Sleep Physiology & Sleep Disorders

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Sleep Physiology

- Sleep is a state of unconsciousness from which the person can be awaked.
- People spend one third of their life in sleep.
- Sleep deprivation and sleepiness is responsible for:
  - Accidents,
  - Missed education,
  - Marital and interpersonal problems,
  - Occupational impairment.
Brain Activities

- The brain has 3 major states of activity and function, which can be recorded by the Electroencephalograph (EEG):

1. Wakefulness:
   - Facilitated by Ascending Reticular Activating System (ARAS) & Posterior Hypothalamus
   - EEG demonstrates low voltage fast activity of mixed alpha (8-13 Hz) & beta (>13 Hz) frequencies.

2. Non Rapid Eye Movement Sleep (N-REM Sleep)

3. Rapid Eye Movement Sleep (REM Sleep)
Electroencephalography (EEG)

- EEG, clinically, is defined as the recording of the brain’s spontaneous electrical activity by the use of multiple electrodes placed on the scalp.

- Recording time usually lasts 20-40 minutes

- Four major brain wave activities are recorded:
  - Alpha activity
  - Beta activity
  - Theta activity
  - Delta activity
Brain Activities (EEG Wave Frequencies)

- **Alpha activity:**
  - Frequency between 7.5 and 13 Hz.
  - It is the major rhythm seen in normal relaxed adults with closed eyes.
  - Strongest over the occipital cortex.
  - Present beyond age 13 year

- **Beta activity:**
  - Has a frequency of 14Hz and greater.
  - Most evident frontally.
  - Dominant rhythm in those who are alert listening and thinking, or anxious, or who have their eyes open.
Brain Activities Frequencies (cont…)

- **Theta activity:**
  - Has a frequency of **3.5 to less than 7.5 Hz** and is classed as "slow" activity.
  - It is seen in connection with creativity, intuition, daydreaming.
  - It reflects the state between wakefulness and sleep.
  - Abnormal in awake adults, but **normal** in children up to age 13 yr.

- **Delta activity:**
  - The lowest frequencies (less than 3.5 Hz).
  - Occurs in **deep sleep** (stages III and IV sleep)
  - Reflects unconscious mind.
  - It is the dominant rhythm in **infants up to one year of age**.
Brain waves as recorded by EEG
The pineal gland is a small endocrine gland located in the centre of the brain.

It produces the serotonin derivative Melatonin

Melatonin is a hormone that affects the modulation of wake/sleep patterns.

The production of melatonin by the pineal gland is stimulated by darkness and inhibited by light.

It is a pervasive and powerful antioxidant, with a particular role in the protection of nuclear and mitochondrial DNA.

It is commonly prescribed for the treatment of circadian rhythm sleep disorders.
Physiology of Normal Human Sleep

- Sleep consists of 70-120 minutes cycles of N-REM & REM sleep

- **Supra chiasmatic nucleus** is a tiny region on the brain's midline, situated directly above the optic chiasm, functions as a pacemaker for most circadian rhythms and is involved in the sleep-wake cycle.

- Sleep can not be localized to a single neurotransmitter or anatomic location within the brain
N-REM Sleep (slow wave sleep)

The **EEG** differentiated 4 stages of N-REM Sleep:

- **Stage I:**
  - EEG demonstrates “theta activity” (4-7 Hz).
  - EMG demonstrates decreased muscular tone.
  - Slow rolling of eyes may be noticed

- **Stage II:**
  - EEG demonstrates “theta activity” + “sleep spindles” (brief bursts of 12-14 Hz) + “K complexes” (high amplitude, slow frequency, electronegative wave followed by electropositive waves)
  - Decreased muscle tone
  - Rare eye movements
N-REM Sleep

- Stages III & IV (slow wave sleep):
  - Deepest stages of sleep.
  - Occurs in the first two N-REM periods.
  - Epochs of sleep consisting of greater than 20% & 50%, respectively, of “delta wave activity” (0.5-3.0), high voltage slow waves
  - Atonia
  - No eye movements

