Neurophysiology 2020: Neurophysiology of sleep and sleep-wake disorders- Dharitri Parmar, Government Medical College

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Sleep & wakefulness are important physiological manifestations of brain, even for clinicians. Review on Physiology of Sleep comprises wakefulness as they are interchangeable, interdependent states. On discussion with introduction to sleep which includes sleep cycle; types of sleep; sleep waves neurotransmitters, pathways, circuits, & receptors are summarized. Role of higher centres, parts of brain & other factors (steroid, aging, biological rhythm etc.) are reviewed. Its implication in various sleep disorders & recent developments in neurophysiology related to sleep are described. As human beings, we sleep for approximately one-third of our lives, yet nobody knows why we do it, which molecular mechanisms are involved, or why sleep manifests as major changes in the brain's electrical activity that are associated with unconsciousness. This condition is inherently risky since it prevents animals from protecting themselves & from foraging for food. Therefore, it must serve important functions. This conclusion is highlighted by the presence of sleep in all animals in which its essential features have been carefully sought. The first of these features is rapidly reversible behavioral quiescence, which distinguishes sleep from seizure, coma, hibernation, & anesthesia. The second feature is reduced arousal. Analytically, this translates to reduced responsiveness to environmental stimuli, which distinguishes sleep from quiet wakefulness. The third feature is homeostatic regulation. This means that a set point exists for daily sleep, with variations from this set point requiring compensation later. Experimentally, this homeostatic property can be proven by preventing an animal from sleeping & then observing a compensatory increase, or rebound, in sleep shortly afterward.

Researchers have taken a further approach to characterizing sleep in some animals. This approach involves using electrophysiological techniques, such as the electroencephalogram to measure brain activity & the electromyogram to measure skeletal muscle tension. These procedures have revealed the existence of two major sleep states in mammals, birds, & certain lizards. Non-rapid eye movement sleep can be distinguished by slowing & synchronization of brain oscillations, whereas rapid eye movement sleep can be distinguished by brain desynchrony & muscle atonia. Importantly, both NREM & REM sleep states are also correlated with the vital behavioral features of sleep described above. Thus, these developmental features alone are sufficient to define sleep in animals in which electrophysiological recordings are particularly challenging, including fish & many invertebrates. Nonetheless, in some of these animals, such as fruit flies, crayfish, & worms, differences in brain activity have been confirmed between low & high arousal states, although in these organisms NREM & REM sleep states have not been observed, presumably because invertebrates lack the brain structures required for these phenomena.

Sleep architecture refers to the basic structural group of normal sleep. There are two different types of sleep, non-rapid eye-movement sleep & rapid eye-movement sleep. NREM sleep is divided into stages of 1, 2, 3 & 4, representing a continuum of relative depth. Each has unique characteristics including variations in brain wave patterns, eye movements, & muscle tone. Sleep cycles & stages were uncovered with the use of electroencephalographic recordings that trace the electrical patterns of brain activity. The function of alternations between these two types of sleep is not yet understood, but irregular cycling &/or absent sleep stages are associated with sleep disorders. For example, instead of entering sleep through NREM, as is typical, individuals with narcolepsy enter sleep directly into REM sleep.

Sleep architecture changes continuously & considerably with age. From infancy to adulthood, there are marked changes in how sleep is initiated & maintained, the percentage of time spent in each stage of sleep, & overall sleep efficiency. A general trend is that sleep efficiency decreases with age. Although the consequences of decreased sleep efficiency are comparatively well documented, the reasons are complex & poorly understood. Examination of sleep characteristics by age, however, allows a closer understanding of the function of sleep for human development & successful aging.

Latest insight into the physiological patterns of sleep & wakefulness has shown that different brain-processing networks & neurochemical systems are involved in both states. The neuronal pathways, transmitters, & receptors that make up the ascending arousal system centered in the hypothalamus interact with sleep-active neurons in the VLPO in a flip-flop switch to produce distinct sleep-wake states with abrupt transitions. Progress in understanding the neural circuitry underlying the regulation of sleep-wake states has led to the identification of new mechanisms, substrates & studies are now underway to investigate these potential targets. In the future, the products of these investigations may offer novel approaches for the treatment of these common & intractable conditions.

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