CORE MEASURES *of* SLEEP

Digital Measures Development

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*Digital Health Measurement
Collaborative Community*
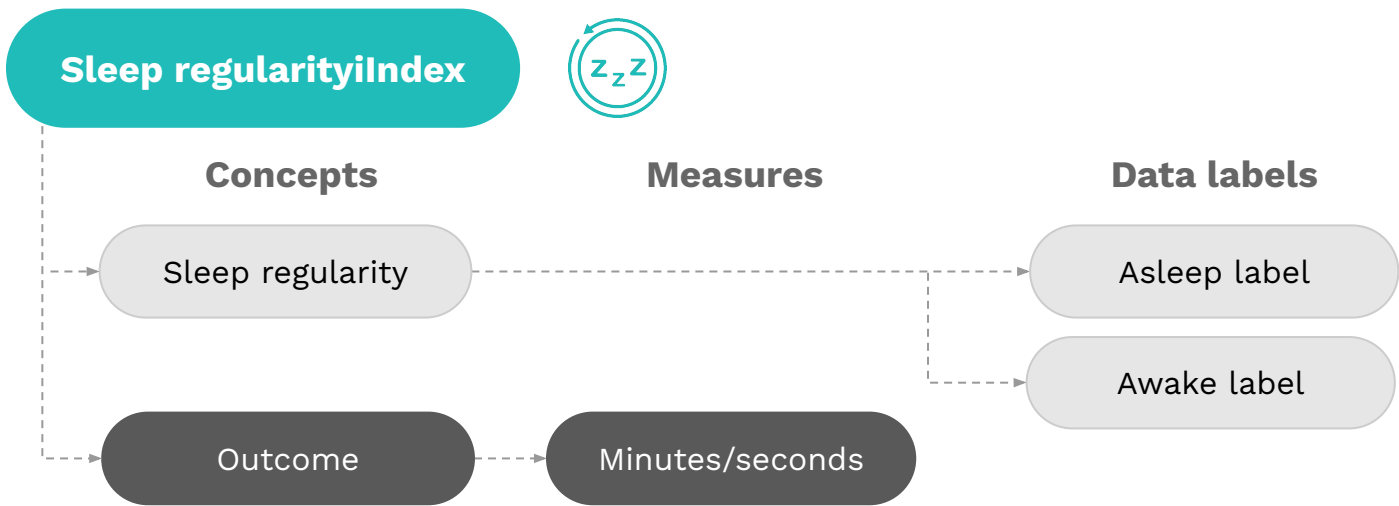
DIGITAL MEDICINE SOCIETY

Emerging Measure: Sleep regularity index (Percentage)

Type: *Percentage*

Definition: *Probability of an individual being in the same awake or asleep state at any two time points 24 hours apart*

Measure considerations

Why is this an emerging measure? The clinical importance of sleep regularity is still developing. Although it can be more predictive of mortality than total sleep time,[1] a consensus panel convened by the National Sleep Foundation assessing evidence across 63 published[2] works found that despite regularities importance, "catch-up sleep" on non-work days is still valuable to health. As catch-up sleep is the antithesis of sleep regularity, the clinical and patient-centric interpretation of sleep regularity is unclear. Evidence also shows that the Sleep Regularity Index may need a large amount of data for assessing group differences (more than one week),[3] suggesting it may not be suitable for all use cases.

Measure derivation: A given data epoch label must be compared with the epoch label of the data point collected exactly 24 hours later. The Sleep Regularity Index is broadly conceptualized as a ratio of the number of epochs with matching sleep state labels over the total number of epochs. For a specific formula which accounts for the number of 24-hour periods collected and between-subject variation in total sleep time, refer to Fischer et al.[3]

Measure Considerations: Specifying the epoch length over which data are labelled by the technology (e.g., 30 seconds) is necessary in order to make a judgement on the quality of the Sleep Regularity Index results.

Asleep label

Description

"Asleep" is a state consisting of a union of REM and the N1-N3 stages of sleep. A state of sleep can be detected in multiple ways, through changes in brain activity, body motion, respiration, heart rate, etc.

Label definition

A label for each epoch denoting when an individual is recorded to be asleep. The parameters or algorithms for detecting sleep should be clearly defined or referenced.

Alternatively, the asleep label can be defined as the presence of any of: light sleep, deep sleep, REM sleep, and N1, N2, N3 and REM labels presented in the Core Measures Sleep System, where these are collected by the selected technology.

Why is this important?

Detecting and evidencing the detection of sleep is integral to the interpretation of all core digital measures of sleep.

Awake Label

Description

Awake is the absence of sleep and a state of conscious awareness of an individual's surroundings. A state of being awake can be detected in multiple ways: through changes in brain activity, body motion, respiration, heart rate, etc., or through the measurement of actions which indicate consciousness.

Label Definition

A label for each epoch denoting when an individual is recorded to be awake. The parameters or algorithms for detecting and distinguishing awake from asleep must be clearly defined or referenced.

Alternatively, the awake label can be defined as the absence of any of: light sleep, deep sleep, REM sleep, and N1, N2, N3 and REM labels presented in the Core Measures Sleep System, where these are collected by the selected technology. This definition does not assume that missing data represents a state of being awake.

Why is this important?

Detecting and evidencing the detection of sleep versus wake is integral to the interpretation of all core digital measures of sleep.

References

1. Windred, D. P., Burns, A. C., Lane, J. M., Saxena, R., Rutter, M. K., Cain, S. W., & Phillips, A. J. (2024). Sleep regularity is a stronger predictor of mortality risk than sleep duration: A prospective cohort study. Sleep, 47(1), zsad253.
2. Sletten, T. L., Weaver, M. D., Foster, R. G., Gozal, D., Klerman, E. B., Rajaratnam, S. M., ... & Czeisler, C. A. (2023). The importance of sleep regularity: a consensus statement of the National Sleep Foundation sleep timing and variability panel. Sleep Health, 9(6), 801-820.
3. Fischer, D., Klerman, E. B., & Phillips, A. J. (2021). Measuring sleep regularity: theoretical properties and practical usage of existing metrics. Sleep, 44(10), zsab103.