**17/MHS01/203**

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**MBBS 300 level**

**Neuro-physiology assignment.**

**1. Discuss the physiology of Sleep.**

**What is sleep?**

Sleep is a state of reduced awareness and responsiveness. In humans, sleep is also associated with reduced movement.

Sleep consists of two different phases:

• Rapid eye movement (REM) sleep; and

• Non-REM sleep or slow wave sleep.

**REM sleep**

REM sleep is characterised by the presence of rapid eye movements during sleep. This type of sleep is less restful than slow-wave sleep and is associated with dreaming and bodily muscle movements. During REM sleep a person’s threshold to be aroused by external stimuli is higher than during slow-wave sleep. Heart rate and breathing become irregular during REM sleep, a feature of the dream state.

The brain is extremely active during REM sleep. The electroencephalogram shows patterns of brain wave activity similar to those that occur during the waking hours. Due to this feature of REM sleep, it is often also referred to as paradoxical sleep as it is a paradox that one can be asleep and yet the brain is incredibly active.

**Non-REM sleep**

In contrast, Non REM sleep is characterized by deep sleep. The duration of REM sleep episodes is longer earlier in the night when one is most tired. As one becomes more rested during the night, the duration of REM sleep episodes decreases.

During non-REM sleep the blood pressure, breathing and metabolic rate are all depressed significantly. Bodily movements do not occur during non-REM sleep.

Non-REM sleep is also referred to as slow wave sleep as during this period the brain waves are very strong and of a very low frequency (i.e. slow).

While non-REM sleep is sometimes referred to as dreamless sleep, dreams and even nightmares can occur during non-REM sleep. These are not associated with movement and are not remembered as they are not consolidated to memory during this sleep phase.

**Sleep cycles**

REM sleep occurs at about 90 minute intervals. There are usually 4 to 6 cycles of REM and non-REM sleep each night. Later into the night, the REM episodes become longer and non-REM sleep becomes shorter and lighter.

Non-REM sleep can be defined as stage 1, 2, 3 or 4. Stages 1 and 2 are often referred to as light sleep and stages 3 and 4 as deep sleep, slow wave sleep or delta sleep.

**Brain wave activity (EEG) during wakefulness and sleep**

Sleep cycles refer to the cyclical nature of our sleep. When we fall asleep, our sleep goes in cycles throughout the night, moving back and forth between deep restorative sleep (stages 3 and 4 of non-REM sleep) and more alert stages (stages 1-2 of non-REM sleep) and dreaming (REM sleep). As the night progresses, we spend more time in dream sleep and lighter sleep.

**Circadian rhythm**

Circadian rhythms occur in 24 hour cycles. The circadian rhythm prompts sleep at night and also to small extent between 2 and 4 pm. Usually the sleep, temperature and hormonal circadian rhythms are synchronised so that all of these factors act together to drive a state of sleep or wakefulness.

The circadian rhythm is generated by a “biological clock” whose activity is modulated by various external stimuli. These external cues ensure that the internal clock is in sync with the external environment.

Special cells within the retina of the eye provide the input to the SCN. The SCN in turn influences melatonin secretion from the pineal gland. Melatonin is synthesised from tryptophan. Melatonin production can be increased by an increased oral intake of tryptophan and vitamin B6 (a co-enzyme in tryptophan metabolism) such as by consuming carbohydrates, milk, bananas, figs and peanuts, so consuming these can help an individual to fall asleep. Melatonin secretion is increased by selective serotonin reuptake inhibitors (anti-depressants) and antipsychotics. Melatonin release is inhibited by caffeine, beta-blockers, benzodiazepines and non-steroidal anti-inflammatories, and their consumption can make it more difficult to sleep.

Regimented times for going to bed, going to sleep, waking and getting up are important for reinforcing circadian rhythm. The most important of these is the time of waking because it helps to ensure that the homeostatic drive to sleep is strong.

