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Questions: 1. Discuss the physiology of sleep

2. Discuss the role of basal ganglia in coordinating movement

1.

Sleep is a naturally recurring state characterized by reduced or absent consciousness, relatively suspended sensory activity, and inactivity of nearly all voluntary muscles. It is distinguished from wakefulness by a decreased ability to react to stimuli.

Types of sleep

Sleep is divided into two broad types :

1. Rapid Eye Movement (REM)
2. Non-Rapid Eye Movement (NREM or non-REM) sleep

* NREM into three stages : N1, N2 and N3, the last of which is also called delta sleep or slow-wave sleep (SWS).

**Rapid Eye Movement (REM)** 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. Rapid eye movement sleep, or REM sleep, accounts for 20–25% of total sleep time in most human adults.

Most memorable dreaming occurs in this stage. A person is even more difficult to arouse by sensory stimuli than during deep slow-wave sleep(NREM), and yet people usually awaken spontaneously in the morning during an episode of REM sleep. A descending muscular atonia is seen and such paralysis may be necessary to protect organisms from self-damage through physically acting out scenes that occur during this stage.

Muscle tone throughout the body is exceedingly depressed, indicating strong inhibition of the spinal muscle control areas. Heart rate and respiratory rate usually become irregular, which is characteristic of the dream state.

Despite the extreme inhibition of the peripheral muscles, irregular muscle movements do occur. The brain is highly active in REM sleep, and overall brain metabolism may be increased as much as 20 per cent. The electroencephalogram (EEG) shows a pattern of brain waves similar to those that occur during wakefulness. This type of sleep is also called **paradoxical sleep** because it is a paradox that a person can still be asleep despite marked activity in the brain.

**Non-Rapid Eye Movement (NREM or non-REM) sleep** is the deep, restful sleep that the person experiences during the 1st hour of sleep after having been awake for many hours. Most sleep during each night is of this type, and this sleep is exceedingly restful and associated with decrease in both peripheral vascular tone and many other vegetative functions of the body. There is about 10 to 30 percent decreases in blood pressure, respiratory rate and basal metabolic rate.

**NREM has three stages;**

Stage N1 refers to the transition of the brain from alpha waves having a frequency of 8–13 Hz (common in the awake state) to theta waves having a frequency of 4–7 Hz. This stage is sometimes referred to as somnolence or drowsy sleep. Sudden twitches and jerks, also known as positive myoclonus, may be associated with the onset of sleep during N1. During N1, the person loses some muscle tone and most conscious awareness of the external environment.

Stage N2 is characterized by sleep spindles ranging from 11–16 Hz and K-complexes. During this stage, muscular activity as measured by EMG decreases, and conscious awareness of the external environment disappears. This stage occupies 45–55% of total sleep in adults.

Stage N3 (deep or slow-wave sleep) is characterized by the presence of a minimum of 20% delta waves ranging from 0.5–2 Hz. This is the stage in which parasomnias such as night terrors, nocturnal enuresis, somnabulism and somniloquy occur. Although slow-wave sleep is frequently called "dreamless sleep“, dreams and sometimes even nightmares 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. The dreams of slow-wave sleep usually are not remembered.

Physiologic Effects of Sleep

Sleep causes two major types of physiologic effects:

* effects on the nervous system itself
* effects on other functional systems of the body.

The CNS is involved in wound healing, Immune system, Development of the brain, Memory processing and Preservation. Lack of sleep certainly affect these functions of the CNS. Prolonged wakefulness is often associated with progressive malfunction of the thought processes and sometimes even causes abnormal behavioral activities. Increased sluggishness of thought that occurs toward the end of a prolonged wakeful period, also a person can become irritable or even psychotic after forced wakefulness.

**Clinical notes**

Some sleep disorders include:

1. **Primary insomnia :** Chronic difficulty in falling

asleep and/or maintaining sleep when no other cause

is found for these symptoms.

1. **Bruxism :** Involuntarily grinding or clenching of the

teeth while sleeping.

1. **Delayed sleep phase syndrome (DSPS) :** inability to

awaken and fall asleep at socially acceptable times

but no problem with sleep maintenance, a disorder

of circadian rhythms - jet lag and shift work sleep

disorder.

1. **Hypopnea syndrome :** Abnormally shallow

breathing or slow respiratory rate while sleeping.

1. **Narcolepsy :** Excessive daytime sleepiness often

culminating in falling asleep spontaneously but

unwillingly at inappropriate times.

1. **Cataplexy :** a sudden weakness in the motor muscles

that can result in collapse to the floor.

1. **Sleep terror disorder :** abrupt awakening from sleep with

behavior consistent with terror.

1. **Parasomnias :** Disruptive sleep-related events

involving inappropriate actions during sleep ; sleep

walking ( Somnabulism ) and talking (Somniloquy).

