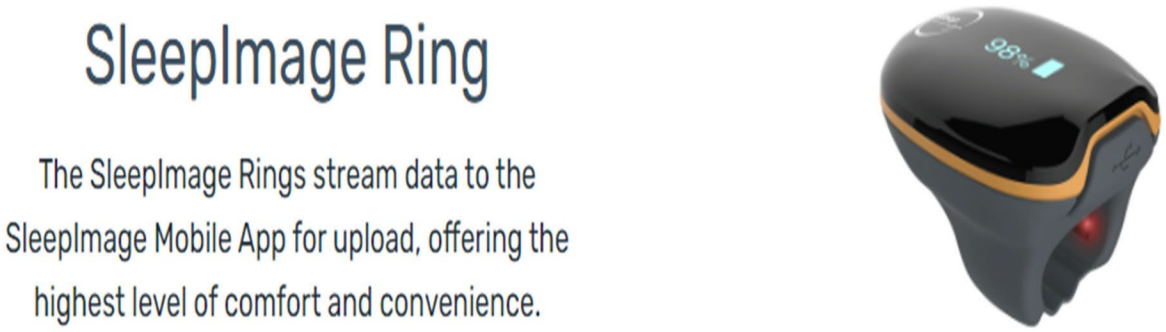
EBM Health Care Strategies
"Helping Medical Professionals Bridge the Gap"

EBM U – Sleep Image



Sleep Quality Index (SQI) is a comprehensive measure of sleep health, summarizing metrics like sleep stability, fragmentation, and periodicity. It is presented on a scale from 0 to 100, with higher scores indicating better sleep quality. SQI is useful for tracking sleep health over time and identifying potential issues that may require clinical attention.

Sleep Efficiency measures the percentage of time spent asleep relative to the total time allocated for sleep (time in bed). It is calculated as the ratio of total sleep time (TST) to sleep opportunity. A sleep efficiency of 85% or higher is generally considered healthy, indicating effective use of time in bed for restorative sleep.

Sleep Latency refers to the amount of time it takes for an individual to transition from being awake to falling asleep. Clinically, a sleep latency of less than 30 minutes is considered typical for healthy sleep. If it's significantly shorter, it might indicate sleep deprivation, while a longer latency could signal conditions like insomnia.

Sleep Duration measures the total time spent asleep during the night. It includes all stages of sleep (light, deep, and REM) and excludes periods of wakefulness after initially falling asleep. Adequate sleep duration varies by age, with adults typically requiring 7–9 hours per night to maintain optimal health and function. Insufficient sleep duration can lead to cognitive impairments, mood changes, and physical health risks.

The SleepImage Apnea Hypopnea Index (sAHI) measures the average number of apneas (complete pauses in breathing) and hypopneas (partial reductions in airflow) per hour of sleep. The distinction between sAHI 3% and sAHI 4% lies in the oxygen desaturation threshold used to define these events:

- **sAHI 3%**: Includes events where oxygen saturation drops by at least 3% from baseline.
- **sAHI 4%**: Includes events with a more significant oxygen saturation drop of at least 4%.

Both metrics are used to assess the severity of sleep-disordered breathing, with sAHI 3% being more sensitive and capturing a broader range of events, while sAHI 4% is more specific and focuses on more severe desaturation events. These thresholds help clinicians tailor diagnoses and treatments for conditions like obstructive sleep apnea. Let me know if you'd like further clarification!

Sleep Fragmentation refers to frequent interruptions during sleep, which disrupt the natural sleep cycle and prevent restorative rest. It is often linked to conditions like insomnia, pain, anxiety, or sleep-disordered breathing such as obstructive sleep apnea (OSA). Fragmentation is characterized by elevated low-frequency coupling broad-band (e-LFCBB), indicating unstable sleep patterns and autonomic arousals.

Sleep Periodicity, on the other hand, involves rhythmic patterns in breathing and heart rate during sleep. It is associated with central sleep apnea (CSA) or periodic breathing and is marked by elevated low-frequency coupling narrow-band (e-LFCNB). Unlike fragmentation, periodicity may occur without significant drops in oxygen saturation, such as in periodic limb movements (PLMs).

Cyclic Variation of Heart Rate (CVHR%) represents the percentage of time during sleep when the heart rate exhibits cyclic patterns related to apnea events. CVHR is a marker of autonomic nervous system responses, triggered by periods of unstable breathing or hypoxemia.

This metric is particularly useful in identifying the severity and frequency of sleep-disordered breathing. High CVHR% often correlates with increased respiratory disturbances, such as apneas and hypopneas, disrupting sleep stability and quality.