**Why do we need sleep?**

The importance of sleep is clear from the strong evolutionary conservation of sleep. Most animals have evolved in such a way that they spend considerable periods of time sleeping, despite sleep making us vulnerable (e.g. to attack from predators). The functions of sleep, that is, how sleep functions to support other bodily processes, are still uncertain. However, it is known that REM and non-REM sleep perform different functions, and biochemical, physiological, neurological and psychological process occur differently when an individual sleeps compared to when they are awake.

**Biochemical**

Different hormones are secreted depending upon whether an individual is asleep or awake. For example growth hormone is secreted during sleep while cortisol is secreted during wakefulness.

Metabolic rate falls during non-REM sleep, energy is conserved and body temperature drops.  During this period protein synthesis and the production of complex molecules within the body is increased.

When we are awake our brain cells use a considerable amount of glucose to function and the intracellular glycogen stores become depleted. During sleep this process is reversed so that glucose is available during the next bout of wakefulness.

**Physiological**

Sleep has been considered a restorative or a recovery phase that prepares the body for the next episode of wakefulness. Cell division is more rapid during non-REM sleep and sleep has an important function on the immune system.

**Neurological**

Sleep may have some role in development of brain cells and connections between brain cells during development. The ability to form new neurons (neurogenesis) slows early in life and it is the development of new neuronal networks that is responsible for new behaviours.

Synchronisation of cortical activity during non-REM sleep may in some way coordinate cortical connections. The prefrontal cortex is inactive during all phases of sleep (this may also confer some benefit). During REM sleep the cerebral Cortex is open to sensory inputs and forms loose associations that cannot be formed during wakefulness.

**Psychological**

Both phases of sleep are involved in memory consolidation. Very little new information is gained during sleep, but consolidation and maintenance of memory from experiences of the previous day is considerable. It is known that learning of visual information is improved during the first night of sleep and that sleep deprivation impairs recall of the information. Different types of sleep have a different effect on memory consolidation and retention of information. Retention is best if stage 3 and 4 non-REM sleep occurs in the first 2 hours of sleep and if the last 25% of sleep is REM sleep.

The type of sleep also affects the type of information which is consolidated by the brain. Learning of movement sequences is best if stage 2 non-REM sleep occurs late in the night, while learning of cognitive sequences occurs best if there is a cycle of REM and non-REM sleep.

Dreams are a manifestation of underlying brain activity and reflect the loose associative connections made during REM sleep. These loose associations are likely to result in increased creative mental activity and problem-solving abilities.

**2. The role of Basal ganglia in coordinating movements**

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.

The basal ganglia are located at the base of the forebrain (cerebrum) and have attracted attention in medicine for various disturbances that appear with dysfunctions caused by diseases or trauma. Disruption of the basal ganglia network forms the basis for several movement disorders eg Parkinson’s disease and Huntington disease.

The function of the basal ganglia is to fine-tune the voluntary movements. They do so by receiving the impulses for the upcoming movement from the cerebral cortex, which they process and adjust. They convey their instructions to the thalamus, which then relays this information back to the cortex.

The basal ganglia are responsible for voluntary motor control, procedural learning, and eye movement, as well as cognitive and emotional functions. The basal ganglia exert their role in motor control through constant interaction with the cerebral cortex and the corticospinal pathway. They get information mainly from the cerebral cortex and send out information. Some other roles of basal ganglia includes :

* Represents the accessory motor system. Mediates between neocortical motor centers and the "elderly" motor areas of the brainstem Selects the purposeful and desired motor activity and suppresses unwanted movements.
* Acts by modifying ongoing neural activity in motor projections
* Delivers an inhibitory role in motor control
* Inhibits muscle tone (balance of excitatory and inbound input signals according to PMN terminating on skeletal muscle)
* Monitor and adjust slow and continuous contractions (equilibrium, body position, etc.)
* Regulates attention and individual cognitive processes
* Participates in motor planning and learning
* Assisting the cerebral cortex in making subconscious, learned movements
* Temporal pattern of movement and gradation of the intensity of movement