NAME: ASITA ONISODUENIYA

COURSE: PHYSIOLOGY

COURSE CODE:

MatNO: 17/MHS01/066

DEPT: MEDICINE & SURGERY

QUESTION

1. Discuss the physiology of sleep.
2. Discuss the role of the basal ganglia in coordinating movement.

ANSWER 1

Sleep is the natural state of rest of the body where there is complete or partial loss of consciousness.

TYPES OF SLEEP

During sleep, the body alternates cyclically between two types of sleep. In normal conditions a person enters into the NREM and later on changes to REM sleep. This cycle occurs back and forth till wake time.

1. Slow wave sleep (Non-rapid eye movement sleep NREM)
2. Rapid eye movement (REM) sleep

Slow wave sleep

This is usually called dreamless sleep. It last for about 70-80% during sleep. It is characterized by deep rest, decrease peripheral muscle movement, movement of the eyeballs does not usually occur.

Although, it is referred as dreamless sleep, dreams occur but the relaxed state of the brain restricts the remembering of these dreams.

Rapid eye movement sleep

As the name implies, it is associated with rapid movement of the eyeball. It occupies about 20-30% of sleep.

This sleep is referred to as paradoxical because the brain functions similarly to its wakeful period. The muscles maybe paralyzed but brain activity is increased as though the individual is awake.

The REM sleep is characterized by increased brain activity, irregular heart and respiratory rate, irregular muscle movement (in response to dreams). The REM sleep is also characterized by dreams. The dreams which occur during the REM sleep are remembered, because of the brains activeness hence, they are consolidated in memory.

BRAIN WAVES

The synchronous firing of neurons in the brain constitutes what we refer to as brain waves. There are four types of brain waves that are stated by the Electroencephalogram EEG during sleep;

- Alpha wave; these wave originate from the thalamic-cortical system and are present during relaxed wakefulness
- Beta waves; they are recorded during absolute wakefulness.
- Theta waves
- Delta waves; these waves originate from the cerebral cortex and are recorded during deep sleep.

PHASES OF SLEEP

REM and NREM sleep alternate cyclically throughout a person's sleep. Each type of sleep has phases that is characterized by a distinct brain activity and physiological state of the body.

REM sleep is also referred to as desynchronous sleep because during this period the EEG records irregular waves with high frequency and low amplitude. These brain waves are desynchronized as if the individual were awake.

The NREM sleep is divided into 3 stages, each characterized by different brain activity and waves.

1. **Stage 1;** It is the lightest stage of REM sleep. It is often defined by the presence of slow eye movements, this drowsy sleep stage can easily be disrupted, causing awakenings or arousals. Muscle tone throughout the body relaxes. The EEG during this stage shows low voltage fluctuation and infrequent delta waves.
2. **Stage 2;** It is the actual stage of defined NREM sleep. It becomes harder for arousals and awakenings to occur as in stage I
   The EEG shows spindle bursts (burst of alpha waves periodically).
3. **Stage 3;** It is referred to as deep sleep. It is characterized by delta waves. Awakening during this stage is rare also, sleep parasominias such as sleep walking sleep talking and night terrors occur during this stage of sleep.

MECHANISM OF SLEEP

Sleep is regulated by the interplay of mechanisms that promote sleep and the ones that maintain wakefulness

Mechanisms that promote sleep

There are two identified sleep centres in the brain that promote sleep

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

Mechanisms that maintain wakefulness

- 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.

PHYSIOLOGICAL CHANGES DURING SLEEP

During sleep, there are changes in the physiological state of the body. These changes include;

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
Blood flow to brain	Decreases from wakefulness	Increases from NREM, depending on brain region
Respiration	Decreases from wakefulness	Increases and varies from NREM, but may show brief stoppages; coughing suppressed

APPLIED PHYSIOLOGY

1. **INSOMNIA;** chronic difficulty in falling asleep and/or maintaining sleep when no other cause is found for these symptoms. Insomnia can also be comorbid with or secondary to other disorders
2. **SLEEP APNEA;** Obstruction of the airway during sleep. It usually occurs repeatedly during sleep. Sleep apnea syndrome involves rapid change in the rate and force or respiration during REM sleep with short apneic episode.

Apnea is due to decreased stimulation of respiratory centres, arrest of diaphragmatic movement, airway obstructuction or the combination of all these factors. When breathing stops, the resultant hypercapnia and hpoxia stimulate respiration.

ANSWER 2

The basal ganglia (basal nucleus) is are masses grey matter located in the subcortical region of the cerebral hemispheres.

It consist of the following structures;

1. The Corpus Straitum
2. The Substantia Niagra
3. The Subthalamic Nucleus (of Luys)

The basal ganglia and its structures are concerned with motor movement

CORPUS STRAITUM

The caudate nucleus and the lentiform nucleus constitute what is referred to as the corpus straitum. The caudate nucleus is separated from the lentiform nucleus by the internal capsule

I. Caudate nucleus: it is a mass of grey matter which lies medial to the internal capsule. It is in close association to the thalamus and the lateral ventricle. The caudate nucleus structurally has 3 parts; a head, body and tail. The head bulges into the anterior horn of the lateral ventricle, the body forms part of the floor of the central horn of the lateral ventricle. The tail runs dorsolaterally to the thalamus forming a C-shape as it terminates inclose relation to the amygloid complex.

