Estimated Sleep-Wake Patterns Obtained from a Large U.S. Sample by Home-Based Under-Mattress Monitoring Devices

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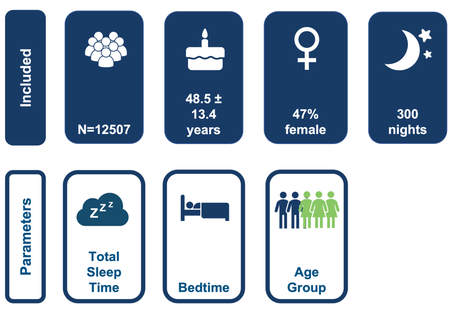
Introduction

Irregular sleep-wake schedules, characterized by high day-to-day variability in sleep duration or timing, were recently associated with cardiovascular disease and unfavorable metabolic profiles, such as increased blood pressure and insulin resistance.[1] However, the prevalence of irregular sleep-wake schedules in a large population has not been studied. This study aims to characterize sleep-wake schedules in a large U.S. sample.

Methods

Descriptive analysis was performed on collected de-identified data from 12507 users (46.9% female, mean age 48.5 ± 13.4 years) of a commercially available home sleep monitoring device (Sleeptracker-AI Monitor, Fullpower Technologies, California, USA). The device passively monitors sleep using piezo-electric sensors that register the forces exerted through the mattress. Only users with at least 300 days of recordings between January 2019 and December 2019 were included in this analysis. More recent data were excluded to avoid effects of the pandemic. In order to understand sleep-wake schedules and regularity of sleep, Total Sleep Time (TST) standard deviation (SD) and bedtime (BT) SD were included as parameters. Users were divided into six different age groups and weekly summaries of sleep parameters per subject were obtained. Statistical analyses were performed using Python (Python Software Foundation, version 3.8.3).



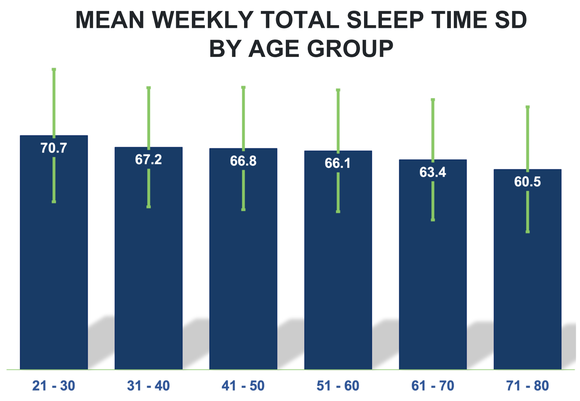
Deidentified data were analyzed, following review and exemption of the study (#57681) from the Stanford University IRB