- N-REM sleep is driven by basal forebrain, area around the solitary tract in the medulla and dorsal Raphe nucleus (serotonergic cells).
Rapid Eye Movement Sleep (REM Sleep) (Paradoxical Sleep)

- Brain electrically & metabolically **activated**.
- EEG demonstrates **low voltage rapid waves**.
- Cerebral Blood Flow (CBF) **increased**.
- Generalized muscle **atonia**.
- Penile and clitoral **engorgement**.
- Fluctuation in respiratory and cardiac rate.
**REM Sleep**

- Vivid and affectively charged **dreams** associated with activities of the **Amygdala**.
- **Polysomnography** demonstrates **rapid eye movements**.
- **REM phases** in the first half of the sleep period are brief and lengthen in successive cycles.
- Occurs in phasic bursts
- Typically occupies 20-25% of total night sleep.
REM Sleep

- Controlled by 2 antagonistic systems:

1. REM “off” cells:
   - Raphe nucleus *(Serotonergic)*
   - Locus coeruleus *(Noradrenergic)*
   - Nucleus peribrachialis lateralis *(Noradrenergic)*

2. REM “on” cells:
   - Mesencephalic Medullary and Pontine Giganto Cellular Region *(Cholinergic cells).*
EEG during sleep

- Awake
- Stage 1
- Stage 2
- Stage 3
- REM sleep

- Spindles
- K-complex
Developmental Periods & Sleep Atterns:

- The baby at birth sleeps **18-20 hours**
- Differentiation of REM & Non-REM sleeping occur at age **3-6 months**
- A newborn baby spends more than **80%** of total sleep time in REM.
- During first **3 years** of life sleep-wake rhythm develops from **ultradian** to **circadian** patterns with principal sleep phase occurring at night

**ultradian rhythms** happen more than once a day
**circadian rhythm** occurs once a day
Developmental Periods & Sleep Phases Patterns (cont...):

- Puberty and adolescence: large percentage of REM sleep and decrease in stage III & IV N-REM (slow wave sleep)
- Age 20-60 years: gradual and slight decline in sleep efficiency and total sleep time
- Old age: light and fragmented sleep with gradual disappearance of slow wave sleep.
Thank You
Functions of Sleep:

1. Restoration of tissues
2. Energy conservation
3. Discarding irrelevant memories from the overloaded brain
4. Consolidation of memory
Impact of poor sleep:

1. Poor job performance
2. Accidents
3. Impaired physical well being
4. Marital and interpersonal problems
5. Increased use of alcohol
6. Mood change
7. Fatigue
8. Muscle aches
9. Impaired attention and concentration and missed education
Sleep Assessment

1. Polysomnography

- A principal diagnostic tool in the field of sleep medicine.
- Applied during sleep.
- Records several data:
  - Electroencephalography (EEG)
  - Electrooculography (EOG)
  - Electromyography (EMG)
  - Electrocardiography (ECG)
  - Oxymetry
Sleep Assessment

Polysomnography provides data on:

- Sleep continuity
- Sleep architecture
- REM sleep physiology
- Sleep related respiratory impairment
- Oxygen desaturation
- Cardiac arrhythmias
- Periodic movements
Sleep Assessment

II. The Multiple Sleep Latency Test (MSLT):

- Measures excessive sleepiness or sleep disorder.
- Used to measure **sleep latency**, the time it takes from the start of a daytime nap period to the first signs of sleep.

- Electrodes are attached to the
  - patient's head to record brain waves.
  - eyes to record eye movement.
  - chin to detect muscle tone.
  - Heart beat may also be monitored.

- The patient is asked to nap for 20 minute periods, and then is awakened.
III. Infrared video monitoring

(Infrared/video electronystagmographic apparatus)

• A system for viewing and recording eye movement during sleep.