The SleepImage system categorizes sleep into three key states based on cardiopulmonary coupling (CPC) analysis:

1. **Stable Sleep (High-Frequency Coupling - HFC)**: This represents restorative, effective sleep, primarily occurring during parts of NREM Stage 2 and all of Stage 3. It is characterized by stable breathing, high vagal tone, consistent delta waves, and blood pressure dipping. Stable sleep supports recovery and restoration processes.
2. **Unstable Sleep (Low-Frequency Coupling - LFC)**: This indicates less effective sleep, occurring during NREM Stage 1 and parts of Stage 2. It is marked by fluctuating breathing patterns, cyclic variations in heart rate, and non-dipping blood pressure. Unstable sleep often reflects sleep fragmentation or pathology, such as obstructive sleep apnea (OSA).
3. **REM Sleep (Very Low-Frequency Coupling - vLFC)**: REM sleep is identified by very low-frequency coupling and is associated with skeletal muscle paralysis and rapid eye

movements. It plays a critical role in memory consolidation and emotional regulation. Fragmented REM sleep may show elevated low-frequency coupling.

These states are visually represented in the SleepImage spectrogram, helping clinicians assess sleep quality and identify potential disorders. Let me know if you'd like to explore this further!

The SleepImage histogram highlights sleep states based on **Cardiopulmonary Coupling (CPC)**. Here's a breakdown of the key terms related to the histogram:

1. **High-Frequency Coupling (HFC)**:
   - Represents **stable NREM sleep**, which is restorative and effective.
   - Shows dark blue peaks on the histogram, typically in the frequency range of 0.1–0.5 Hz.
   - Associated with steady breathing, high vagal tone, blood pressure dipping, and minimal arousals.
2. **Low-Frequency Coupling (LFC)**:
   - Reflects **unstable NREM sleep**, which is less effective and often fragmented.
   - Appears as light blue peaks on the histogram within the frequency range of 0.01–0.1 Hz.
   - Linked to fluctuating breathing patterns, cyclic variations in heart rate, and non-dipping blood pressure.
3. **Very Low-Frequency Coupling (vLFC)** (Wake and REM):
   - Indicates **REM sleep and wakefulness**.
   - Displays orange peaks within the frequency range of 0.004–0.01 Hz.
   - REM sleep is critical for memory consolidation, while wakefulness transitions may disturb sleep stability.

These frequency patterns visually represent the dynamics of sleep states, helping clinicians assess sleep quality and pinpoint disruptions.

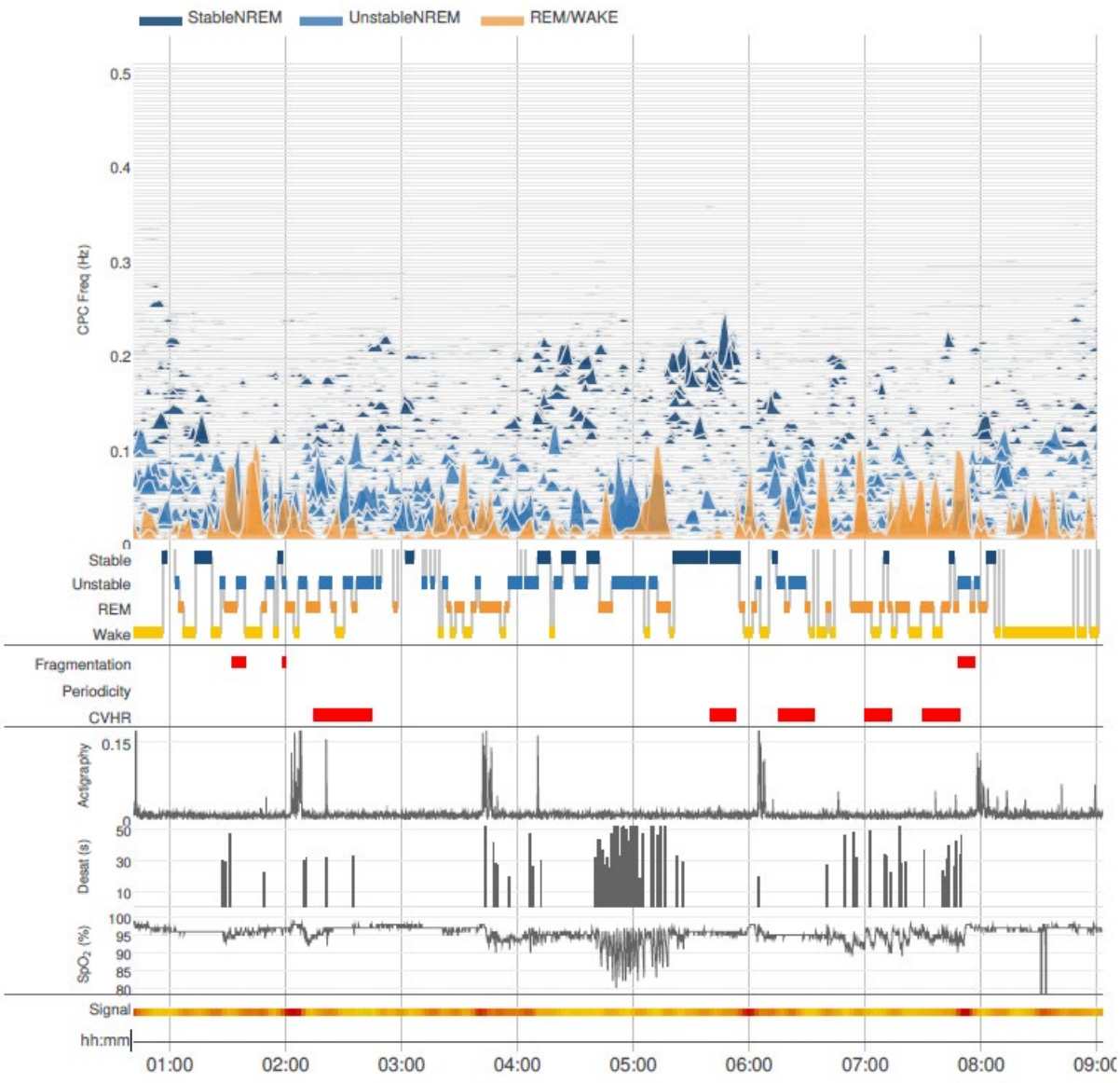
Here's a concise summary of the metrics you mentioned from the SleepImage raw data:

