EISENBERG FAMILY DEPRESSION CENTER
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Sleep Parameters

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October 22, 2024
Tags sleep-research research-best-practices sleep-tracking

Summary

Sleep estimation is a near ubiquitous feature of smart watches and fitness trackers; therefore, sleep parameters have become desirable to include in research as both predictor variables or outcomes. However, not all sleep parameters provided by wearable sleep trackers are considered reliable for the purpose of research and appropriate selection and calculation of aggregate sleep values are required for hypothesis generation and testing.

Recommendations

Parameters with unclear value in research

At this time, wearable estimated sleep stages (i.e., light, deep, and REM), proprietary sleep measures (i.e., "restless sleep", "readiness"), and arousals are considered of unclear value in research. However, sleep stages can be helpful for automated data cleaning, and when aggregating granular non-sleep parameters (e.g. RMSSD, LH, RF, SPO2) into a single value for each 30-second sleep epoch.

Parameters always recommended for use in research

Wearable sleep trackers have demonstrated excellent performance in distinguishing sleep from wake allowing for measurement of total sleep time, wakefulness during the sleep period, and the timing of sleep.

For each day, we recommend the extraction and calculation of the following from wearable data:

- Sleep onset (HH:MM AM/PM)
- Sleep offset (HH:MM AM/PM)
- Sleep period time (minutes elapsed between sleep onset and sleep offset)

- Total sleep time (TST, minutes asleep between sleep onset and sleep offset)
- Wake after sleep onset (WASO) (minutes awake between sleep onset and offset)
- Sleep efficiency (SE) [TST/sleep period time] *100%
- Midpoint of sleep (halfway point between Sleep onset and Sleep offset, HH:MM AM/PM)

If self-report data collection is feasible along with wearable data, for each day, we recommend the extraction and calculation of the following:

- Time in bed (TIB) (minutes elapsed from 'bedtime' to 'rise time') (self report)
- Bedtime (HH:MM AM/PM) (self report)
- Rise Time (HH:MM AM/PM) (self report)
- Sleep onset latency (SOL) (minutes elapsed from 'bedtime' to sleep onset; self report and wearable)
- Sleep efficiency (SE) [TST/TIB] *100%

Multidimensional sleep

TST is often the wearable sleep measure used as a predictor variable or outcome. However, sleep health is increasingly considered a multidimensional construct and different options for the inclusion of multidimensional sleep in your study are outlined in papers below (if data has already been collected, selection may be based on what you have available as many of the below definitions include self-report measures of sleepiness and sleep quality combined with objective sleep data).

- Multidimensional sleep health domains in older men and women: an actigraphy factor analysis - PubMed (nih.gov)
- A preliminary study of a composite sleep health score: associations with psychological distress, body mass index, and physical functioning in a low-income African American community - PubMed (nih.gov)
- Which Sleep Health Characteristics Predict All-Cause Mortality in Older Men? An Application of Flexible Multivariable Approaches - PubMed (nih.gov)

Intraindividual variability (IIV)

Another method to conceptualize sleep predictors is intraindividual variability; usually thought of as standard deviation in sleep parameters of total sleep time, sleep onset, sleep offset, and midpoint of sleep.

Beyond the mean: A systematic review on the correlates of daily intraindividual variability of sleep/wake patterns

Resources

Other helpful papers:

- The Consensus Sleep Diary: Standardizing Prospective Sleep Self-Monitoring
- State of the science and recommendations for using wearable technology in sleep and circadian research

About the Author



Dr. Cathy Goldstein, MD is a professor of Neurology at the University of Michigan Sleep Disorders Center and faculty lead of the Eisenberg Family Depression Center Mobile Technologies core and the U-M Mobile Technology Research Innovation Collaborative (MeTRIC).
Dr. Goldstein's research uses consumer facing sleep tracking devices and mathematical modeling to assess sleep patterns and circadian rhythms in the ambulatory, day-to-day setting to determine their role in health and disease.