• The output of the video camera is connected to monitoring apparatus for monitoring and recording the user's eye movements during sleep.
Sleep Assessment

IV. Nocturnal penile tumescence

- Is the spontaneous occurrence of a penile erection during sleep.

- All men experience this phenomenon several times a night.

- It typically happens during REM Sleep and it is not uncommon for an erection to be present when a man wakes.

- It helps differentiation between psychogenic and organic erectile dysfunction
Sleep Assessment

V. Body Temperature

- Changing body temperature could change how well one can sleep.

- Warming up body while cooling hands could help stay awake

- In most people, the body is warmer than hands and that helps keep the body alert.
### Sleep-Wake Disorders Classification (DSM-5)

1. Insomnia Disorders
2. Hypersomnolence
3. Narcolepsy
4. Breathing-related sleep disorders
5. Circadian rhythm sleep-wake disorder
6. NREM Sleep Arousal Disorders
7. REM sleep behaviour disorder
8. Restless leg syndrome
9. Substance/Medication induced sleep disorder

- Individuals with these disorders are dissatisfied regarding quality, timing, and amount of sleep.
- They share daytime distress and impairment
Insomnia Disorder

- Difficulty initiating, maintaining sleep, prolonged sleep latencies, or decreased sleep efficiency.
- The insomnia lasting at least one month.
- Extremely light sleep; easily affected by noise, temperature fluctuation and anxiety.
- Not secondary to another sleep disorder.
- May develop after a period of severe stress.
- Primary insomnia can be chronic causing fatigue, muscle aches and mood disturbances.
Insomnia

- **Treatment:**
  - Avoid hypnotic use
  - Relaxation
  - Stimulus control
  - Behaviour modification
  - Sleep restriction therapy.
Stimulus Control

- A group of behavioural instructions that make the person learns to associate the bed and bedroom with sleep.

- Achieved by:
  1. Going to bed only when sleepy
  2. Avoidance of activities in the bedroom that awaken the individual
  3. Sleep should be restricted to bedroom
  4. Leaving the bedroom when can't sleep
  5. Arising at the same time each morning regardless of the amount of sleep obtained that night
  6. Avoiding daytime napping
Sleep restriction therapy

- Stay awake even if you feel sleepy during the day.
- Wake at a fixed time in the morning, even if this means you only get a few hours sleep for the first few nights.
- If you don't fall asleep within 30 minutes, get up until you feel sleepy again.
- As your sleep improves gradually go to bed earlier and continue to get up early so you get a full night's sleep and establish a regular routine.
Hypersomnolence disorder (Hypersomnia)

- is a disorder characterized by:
  - excessive sleepiness day and night,
  - extended sleep time in a 24-hour cycle,
  - inability to achieve the feeling of refreshment that usually comes from sleep.
Narcolepsy

- Recurrent periods of an irresistible need to sleep, lapsing into sleep, or napping occurring within the same day.
- At least 3 times per week over the past 3 months.

Narcolepsy is characterized by:
- **Cataplexy**: sudden and transient episode of loss of muscle tone, often triggered by laughter or joking, without loss of consciousness.
- Hypocretin deficiency in the CSF
- Reduced nocturnal REM sleep latency (less than 15 minutes) as recorded by the polysomnograph & MSLT
- Vivid hypnagogic or Hypnopompic hallucinations
- Sleep paralysis upon falling asleep or awakening
- Obesity is common and nocturnal eating may occur
Narcolepsy

- Often associated with:
  - Increased job related injuries
  - Impaired occupational and academic performance
  - Increased prevalence of anxiety, mood disorder and cognitive disorders

- Treatment of Narcolepsy:
  1. Stimulants: Methylphenidate 10-60mg daily
  2. Tricyclic agents (to control cataplexy)
Breathing Related Sleep Disorders (Sleep Apnea)

- Characterized by frequent respiratory pauses during sleep (Apnea)
- Associated with loud snoring
- Terminated by:
  - Loud gasping
  - Threshing movements
  - Arousal
- Leads to hypoxia and sleep fragmentation
- An age related disorder (Affects 24% of people over age of 65)
Breathing Related Disorders

