PHYSIOLOGY ASSIGNMENT by DR ONIYIDE

NAME: Awoniyi Gloria Funmilola

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QUESTION 1: Discuss the physiology of sleep

DEFINITION: Sleep is the natural periodic **state of rest for mind and body** with closed eyes characterized by partial or complete loss of consciousness. Loss of consciousness leads to decreased response to external stimuli and decreased body movements. Depth of sleep is not constant throughout the sleeping period. It varies in different stages of sleep.

SLEEP REQUIREMENT Sleep requirement is not constant. However, average sleep requirement per day at different age groups is:

1. Newborn infants : 18 to 20 hours
2. Growing children : 12 to 14 hours
3. Adults : 7 to 9 hours
4. Old persons : 5 to 7 hours.

PHYSIOLOGICAL CHANGES

DURING SLEEP: During sleep, most of the body functions are reduced to basal level. Following are important changes in the body during sleep:

1. PLASMA VOLUME: Plasma volume decreases by about 10% during sleep.

2. CARDIOVASCULAR SYSTEM

***Heart Rate*:** During sleep, the heart rate reduces. It varies between 45 and 60 beats per minute.

***Blood Pressure*:** Systolic pressure falls to about 90 to 110 mm Hg. Lowest level is reached about 4th hour of sleep and remains at this level till a short time before waking up. Then, the pressure commences to rise. If sleep is disturbed by exciting dreams, the pressure is elevated above 130 mm Hg.

3. RESPIRATORY SYSTEM: Rate and force of respiration are decreased. Respiration **becomes** irregular and **Cheyne-Stokes type** of periodic breathing may develop.

4. GASTROINTESTINAL TRACT: Salivary secretion decreases during sleep. Gastric **secretion** is not altered or may be increased slightly. Contraction of empty stomach is more vigorous.

5. EXCRETORY SYSTEM: Formation of urine decreases and specific gravity of urine

6. SWEAT SECRETION: Sweat secretion increases during sleep.

7. LACRIMAL SECRETION: Lacrimal secretion decreases during sleep.

8. MUSCLE TONE Tone in all the muscles of body except ocular muscles decreases very much during sleep. It is called sleep paralysis.

9. REFLEXES Certain reflexes particularly knee jerk, are abolished. **Babinski sign** becomes positive during deep sleep. Threshold for most of the reflexes increases. Pupils are constricted. Light reflex is retained. Eyeballs move up and down.

10. BRAIN Brain is not inactive during sleep. There is a characteristic cycle of brain wave activity during sleep with irregular intervals of dreams. Electrical activity in the brain varies with stages of sleep (see below).

TYPES OF SLEEP Sleep is of two types:

1. Rapid eye movement sleep or REM sleep
2. Non-rapid eye movement sleep, NREM sleep or non-REM sleep.

1. RAPID EYE MOVEMENT SLEEP or REM SLEEP Rapid eye movement sleep is the type of sleep associated with rapid conjugate movements of the eyeballs, which occurs frequently. Though the eyeballs move, the sleep is deep. So, it is also called paradoxical sleep. It occupies about 20% to 30% of sleeping period. Functionally, REM sleep is very important because, it plays an important role in consolidation of memory. Dreams occur during this period.

2. NON-RAPID EYE MOVEMENT SLEEP –NREM OR NON-REM SLEEP Non-rapid eye movement (NREM) sleep is the type of sleep without the movements of eyeballs. It is also called slow-wave sleep. Dreams do not occur in this type of sleep and it occupies about 70% to 80% of total sleeping period. Non-REM sleep is followed by REM sleep.

STAGES OF SLEEP AND EEG PATTERN

RAPID EYE MOVEMENT SLEEP During REM sleep, electroencephalogram (EEG) shows irregular waves with high frequency and low amplitude. These waves are desynchronized waves.

NON-RAPID EYE MOVEMENT SLEEP The NREM sleep is divided into four stages, based on the EEG pattern. During the stage of wakefulness, i.e. while lying down with closed eyes and relaxed mind, the alpha waves of EEG appear. When the person proceeds to drowsy state, the alpha waves

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 100μV.

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

MECHANISM OF SLEEP Sleep occurs due to the activity of some **sleep-inducing centers** in brain. Stimulation of these centers induces sleep. Damage of sleep centers results in sleeplessness or persistent wakefulness called **insomnia.**

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
2. Locus ceruleus of pons.

Recently, many more areas that induce sleep are identified in the brain of animals. Inhibition of ascending reticular activating system also results in sleep.

1. *Role of 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. *Role of Locus Ceruleus of Pons* Activation of this center produces REM sleep. **Noradrenaline** released by the nerve fibers arising from locus ceruleus induces REM sleep.

Inhibition of Ascending Reticular Activating System Ascending reticular activating system (ARAS) is responsible for wakefulness because of its afferent and efferent connections with cerebral cortex.

Inhibition of ARAS induces sleep. Lesion of ARAS leads to permanent somnolence, i.e. coma.

APPLIED PHYSIOLOGY –SLEEP DISORDERS

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 sleep or 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 (Chapter 127) 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. Insevere 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 **walking during sleep** or **sleep walking** (somnus = sleep; ambulare = to walk). 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. In children, it is associated with bedwetting or night terror without any psychological disturbance. However, in adults it is associated with psychoneurosis

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 ofarms or legs.

QUESTION 2: 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. Basal ganglia form the part of **extra pyramidal system,** which is concerned with motor activities.

COMPONENTS OF BASAL GANGLIA Basal ganglia include three primary components:

1. Corpus striatum
2. Substantia nigra
3. Subthalamic nucleus

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.

i. *Caudate Nucleus* Caudate nucleus is an elongated arched gray mass, lying medial to internal capsule. Throughout its length, the caudate nucleus is related to lateral ventricle. Caudate nucleus has a head portion and a tail portion. Head is bulged into lateral ventricle and situated rostral to thalamus. The tail is long and arched. It extends along the dorsolateral surface of thalamus and ends in amygdaloid nucleus.

ii. *Lenticular Nucleus* Lenticular nucleus is a wedgeshaped gray mass, situated lateral to internal capsule. A vertical plate of white matter called **external medullary lamina,** divides lenticular nucleus into two portions:

a. Outer putamen
b. Inner globus pallidus. Putamen and caudate nucleus are the phylogenetically newer parts of corpus striatum and these two parts are together called **neostriatum** or **striatum.** Globus pallidus is phylogenetically older part of corpus striatum. And, it is called **pallidum** or **paleostriatum.** Globus pallidus has two parts, an outer part and an inner part.

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.

SUBTHALAMIC NUCLEUS OF LUYS Subthalamic nucleus is situated lateral to red nucleus and dorsal to substantia nigra. □

CONNECTIONS OF BASAL GANGLIA afferent and efferent connections, different components of corpus striatum of the same side are interconnected by intrinsic fibers.

1. Putamen to globus pallidus
2. Caudate nucleus to globus pallidus
3. Caudate nucleus to putamen.

Different components of corpus striatum in each side are connected to those of the opposite side by commissural fibers.

CONTROL OF MOTOR ACTIVITY

i. *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 **m**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.

ii. *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.

iii. *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.