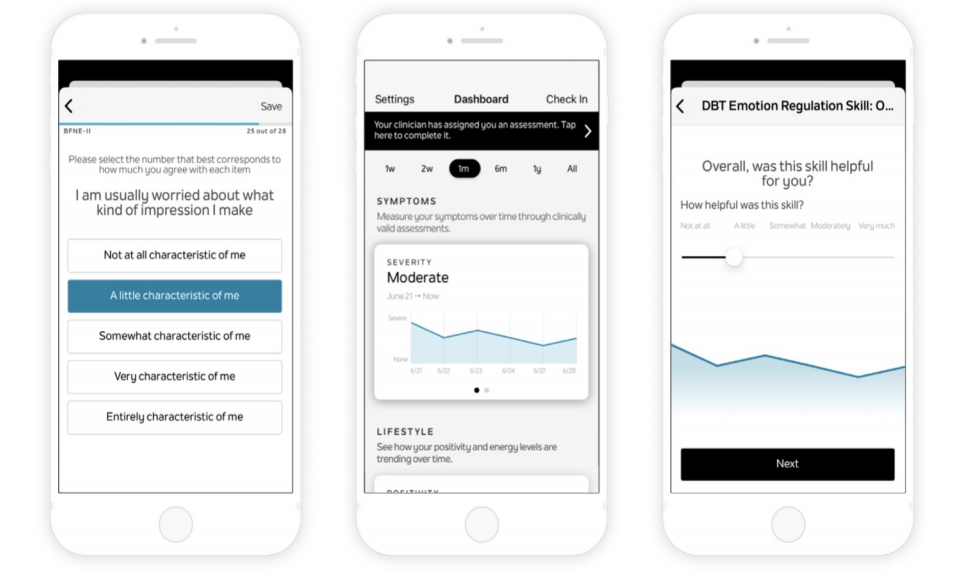


Association between patient-reported sleep quality and passive sleep measurements in patients with psychiatric disorders using mobile-based questionnaires and wearable sensors



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Introduction

Historically, tracking symptoms related to behavioral health has been challenging. Outside of a clinical trial setting, it is difficult to capture consistent, frequent measures of symptoms such as sleep to understand response. Mobile health apps like TempusPRO™ can administer measurement-based care (MBC) to track patients' symptom severity longitudinally and append these measurements with additional symptom monitoring, like Apple health kit data. When combined, these tools can provide unique insights for real-time tracking of patient sleep quality and fill some of the gaps observed in more traditional symptom monitoring.

Objective

To compare patient-reported and passive-sensor-based measures of sleep in patients with a psychiatric diagnosis.

Methods

This is a retrospective study of 1,503 patients being treated for psychiatric disease from 2021 to 2022 who received the Tempus nP pharmacogenomics assay and used the TempusPRO app. We extracted patient reported sleep scores from standard psychiatric assessments and a 1-question daily score ("check-in"). Sleep from the 2 weeks prior to an assessment was included when at least 7 nights were measured, and summarized with average sleep duration and variance. The association between sensed sleep and patient-reported sleep and cardiac sensor data was tested using Spearman's and Pearson correlation, respectively.

Analysis Cohorts	No. of patients
Retention	1,503
Sleep Questions	115
Symptom severity	115
Sleep and heart sensors	193

Table 1. Distribution of analysis cohorts. Sleep questions were on DSM5-C and PHQ-9. DSM5-C was rescaled to match PHQ-9. Symptom severity assessments included ADHD, GAD-7, PHQ-9, Insomnia Severity index, and DSM5 cross cutting symptom measure ("DSM5-C"). Sleep and heart sensor data were required same-day.