Conditions that may be associated with Sleep Apnea include:

- Obesity
- Hypertension and pulmonary hypertension
- Cardiac arrhythmia
- Nocturnal cardiac ischemia
- Myocardial infarction
- Excessive mortality
Breathing Related Disorders

Sleep Apnea causes:

- daytime somnolence
- impaired concentration
- impaired intellectual functioning
- morning headache

Types of Sleep Apnoea:

- Central apnea: due to impairment of central respiratory drive
- Obstructive apnea: due to intermittent upper airway obstruction
- Mixed apnea: combination of both
Breathing Related Disorders

Treatment:
- Abstinence from sedatives and hypnotics
- Weight Reduction
- Sleep position training
- Mechanical use of tongue retaining devices
- Nasal CPAP (Continuous Positive Airway Pressure): The process of delivering a continuously raised airway pressure via a mask on the nose
- 50% benefit from surgery for long uvula [Uvulopalatopharyngoplasty (UPPP)]
Circadian Rhythm Sleep-Wake Disorders (Sleep -Wake Schedule Disorder)

- A persistent or recurrent pattern of sleep disruption that is primarily due to an alteration of the circadian system or the sleep-awake schedule required by the individual’s physical environment or social or professional schedule affecting, among other things, the timing of sleep.
- People with these disorders are unable to sleep and wake at the times required for normal work, school, and social needs.
- Presents with either insomnia or hyper somnolence
- Associated with significant medical comorbidity and impairment in psychosocial functioning
Circadian Rhythm Sleep Disorders
(Sleep -Wake Schedule Disorder)

Examples:

- **Jet lag** which affects people who travel across several time zones.
- **Shift work sleep disorder**, which affects people who work nights or rotating shifts.
- **Delayed sleep phase disorder** (DSPD), characterized by a much later than normal timing of sleep onset.
- **Advanced sleep phase disorder** (ASPS), characterized by difficulty staying awake in the evening and difficulty staying asleep in the morning.
Circadian Rhythm Sleep Disorders
(Sleep -Wake Schedule Disorder)

- Are associated:
  - Poor sleep
  - More cognitive errors
  - Higher rate of divorce
  - Higher rate of on job sleepiness
  - Higher rate of drug use
  - Mood disturbance
  - Decreased work performance
  - Malaise

**Treatment:**
- promote good sleep hygiene,
- improve shift work
Parasomnias

• **Parasomnias** are disorders characterized by abnormal behavioural, experimental or physiological events occurring in association with sleep, specific sleep stages, or sleep-wake transitions.

• Involve abnormal movements, behaviors, and dreams that occur while falling asleep, sleeping, between sleep stages, or during arousal from sleep.

• Most parasomnias are partial arousals during the transitions between wakefulness and N-REM sleep, or wakefulness and REM-sleep.
Parasomnias

- Include:
  - N-REM Sleep Arousal Disorders
  - REM Sleep Behaviour Disorders
N-REM Sleep Arousal Disorders

- These disorders include:
  - sleep walking
  - night terror
  - confusional arousals
  - sleep sex,
  - sleep eating
  - teeth grinding
N-REM Sleep Arousal Disorders

- N-REM parasomnias are recurrent episodes of incomplete arousal from sleep usually occurring during stage 3 or 4 N-REM sleep, accompanied by one of the following:

  1. Sleep walking
  2. Sleep terrors

- No or little dream imagery is recalled
- Amnesia for the episode
- The episode causes significant distress or impairment in socio occupational functioning
N-REM Sleep Arousal Disorders

1. Sleep walking:
   - Repeated episodes of rising from bed during sleep and walking about
   - The individual has a blank, staring face
   - Frequently unresponsive to the efforts of others to communicate with
   - Can be awakened only with great difficulty
N-REM Sleep Arousal Disorders