II. Lentiform nucleus: it is located lateral to the internal capsule and consist of 2 part;
   - Outer Putamens
   - Globus pallidus

Phylogenetically, the outer putamen along with the caudate nucleus forms the newer parts of the corpus straitum which is called neostraitum while the globus pallidus form the older parts which is referred to as pallidum.

SUBSTANTIA NIAGRA

It is a large maotor nucleus present in the mid-brain. It consist of two parts; the pars reticulate and the pars compacta. Par reticulate is related functionally to the internal part of glonous pallidus.

SUBTHALAMIC NUCLEUS OF LUYS

Subthalamic nucleus is situated lateral to red nucleus and dorsal to substantia nigra.

THE CONNECTIONS OF THE BASAL GANGLIA

The Corpus Straitum

The corpus straitum receives afferent connections from the following structures;

- The cortex of the entire cerebrum via the corticostraite fibres
- The thalamus via the thalamostraite fibres
- The substantia niagra to the neostraitum via the nigrostraite fibres(which are dopaminergic)

It sends efferent fibres to the following structures;

- Subthalamic nucleus
- Thalamic nucleus
- The substantia niagra (pars reticularis)

The Substantia Niagra

The substantia niagra mainly sends and receive both afferent and efferent fibres from the corpus straitum. Its connections are;

- It receives fibres from the pallidum of the corpus straitum
- It sends out fibres (nigrostraite fibres which are dopaminergic) to the straitum.
- The pars reticularis projects to the thalamic nucleus and the superior colliculus of the midbrain.

The superior colliculus in turn sends fibres to the reticular formation in the spinal cord. This gives the basal ganglia control of the motor neuron in the spinal cord.

The Subthalamic Nucleus of Luys

- Afferent; Globus pallidus.
- Efferent; Globus pallidus and the red nucleus.

FUNCTIONS OF THE BASAL GANGLIA

1. **MUSCLE TONE:** The basal ganglia causes inhibition of gamma neurons in the spinal cord which are responsible for increasing muscle tone. It does this through the decending inhibitory reticular system in the brain stem. Lesion to the basal nuclei causes increased tension in relaxed muscles.
2. **VOLUNTARY MOVEMENTS:** It controls voluntary movements of the cerebral cortex. The cerebral cortex is responsible for voluntary muscle movements and the basal ganglia acts to regulate and fine tune these movements.

   The cerebral cortex has 3 areas responsible for voluntary movement;

   - The premotor area
   - The primary motor area
   - The supplementary motor area

The relation between the cerebral cortex and the basal nuclei is that of an indirect loop which involves the thalamus.

These 3 areas send fibres to the corpus straitum. The globus pallidum of the corpus straitum send fibres to the thalamic nucleus, subthalamic nucleus and the substantia niagra. The substantia niagra and the subthalamic nucleus in turn, send fibres to the thalamus. The thalamus sends this fibres back to the 3 motor areas in the cerebral cortex.

3. **REFLEX MOVEMENTS:** Reflex movements are also controlled by the basal ganglia. The corneal reflex and labyrinthine reflex which aid maintenance of posture are influenced by the basal ganglia. The blinking centre for the eye is located in the globus pallidus of the basal ganglia.
4. **ASSOCIATED MOTOR MOVEMENTS:** The involuntary movements that accompany voluntary movements are controlled by the basal ganglia. An example of such movement is arm swing during walking. Lesion to the basal ganglia causes these movements to be awkward and abnormal.

The basal ganglia is also involved in motor learning.

APPLIED PHYSIOLOGY

1. **Wilson Disease:** An autosomal recessive defect causes this disease in copper transport and the neurological manifestations are due to the

accumulation of copper in basal ganglia, especially in the putamen. Because copper also accumulates in other tissues, like eyes, Kayser–Fleischer rings, a brown-green pigmentation of the Descemet membrane of the eye are diagnostic signs of Wilson's disease.

2. **Hemiballismus (ballism on the one side of the body)**: It typically occurs after a lesion (ex. stroke, neoplasm) adjacent to the subthalamic nucleus.
3. **Chorea**, **ballism**, and **athetosis** are irregular, involuntary, jerky, and purposeless, "dance-like" movements. They are relatively similar in physiology. Ballism has a more proximal (shoulder and hip) origin and is slower than chorea. Athetosis, in nature, is slower and more twitching.
4. **Huntington's disease:** It is characterized by the degeneration of striatal GABAergic neurons, causing atrophy of the head of the caudate nucleus. Huntington's disease is a genetic, autosomal dominant disease manifested by chorea, dementia and psychiatric abnormalities, bulbar symptoms, and gait disturbance.
5. **Parkinson disease:** Parkinson's disease results from the degeneration of the dopaminergic nigrostriatal projection. In substantia nigra pars compacta, dopaminergic neurons are decreased, so the dopaminergic output to the striatum is decreased. This leads to the reduction of the inhibition of the indirect (inhibitory) pathway and reduction of the excitation of the direct (excitatory) pathway resulting in bradykinesia, which is the main symptom of Parkinson's disease. The condition is also characterized by resting tremor, rigidity and postural instability.