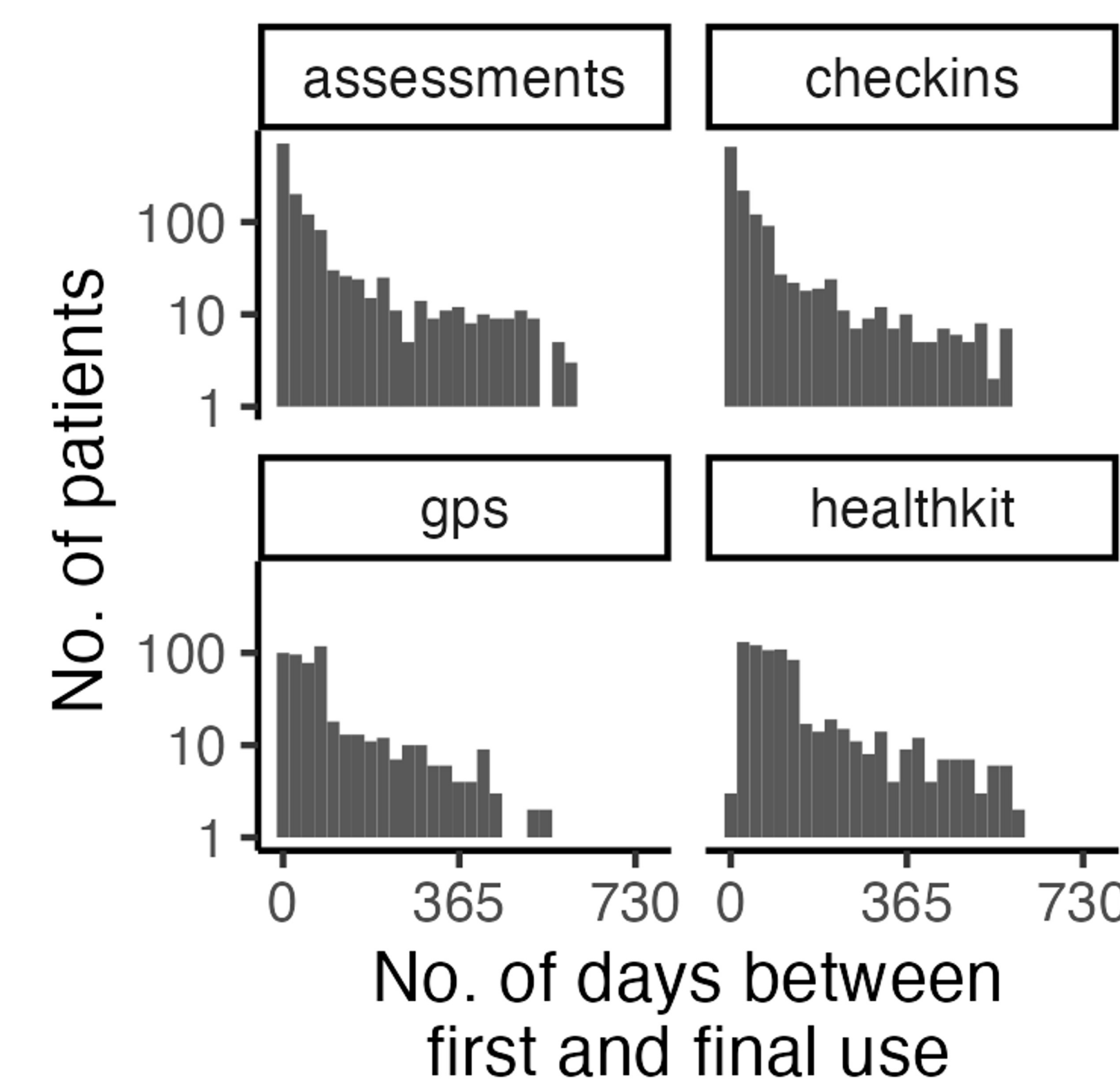
Results

Cohort Demographics

Characteristics	
Age (median, range)	34 (13-78)
Gender	n (%)
Male	255 (22%)
Female	884 (77%)
n/a	5 (1%)
Diagnosis	
MDD	551 (59%)
GAD	511 (55%)
ADD	223 (24%)
PTSD	97 (10%)
BPD	84 (9%)

Table 2. Distribution of age, gender, and diagnosis of TempusPRO™ users with associated clinical data. MDD: major depressive disorder, GAD: generalized anxiety disorder, ADD: Attention Deficit Disorder, PTSD: post-traumatic stress disorder, BPD: bipolar disorder.

Retention for Different Types of Data



Activity	N patients	Mean	Median
Assessments	1361	64	9
Check-ins	1299	59	12
GPS	551	94	62
Healthkit	721	129	90

Figure 1 and Table 3. Duration of app use for different types of data. Patients actively complete assessments and check ins, and allow gps and healthkit data to flow passively.