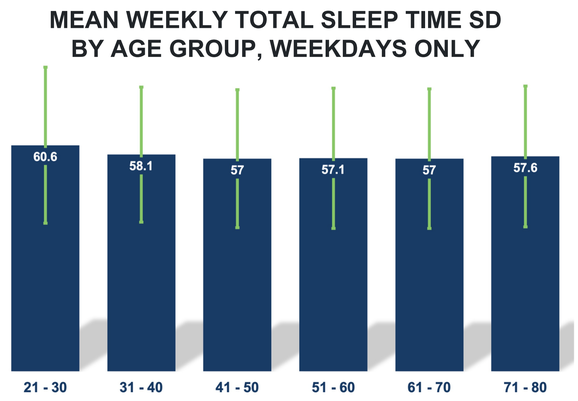
Results

4,175,260 recorded nights were included in the analyses. In minutes, overall estimated TST SD across subjects' mean was 66.1 (18.7*) and BT SD was 55.6 (20.5*). Importantly, for TST SD over the week, across subjects only 25.0% (10.9%) of the variance is explained by the difference between weekends and weekdays, and for BT SD this value is only 26.7% (11.3%*); substantial variation remains even when considering only weekdays. Population was arbitrarily divided in 6 groups by age: Group 1 (20-30), 2 (30-40), 3 (40-50), 4 (50-60), 5 (60-70), and 6 (70-80). The estimated TST SD in age groups 1, 2, 3, 4, 5, 6 were as follows: 70.7 (20.0*), 67.2 (18.0*), 66.8 (18.5*), 66.1 (18.4*), 63.4 (18.2*), and 60.5 (18.9*) minutes. The estimated BT SD in each age group were: 62.1 (21.1*), 57.4 (19.4*), 57.0 (20.2*), 55.7 (20.0*), 51.6 (20.3*), and 46.7 (20.8*) minutes. When divided categorically into 2 groups of regular or irregular sleep schedules (≤60 mins TST SD and >60 mins TST SD respectively) we found the following: 67%, 61%, 60%, 58%, 53%, and 47% of Group 1, 2, 3, 4, 5 and 6 had an irregular sleep-wake schedule, and 58.4% overall.

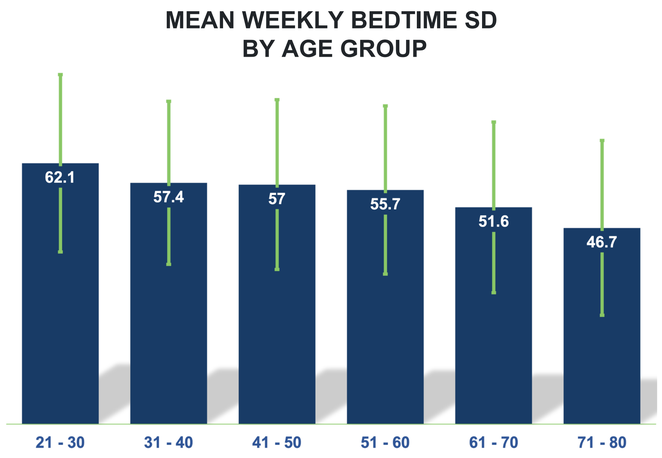
*Standard deviation of mean sleep parameter SD

Weekly Variation in Total Sleep Time and Bedtime by Age Group





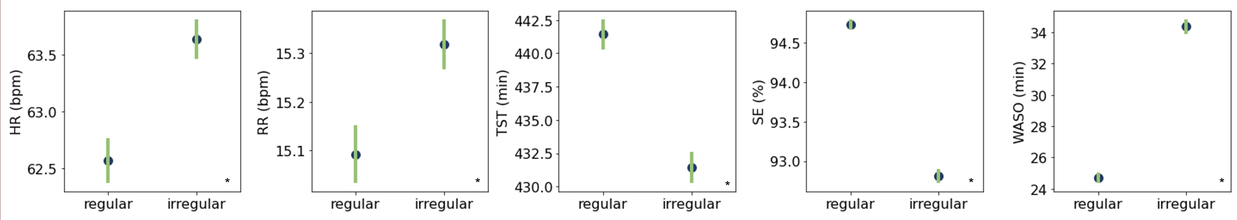
Total sleep time variation remains substantial even only during weekdays. Across subjects only 25.0% (10.9%) of the variance is explained by the difference between weekends and weekdays



Green bars show standard deviation of mean sleep parameter SD

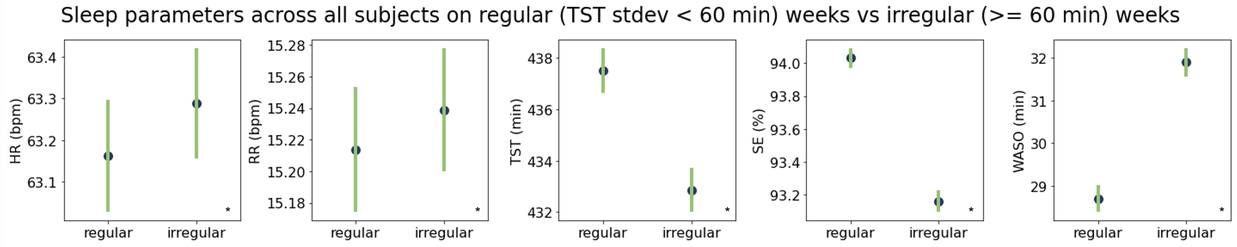
Sleep Parameters with Regular vs Irregular Schedules

Sleep parameters in typically regular (average TST stdev < 60 min) vs irregular (>= 60 min) subjects



Subjects with on-average regular sleep schedules have significantly lower HR, RR, WASO and significantly higher TST and SE than subjects with on-average irregular sleep schedules by unpaired t-test ($p < 0.05$).

