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**COURSE: NEUROPHYSIOLOGY**

1. **DISCUSS THE PHYSIOLOGY OF SLEEP**

Introduction

Sleep is defined as unconsciousness from which the person can be aroused by sensory or other stimuli. There are multiple stages of sleep, from very light sleep to very deep sleep; sleep researchers also divide sleep into two entirely different types of sleep that have different qualities, as follows. During each night, a person goes through stages of two types of sleep that alternate with each other. They are called

1. slow-wave sleep, in which the brain waves are strong and of low frequency.

This sleep is exceedingly restful and is associated with decreases in both peripheral vascular tone and many other vegetative functions of the body. For instance, there are 10 to 30 percent decreases in blood pressure, respiratory rate, and basal metabolic rate. Although slow-wave sleep is frequently called "dreamless sleep," dreams and sometimes even nightmares do occur during slow-wave sleep. The difference between the dreams that occur in slow wave sleep and those that occur in REM sleep is that those of REM sleep are associated with more bodily muscle activity. Also, the dreams of slow-wave sleep are usually not remembered because consolidation of the dreams in memory does not occur.

1. rapid eye movement sleep (REM sleep), in which the eyes undergo rapid movements despite the fact that the person is still asleep.

In a normal night of sleep, bouts of REM sleep lasting 5 to 30 minutes usually appear on the average every 90 minutes. When the person is extremely sleepy, each bout of REM sleep is short and may even be absent. Conversely, as the person becomes more rested through the night, the durations of the REM bouts increase.

REM sleep has several important characteristics:

1. It is an active form of sleep usually associated with dreaming and active bodily muscle movements.

2. The person is even more difficult to arouse by sensory stimuli than during deep slow-wave sleep.

3. Muscle tone throughout the body is exceedingly depressed, indicating strong inhibition of the spinal muscle control areas.

4. Heart rate and respiratory rate usually become irregular, which is characteristic of the dream state.

5. Despite the extreme inhibition of the peripheral muscles, irregular muscle movements do occur. These are in addition to the rapid movements of the eyes.

6. The brain is highly active in REM sleep, and overall brain metabolism may be increased as much as 20 percent.

In summary, REM sleep is a type of sleep in which the brain is quite active. However, the brain activity is not channeled in the proper direction for the person to be fully aware of his or her surroundings, and therefore the person is truly asleep.

STAGES OF SLEEP

Stage I: Stage of Drowsiness. Alpha waves are diminished and abolished. EEG shows only low voltage fluctuations and infrequent delta waves.

Stage II: Stage of Light Sleep. Stage II is characterized by spindle bursts at a frequency of 14 per second, superimposed by low voltage delta waves.

Stage III: Stage of Medium Sleep. During this stage, the spindle bursts disappear. Frequency of delta waves decreases to 1 or 2 per second and amplitude increases to about 100 µV.

Stage IV: Stage of Deep Sleep. Delta waves become more prominent with low frequency and high amplitude.

SLEEP CENTERS

Complex pathways between the reticular formation of brainstem, diencephalon and cerebral cortex are involved in the onset and maintenance of sleep. However, two centers which induce sleep are located in brainstem:

1. Raphe nucleus: Raphe nucleus is situated in lower pons and medulla. Activation of this nucleus results in non-REM sleep. It is due to release of serotonin by the nerve fibers arising from this nucleus. Serotonin induces non-REM sleep.

2. Locus ceruleus of pons: Activation of this center produces REM sleep.

Inhibition of ascending reticular activating system also results in sleep.

APPLIED PHYSIOLOGY

1. INSOMNIA: Insomnia is the inability to sleep or abnormal wakefulness. It is the most common sleep disorder. It occurs due to systemic illness or mental conditions such as psychiatric problems, alcoholic addiction and drug addiction.

2. HYPERSOMNIA: Hypersomnia is the excess need to sleep. It occurs because of lesion in the floor of the third ventricle, brain tumors, encephalitis, chronic bronchitis and disease of muscles. Hypersomnia also occurs in endocrine disorders such as myxedema and diabetes insipidus.

3. NARCOLEPSY AND CATAPLEXY Narcolepsy is the sudden attack of uncontrollable sleep. Cataplexy is sudden outburst of emotion. Both the diseases are due to hypothalamic disorders.

4. SLEEP APNEA SYNDROME Sleep apnea is the temporary stoppage of breathing repeatedly during sleep. Sleep apnea syndrome is the disorder that involves fluctuations in the rate and force of respiration during REM sleep with short apneic episode. Apnea is due to decreased stimulation of respiratory centers, arrest of diaphragmatic movements, airway obstruction or the combination of all these factors. When breathing stops, the resultant hypercapnia and hypoxia stimulate respiration. Sleep apnea syndrome occurs in obesity, myxedema, enlargement of tonsil and lesion in brainstem. Common features of this syndrome are loud snoring, restless movements, nocturnal insomnia, daytime sleepiness, morning headache and fatigue. In severe conditions, hypertension, right heart failure and stroke occur. 5. NIGHTMARE: Nightmare is a condition during sleep that is characterized by a sense of extreme uneasiness or discomfort or by frightful dreams. 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 troubled state of mind. It occurs mostly during REM sleep. Nightmare occurs due to improper food intake, digestive disorders or nervous disorders. It also occurs during drug withdrawal or alcohol withdrawal.

6. NIGHT TERROR Night terror is a disorder similar to nightmare. It is common in children. It is also called pavor nocturnus or sleep terror. The child awakes screaming in a state of fright and semiconsciousness. The child cannot recollect the attack in the morning. Nightmare occurs shortly after falling asleep and during non-REM sleep. There is no psychological disturbance.