1. **Plethysmography (Pleth)**: This measures changes in blood volume within the peripheral vasculature, providing insights into respiratory patterns and autonomic nervous system activity during sleep.
2. **Heart Rate (HR)**: Tracks the number of heartbeats per minute, reflecting overall cardiovascular activity and its response to sleep stages and disruptions.
3. **Heart Rate Variability (HRV)**: Represents the variation in time intervals between consecutive heartbeats, offering valuable information about autonomic nervous system balance and sleep stability.
4. **Plethysmograph-Derived Respiration (PDR)**: Utilizes plethysmography signals to assess respiratory effort and tidal volume variability, aiding in the detection of sleep-disordered breathing.

5. **Actigraphy**: Monitors movement during sleep using accelerometer data, helping to identify wake periods, sleep fragmentation, and overall sleep efficiency.

These metrics collectively provide a comprehensive view of sleep physiology and are integral to analyzing sleep quality and disorders.

Spectrogram:



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Sleep Quality Report

Apr 1, 2025 | 12:41 AM - 9:02 AM

EBM Healthcare Strategies

Patient Name:
Patient Id:
Date Of Birth:

Sleep Quality

SQI 48	EFFICIENCY 62%
Expected > 55	Expected > 85%

Sleep Opportunity

LATENCY 0h:14m	DURATION 7h:10m
Expected < 30 min	Expected 7-8 hours

Sleep Apnea

$sAHI_{4\%}$ 8	$sAHI_{3\%}$ 13
Mild	Mild

Sleep Pathology

FRAGMENTATION 3% (dLFC$_{BB}$)	PERIODICITY 0% (dLFC$_{NB}$)
Expected < 15%	Expected ≤ 2%

Stable 26% • 1h:18m CVHR 22% • $sAHI_{3\%}$ 5 — Expected > 50%

Unstable 38% • 1h:57m CVHR 27% • $sAHI_{3\%}$ 14 — Expected < 30%

REM 37% • 1h:53m CVHR 27% • $sAHI_{3\%}$ 18 — Expected ~ 20%

Sleep Onset	12:56 AM
Sleep Conclusion	8:07 AM
TST	5h:09m
WASO	2h:05m
WAKE TRANSITIONS	#21
SAI	16

	Desaturations 3%	4%
$sAHI_{TOTAL}$	13	8
$sAHI_{OBSTRUCTIVE}$	13	8
$sAHI_{CENTRAL}$	0	0
sRDI	14	14
ODI	12	7

SpO_2 <90%	0h:10m - 2%
SpO_2 <88%	0h:07m - 1%
SpO_2 <80%	0h:0m - 0%
MIN-MAX-MEAN SpO_2	80% - 99% - 95%

	Min	Max	Mean
APNEA DURATION (sec)	10	87	34
HEART RATE (BPM)	40	102	63

Test Summary:

Patient: 68 year old Male

Average Signal Quality is **65** %.
Sleep Quality is **below** expected value.
Sleep Efficiency is **below** expected value.
Sleep Duration is **within** expected value.

Sleep Apnea Indicator is **above** expected value.
Apnea Hypopnea Index is **Mild**.
Sleep Fragmentation is **below** expected value.
Periodicity is **below** expected value.