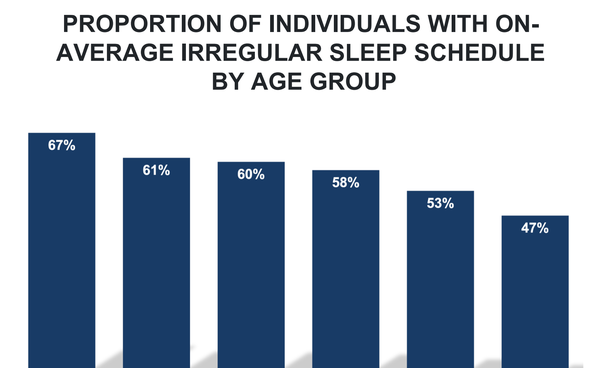
Sleep parameters across all subjects on regular (TST stdev < 60 min) weeks vs irregular (>= 60 min) weeks



Averaged across subjects, regular weeks show significantly lower WASO and significantly higher TST and SE than irregular weeks, and also significantly lower HR and RR by paired t-test ($p < 0.05$).

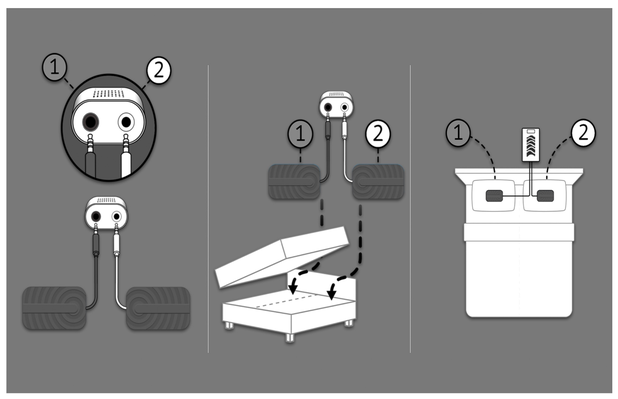
Heart Rate (HR), Respiration Rate (RR), Sleep Efficiency (SE), Wake After Sleep Onset (WASO)
Green bars show 95% confidence intervals for the mean
* Significant at $p < 0.05$ level, unpaired t–test (typically regular vs irregular subjects) or paired t-test (regular vs irregular weeks)

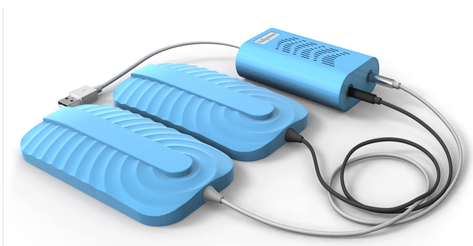
Irregular Schedule Prevalence



- Irregular sleep schedule: >60 mins TST SD
- Regular sleep schedule: ≤60 mins TST SD

Device Setup





Conclusion

Irregular sleep duration and timing were common over all age categories in this population, indicating that sleep habits might be a common and treatable risk factor of cardiovascular disease. Interestingly, this follows a clear age-dependent trend, with older age corresponding to more regular sleep-wake schedules. This provides a possible and important target for health policy. Furthermore, the ability to estimate sleep parameters in the home environment represents a powerful tool for public health campaigns.

[1]Huang T, Mariani S, Redline S. Sleep Irregularity and Risk of Cardiovascular Events: The Multi-Ethnic Study of Atherosclerosis. J Am Coll Cardiol 2020;75:991-999.

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