7. SOMNAMBULISM: Somnambulism is getting up from bed and walking in the state of sleep. It is also called sleep walking. It varies from just sitting up in the bed to walking around with eyes open and performing some major complex task. The episode lasts for few minutes to half an hour. It occurs during non-REM sleep

8. NOCTURNAL ENURESIS: Nocturnal enuresis is the involuntary voiding of urine at bed. It is also called or bedwetting. It is common in children

9. MOVEMENT DISORDERS DURING SLEEP: 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. Sleep start is a physiological form of clonus. Other movement disorders are teeth grinding (bruxism), banging the head and restless moment of arms or legs.

1. **DISCUSS THE ROLE OF BASAL GANGLIA IN COORDINATING MOVEMENT**

Introduction

Basal ganglia are the scattered masses of gray matter submerged in subcortical substance of cerebral hemisphere. It forms the part of extra pyramidal system, which is concerned with motor activities. The basal ganglia, like the cerebellum, constitute another accessory motor system that functions usually not by itself but in close association with the cerebral cortex and corticospinal motor control system

Components

Basal ganglia include three primary components:

1. Corpus striatum: Corpus striatum is a mass of gray matter situated at the base of cerebral hemispheres in close relation to thalamus. Corpus striatum is incompletely divided into two parts by internal capsule: i. Caudate nucleus ii. Lenticular nucleus
2. Substantia nigra: Substantia nigra is situated below red nucleus. It is made up of large pigmented and small non­pigmented cells. The pigment contains high quantity of iron.
3. Subthalamic nucleus of Luys: Subthalamic nucleus is situated lateral to red nucleus and dorsal to substantia nigra.

Function of the Basal Ganglia in Executing Patterns of Motor Activity

One of the principal roles of the basal ganglia in motor control is to function in association with the corticospinal system to control complex patterns of motor activity. An example is the writing of letters of the alphabet. When there is serious damage to the basal ganglia, the cortical system of motor control can no longer provide these patterns. Instead, one's writing becomes crude, as if one were learning for the first time how to write.

1. Regulation of Voluntary Movements

Movements during voluntary motor activity are initiated by cerebral cortex. However, these movements are controlled by basal ganglia, which are in close association with cerebral cortex. During lesions of basal ganglia, the control mechanism is lost and so the movements become inaccurate and awkward. Basal ganglia control the motor activities because of the nervous (neuronal) circuits between basal ganglia and other parts of the brain involved in motor activity. Neuronal circuits arise from three areas of the cerebral cortex:

a. Premotor area

b. Primary motor area

c. Supplementary motor area

All these nerve fibers from cerebral cortex reach the caudate nucleus. From here, the fibers go to putamen. Some of the fibers from cerebral cortex go directly to putamen also. Putamen sends fibers to globus pallidus. Fibers from here run towards the thalamus, subthalamic nucleus of Luys and substantia nigra. Subthalamic nucleus and substantia nigra are in turn, projected into thalamus. Now, the fibers from thalamus are projected back into primary motor area and other two motor areas, i.e. premotor area and supplementary motor area.

1. Regulation of Conscious Movements

Fibers between cerebral cortex and caudate nucleus are concerned with regulation of conscious movements. This function of basal ganglia is also known as the cognitive control of activity. For example, when a stray dog barks at a man, immediately the person, understands the situation, turns away and starts running.

1. Regulation of Subconscious Movements

Cortical fibers reaching putamen are directly concerned with regulation of some subconscious movements, which take place during trained motor activities, i.e. skilled activities such as writing the learnt alphabet, paper cutting, nail hammering, etc.

Applied Physiology

1. Parkinson's Disease: Parkinson's disease, known also as paralysis agitans, results from widespread destruction of that portion of the substantia nigra (the pars compacta) that sends dopamine-secreting nerve fibers to the caudate nucleus and putamen. The disease is characterized by rigidity of much of the musculature of the body, involuntary tremor of the involved areas even when the person is resting at a fixed rate of three to six cycles per second, serious difficulty in initiating movement (akinesia), postural instability caused by impaired postural reflexes, leading to poor balance and falls; and other motor symptoms including dysphagia (impaired ability to swallow), speech disorders, gait disturbances, and fatigue.
2. Huntington's Disease (Huntington's Chorea): Huntington's disease is a hereditary disorder that usually begins causing symptoms at age 30 to 40 years. It is characterized at first by flicking movements in individual muscles and then progressive severe distortional movements of the entire body. In addition, severe dementia develops along with the motor dysfunctions.
3. Wilson disease: It is an inherited disorder characterized by excess of copper in the body tissues. It is also known as progressive hepatolenticular degeneration. This disease develops due to damage of the lenticular nucleus particularly, putamen. In Wilson disease, copper is deposited in the liver, brain, kidneys and eyes. Copper deposits cause damage of tissues. And the affected organs stop functioning. In addition to symptoms of Parkinson disease, liver failure and damage to the central nervous system are the most predominant effects of this disorder. Wilson disease is fatal if not treated early.
4. Hemiballismus: It is a disorder characterized by violent involuntary abnormal movements on one side of the body involving mostly the arm. While walking, the arm swings widely. These movements are called the flinging movements. These movements are due to the release phenomenon because of the absence of inhibitory influence on movements. Hemiballismus occurs due to degeneration of subthalamic nucleus of Luys.
5. Chorea: It is an abnormal involuntary movement. Chorea means rapid jerky movements. It mostly involves the limbs. Chorea is due to the lesion in caudate nucleus and putamen.
6. Athetosis: It is another type of abnormal involuntary movement, which refers to slow rhythmic and twisting movements. It is because of the lesion in caudate nucleus and putamen.
7. Choreoathetosis: It is the condition characterized by aimless involuntary muscular movements. It is due to combined effects of chorea and athetosis.