2. Sleep terrors:

- Recurrent episodes of abrupt terror arousals from sleep
- Usually beginning with a panicky scream
- Associated with intense fear and signs of activation of the autonomic nervous system, motor system or cognitive processes during sleep or sleep-wake transitions.
- The individual is unresponsive to efforts of others to comfort him during the episodes.
3. Confusional arousals

- **Confusional arousal** is a condition when an individual awakens from sleep and remains in a confused state.
- It is characterized by the individual's partial awakening and sitting up to look around. They usually remain in bed and then return back to sleep.
- These episodes last from seconds to minutes and may not be reactive to stimuli.
- Confusional arousals are not considered dangerous.
- Confusional arousals are common in children. Not observed very often in adults.
- Infants and toddlers experience confusional arousals beginning with large amounts of movement and moaning, which can later progress to occasional thrashings or inconsolable crying.
Teeth grinding (bruxism)

- **Bruxism** is a common sleep disorder where the individual grinds their teeth during sleep.
- This can cause sleep disruption for the individual and also the bed partner.
- Grinding can wear and fracture the teeth, and also cause severe jaw pain. This can lead to migraines, teeth impairment, and other complications.
- A lot of people are not aware of their teeth grinding.
- Teeth grinding may be caused by stress and anxiety.
- It could also be caused by a non-typical bite, or missing teeth.
5. Periodic limb movement disorder (PLMD),

- Previously known as **nocturnal myoclonus**.
- Is a sleep disorder where the patient moves limbs involuntarily during sleep, **Stage 1 and 2 of non-REM sleep**.
- Periodic leg movements of sufficient severity leading to sleep disturbance, insomnia or daytime sleepiness.
- The patient is often unaware of these movements.
- **Seen in association to:**
  - Sleep apnea, Narcolepsy, Uremia, Diabetes mellitus, Cortex, brainstem and spinal cord disorders
- **Treatment:** Benzodiazepine drugs, L-dopa/ carbidopa, Carbamazepine
REM Sleep Behavior Disorder

- Repeated episodes of arousal, often associated with vocalizations and/or complex motor behaviours arising from REM sleep (Dream enacting behaviours e.g. talking, yelling, punching, kicking, sitting, jumping from bed, arm flailing, and grabbing).
- The hypotonia that normally occurs during REM sleep is incomplete or absent, allowing the person to "act out" his or her dreams.
- Usually seen in middle-aged to elderly people
- Can be transient during intoxications or withdrawal
- May exist as a chronic condition in patient with neurologic disorder
- Treated with Benzodiazepine or Carbamazepine
Nightmare
(Dream Anxiety Disorder)

- An unpleasant dream characterized by vivid detailed imagery with good recall.
- Causes a strong negative emotional response.
- Sufferers usually awaken in a state of distress and may be unable to return to sleep for a prolonged period of time.
- The dream may contain situations of danger, discomfort, psychological or physical terror.
- Recurrent nightmares cause insomnia and can interfere with sleeping patterns and
Nightmare

- **Causes include:**
  - sleeping in an uncomfortable or awkward position
  - having a fever
  - Psychological causes such as stress, anxiety, PTSD
  - ingestion of opioid drugs
  - eating before going to sleep
- Occurs in 10-50% of children with peak age 3-6, College students 10-29%
- One or more attack per month
- Increased frequency with PTSD
Restless Leg Syndrome (RLS)

- RLS occurs while awake and when asleep.
- RLS is characterized by an irresistible urge to move one's body to stop uncomfortable or odd sensations, pain, an aching, an itching or tickling in the muscles.
- Most commonly affects the legs, but can affect the arms.
- The sensations typically begin or intensify during wakefulness, such as when relaxing, reading, studying.
- Associated with: Anemia, Pregnancy, Nocturnal myoclonus Uremia

Treatment: Benzodiazepines, L-Dopa, Carbamazepine, Clonidine, Baclofen
Thank You