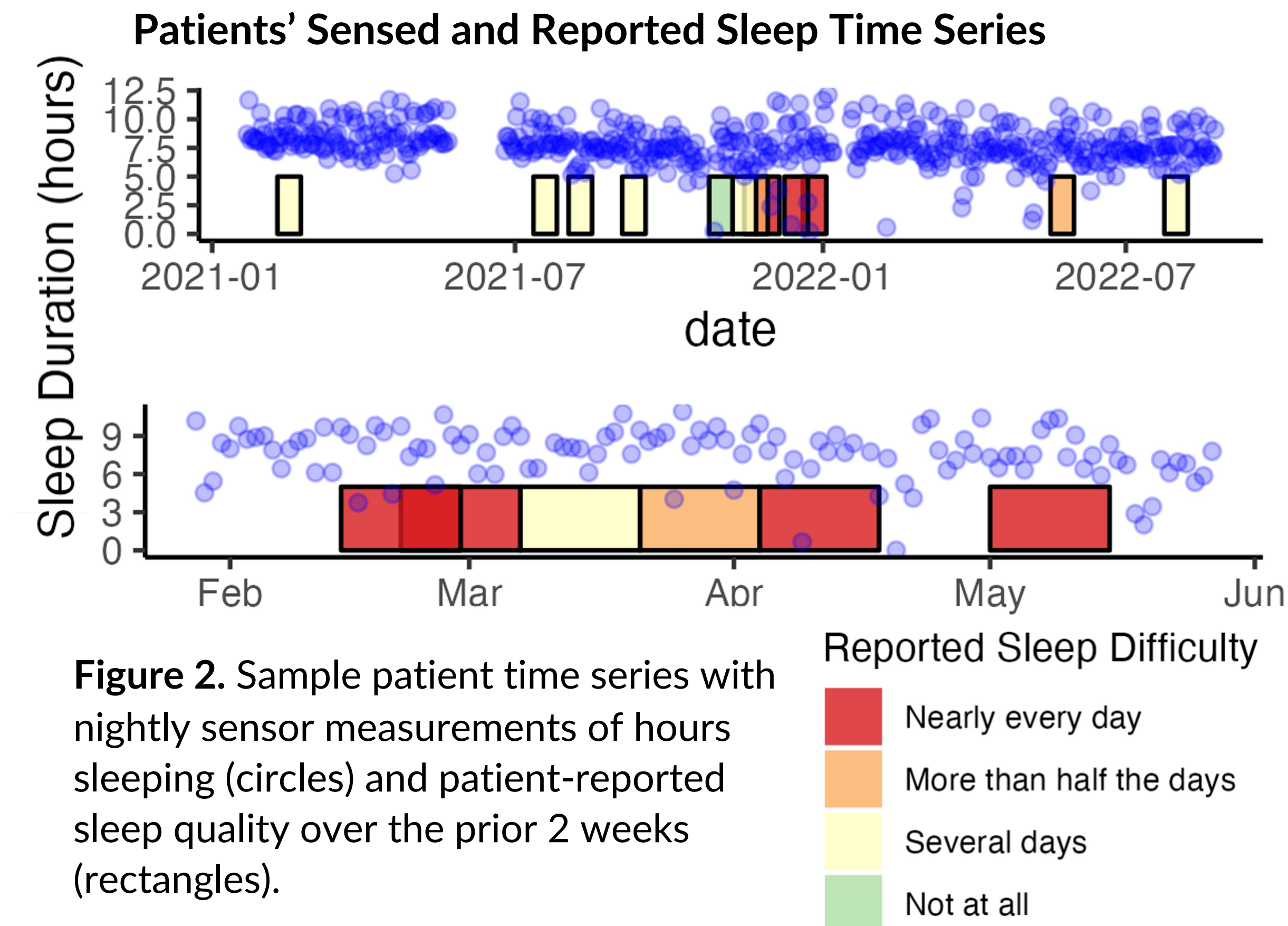


Figure 2. Sample patient time series with nightly sensor measurements of hours sleeping (circles) and patient-reported sleep quality over the prior 2 weeks (rectangles).