1. **Rapid eye movement behavior disorder :** Acting out

violent or dramatic dreams while in REM sleep (REM

sleep disorder or RSD).

1. **Sleep paralysis :** is characterized by temporary paralysis of the body shortly before or after sleep. Sleep paralysis may be accompanied by visual, auditory or tactile hallucinations. Not a disorder unless severe. Often seen as part of narcolepsy.
2. **Sleep Apnea, and mostly Obstructive sleep apnea :** Obstruction of the airway during sleep, causing lack of sufficient deep sleep; often accompanied by snoring.

2.

The **basal ganglia**, or basal nuclei, are a group of [subcortical structures](https://www.kenhub.com/en/library/anatomy/subcortical-structures-anatomy) found deep within the white matter of the [brain](https://www.kenhub.com/en/library/anatomy/cerebral-cortex). They form a part of the [extrapyramidal motor system](https://www.kenhub.com/en/library/anatomy/extrapyramidal-system) and work in tandem with the pyramidal and [limbic systems](https://www.kenhub.com/en/library/anatomy/limbic-system).

The function of the basal ganglia is to fine-tune the **voluntary** [**movements**](https://www.kenhub.com/en/library/anatomy/types-of-movements-in-the-human-body). They do so by receiving the impulses for the upcoming movement from the [cerebral cortex](https://www.kenhub.com/en/library/anatomy/cortical-cytoarchitecture), which they process and adjust. They convey their instructions to the [thalamus](https://www.kenhub.com/en/library/anatomy/thalamus), which then relays this information back to the cortex. Ultimately, the fine-tuned movement instruction is sent to the [skeletal muscles](https://www.kenhub.com/en/library/anatomy/histology-of-skeletal-muscle) through the tracts of the pyramidal motor system. Basal ganglia mediate some and other higher cortical functions as well, such as planning and modulation of movement, memory, eye movements, reward processing, and motivation.

Moreover, the basal nuclei use **proprioceptive feedback** from the periphery to compare the **movement patterns** generated by the cerebral cortex with the **actual movement**, so that the movement is subject to ongoing refinement by a continuous servo-control mechanism.

**Clinical notes**

Degeneration of the basal ganglia and, consequently, its dysfunction can lead to several neurological conditions. The characteristic feature of the basal ganglia lesion is a movement disorder in which there is either too little movement (hypokinesia), too much (hyperkinesia), or a combination of both, depending on the location and extent of the affected structure.

**Bradykinesia** represents a generalized slowness of movement and is the most common hypokinesia. The prototypical hypokinetic movement disorder is Parkinson's 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.

**Parkinsonism** is the umbrella term used to describe the symptoms of bradykinesia, tremor, and rigidity. Parkinson's disease is the most common type of parkinsonism, but there are also some rarer types where a specific cause can be identified (ex. drug-induced parkinsonism, progressive supranuclear palsy).

The hyperkinetic movement disorders, unlike Parkinson's disease, are characterized by too much movement. The different clinical types of hyperkinesia include dystonia, chorea, ballism, athetosis tremor, myoclonus, tics, and others.

**Dystonia** is characterized by involuntary, sustained muscle contraction that leads to abnormal postures of the neck, toes, hands, or other parts of the body. The exact mechanism of dystonia is not completely clear. However, the best evidence suggests that there is relevant hypoactivity in the indirect (inhibitory) pathway resulting in less inhibition and more unwanted movement. The clinical types of dystonia classify as either focal, that affects only isolated muscle groups (ex. Spasmodic Torticollis), or generalized, that typically affects muscles in the torso and limbs, and sometimes the neck and face (ex. DYT1 mutation).

**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.

Several disorders are presenting with chorea, and the most common is 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.

**Hemiballismus** (ballism on the one side of the body) typically occurs after a lesion (ex. stroke, neoplasm) adjacent to the subthalamic nucleus.

**Tremor** is an abnormal involuntary, rhythmic and oscillatory movement 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 (intention tremor).

**Myoclonus** is a jerky, involuntary, and usually arrhythmic movement. To imagine how myoclonus looks like, think of body jerks as one is falling asleep, this is physiological myoclonus. A full list of myoclonus-related disorders is very long. Myoclonus can present in some hereditary diseases (ex. Juvenile myoclonic epilepsy) and any central nervous syndrome lesions like tumor, hemorrhage, stroke or abscess.

**Tics** are brief, stereotyped semi-voluntary movements, which means that unlike other movement disorders, they are partially suppressible. Tics can be either motor (motor tics) or sounds (vocal tics). They are common in children and can appear as the result of direct brain injury (ex. head trauma or encephalitis). However, most of them are idiopathic and are part of the spectrum of Gilles de la Tourette syndrome or another idiopathic disorder.