dopamine in their striatum. Parkinson's disease is also well characterized by hypokinesia (paucity or insufficient movement).

2. **Cerebral palsy:** People with cerebral palsy have various motor problems, such as spasticity, paralysis, and even seizures. Spasticity is a condition in which some muscles are abnormally stiff and as a result interfere with normal movement. This is the reason for the unusual hand and arm positions seen in some people with cerebral palsy. Causes may include fetal infection, environmental toxins, or lack of oxygen (hypoxia). Although cerebral palsy tends to remain relatively stable throughout life, there is no cure currently, and is very difficult to deal with for both the person and his or her family.

3. **Tremor:** This is an abnormal movement in which there is an involuntary shaking (tremor) of the hand, head or other parts of the body. Usually the basal ganglia, cerebellum and the subthalamic nucleus are involved. However, intention tremor is also seen in disorders of the cerebellum, in which case, the tremor comes when the individual tries to perform a voluntary movement.