Sensed Sleep and Reported Symptom Severity

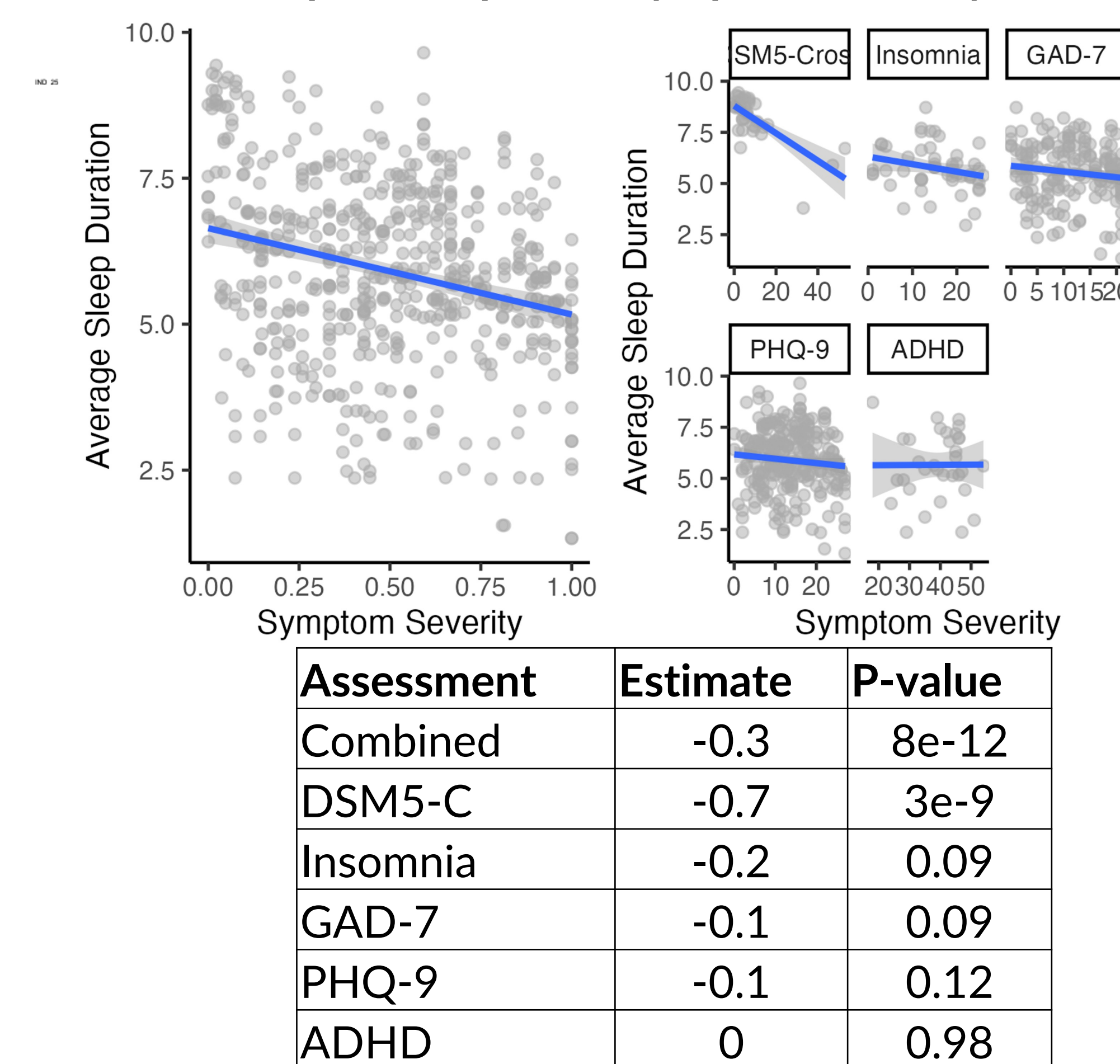


Figure 3. Association between passive sleep measures and symptom severity. Across all assessments (scores normalized from 0 to 1), worse symptom severity is associated with less sleep. This association is significant for DSM5-C alone, and there are trends for insomnia and mood questionnaires, while ADHD severity is not correlated to sleep.

Conclusions

Sensed sleep duration over a 2-week period captured through a wearable device is significantly correlated to patients' sleep quality and psychiatric symptoms on self-reported clinical assessments. This correlation supports the use of wearable data as a clinical input given the average retention of wearable data is 10X longer than clinical assessments (50% of patients shared wearable data for at least 3 months). We also found expected correlations between sensed sleep and cardiac activity that reflect the nervous system's (para)sympathetic tone. The longer retention provides a more holistic understanding of patient response to treatment.

