Assessing day-to-day regularity of sleep: theoretical and practical implications of available metrics

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Objectives

Sleep regularity has emerged as an important factor for health in recent years. Metrics differ in their approach to quantifying sleep regularity: Interdaily Stability (IS), Social Jet Lag (SJL), and Standard Deviation (SD) assess variability relative to the mean, whereas the more recent metrics Composite Phase Deviation (CPD) and Sleep Regularity Index (SRI) capture variability on a circadian timescale (i.e., between consecutive days). We systematically assessed and compared these metrics using a range of simulations.

Methods

Daily sleep patterns were generated for 8 weeks, with later and longer sleep on weekends (0:00-9:00) than weekdays (23:00-6:00). Random variation in sleep timing was systematically increased from ±0 min to ±360 min in 30-min steps. Mean values and 95% confidence intervals (CIs) were calculated across 10,000 iterations for IS, SJL, SD, CPD, and SRI. Missing data were generated by removing 24h entries, either randomly or non-randomly (e.g., 50% earliest/latest sleep onsets).

Results

With increasing variation in sleep onset time, all metrics reflected higher irregularity, except SJL, which is sensitive to weekly but not daily changes in sleep timing. As expected, 95% CIs were generally wider for consecutive metrics CPD and SRI than for overall metrics IS and SD. Over the first 14 days, average estimates of IS changed as much as 50% while CPD and SRI remained stable, indicating that IS tends to overestimate how regular sleep patterns are when based on relatively few days. For missing data, 95% CIs were generally wider for consecutive than overall metrics, while their average estimates were more stable, especially for ≥50% of missing data. The amount of tolerable missing data (e.g., not affecting mean estimates) decreased substantially with increasing non-randomly missing data or variation in sleep timing.

Conclusions

Overall metrics require relatively many days for an accurate estimate, whereas consecutive metrics such as CPD and SRI are sensitive to daily changes and can better reflect the regularity of patterns that are based on only a few sleep episodes. The right choice of metric may depend on study length, anticipated regularity of the study population, likelihood and distribution of missing data as well as whether the outcome of interest is local vs. global (i.e., accident vs. chronic illness). Future work will examine the metrics' sensitivity to shift work, nights with no sleep, naps, and fragmented sleep patterns.