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**DEPARTMENT: MEDICINE AND SURGERY**

**LEVEL: 300**

**COURSE TITLE: NEUROPHYSIOLOGY**

**ASSIGNMENT**

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

**THE PHYSIOLOGY OF SLEEP**

Sleep is defined as unconsciousness from which the person can be aroused by sensory or other stimuli. Humans spend about one-third of their lives asleep, yet most individuals know little about sleep. Although its function remains to be fully elucidated, sleep is a universal need of all higher life forms including humans, absence of which has serious physiological consequences.

**SLEEP ARCHUTECTURE** Sleep architecture refers to the basic structural organization of normal sleep. There are two types of sleep; non-rapid eye-movement ([NREM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/)) sleep and rapid eye-movement ([REM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl98/)) sleep. NREM sleep begins the sleep cycle and is divided into stages 1, 2, 3, and 4, representing a continuum of relative depth. Each has unique characteristics including variations in brain wave patterns, eye movements, and muscle tone. Sleep cycles and stages were uncovered with the use of electroencephalographic (EEG) recordings that trace the electrical patterns of brain activity. Over the course of a period of sleep, [NREM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/) and [REM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl98/) sleep alternate cyclically.

**Non-REM sleep:** NREM sleep constitutes about 75 to 80 percent of total time spent in sleep. Before entering the REM sleep phase, the body goes through each of the stages of non-REM sleep, that is;

***Stage 1 Sleep***: [NREM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/) stage 1 sleep serves a transitional role in sleep-stage cycling*.* *t*his stage usually lasts 1 to 7 minutes in the initial cycle, constituting 2 to 5 percent of total sleep, and is easily interrupted by a disruptive noise. Brain activity on the EEG in stage 1 transitions from wakefulness (marked by rhythmic alpha waves) to low-voltage, mixed-frequency waves.

***Stage 2 Sleep***: st[age 2 sleep](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl118/) lasts approximately 10 to 25 minutes in the initial cycle and lengthens with each successive cycle, eventually constituting between 45 to 55 percent of the total sleep episode. An individual in stage 2 sleep requires more intense stimuli than in stage 1 to awaken. Brain activity on an EEG shows relatively low-voltage, mixed-frequency activity characterized by the presence of sleep spindles and K-complexes. Body temperature drops and heart rate slows down.

***Stages 3 and 4, Slow-Wave Sleep***: sleep stages 3 and 4 are collectively referred to as slow-wave sleep ([*SWS*](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl113/)), most of which occurs during the first third of the night. Each has distinguishing characteristics. Stage 3 lasts only a few minutes and constitutes about 3 to 8 percent of sleep. The EEG shows increased high-voltage, slow-wave activity.

The last [*NREM*](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/) stage is stage 4, which lasts approximately 20 to 40 minutes in the first cycle and makes up about 10 to 15 percent of sleep. The arousal threshold is highest for all NREM stages in stage 4. This stage is characterized by increased amounts of high-voltage, slow-wave activity on the EEG.

**NOTE:** Most of us can understand the characteristics of deep slow-wave sleep by remembering the last time we were kept awake for more than 24 hours and then the deep sleep that occurred during the first hour after going to sleep. 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.

**REM Sleep (Paradoxical Sleep, Desynchronized Sleep):** 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:

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

**b.** The person is even more difficult to arouse by sensory stimuli than during deep slow-wave sleep, and yet people usually awaken spontaneously in the morning during an episode of REM sleep.

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

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

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

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

**THE PHYSIOLOGY DURING SLEEP:** In addition to the physiological changes listed, 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:

* **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. Furthermore, 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.
* **Sympathetic-nerve activity:** Sympathetic-nerve activity decreases as [NREM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/) 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](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl98/) sleep.
* **Respiratory:** Ventilation and respiratory flow change during sleep and become increasingly faster and more erratic, specifically during [REM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl98/) sleep. Ventilation data during REM sleep are somewhat unclear, but they suggest that hypoventilation. 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. 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.
* **Cerebral blood flow:** [NREM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/) sleep is associated with significant reductions in blood flow and metabolism, while total blood flow and metabolism in [REM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl98/) 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.
* **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.
* **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 and generally occurs during [SWS](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl113/), while thyroid hormone secretion takes place in the late evening. [Melatonin](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl74/), 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.

**ROLE OF BASAL GANGLIA IN CO-ORDINDINATION OF MOVEMENT**

The “basal ganglia” refers to a group of subcortical nuclei within the brain responsible primarily for **motor** control, as well as other roles such as **motor** learning, executive functions, emotional behaviours, and play an important role in reward and reinforcement, addictive behaviours and habit formation.

**ROLES**

Basal ganglia controls voluntary movement initiated by motor cortex. Roles include;

* **Cognitive control of motor activity**
* **Timing and scaling of intensity of movement**
* **Subconscious execution of some movements**.
* **Cognitive control of motor activity:** physiological studies have shown that neural discharge in basal ganglia, begins well before the movements begins. Therefore,it is believed that basal ganglia, like cerebellum, are involved in the planning and programming of movement.

Most of the motor movements occur as a consequence of thoughts generated in the mind. This process is known as cognitive control of motor activity.

The cognitive control of motor activity is excuted by the basal ganglia through the feedback loops (functional neuronal circuit). As described above, the caudate loop is primarily involved in the cognitive control of motor activity.

* **Timing and scaling of intensity of movement:** two important capabalities of brain in controlling the movements are;
* Timing of movements i.e how rapidly the moevments should be performed.
* Scaling of the intensity of movements, i.e how large the movement should be.
* **Subconscious execution of some movements:** basal ganglia subconscioulsly executes some movements during the performance of trained motor activities, i.e skilled activites. Examples of movements executed sub-consciously at the level of basal ganglia are;
* Swinging of arms while walking,
* Crude movement of facial expressions that accompany emotions,
* Movements of limbs while swimming.

Importance: by subconscious control of activites, the basal ganglia relieve cortex from routine acts so that cortex can be free to plan its actions.