Sensed Sleep and Reported Sleep Difficulty

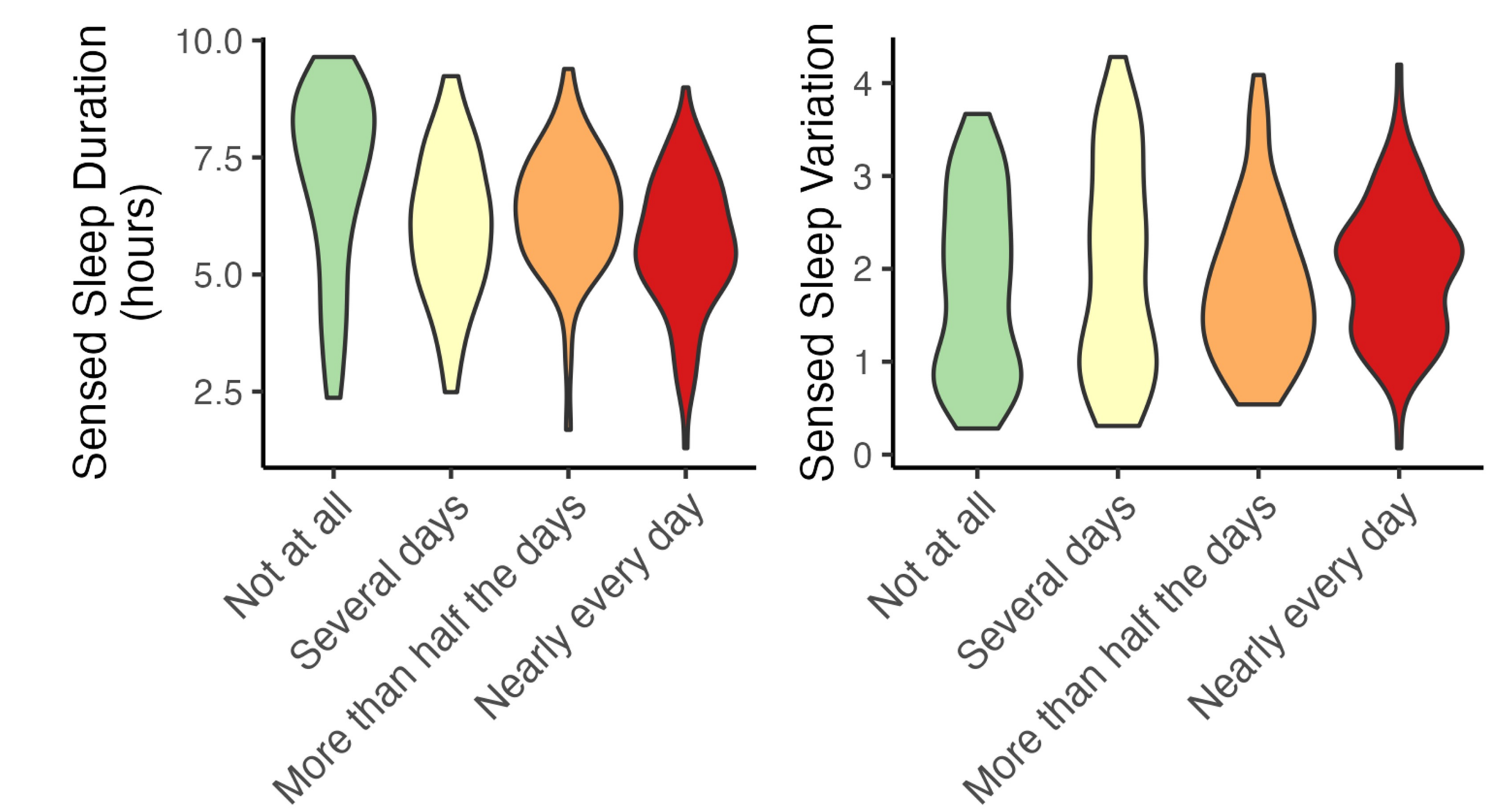


Figure 4. Association between passive sleep measures and specific questions on sleep difficulty from PHQ-9 and DSM5-C assessments. Patients have significantly less sleep when they report worse sleep (Spearman's rho -0.3 , $p = 5e-10$), and higher night-to-night variability (Spearman's rho $.2$, $p = 5e-7$).

Sensed Sleep and Heart Rate

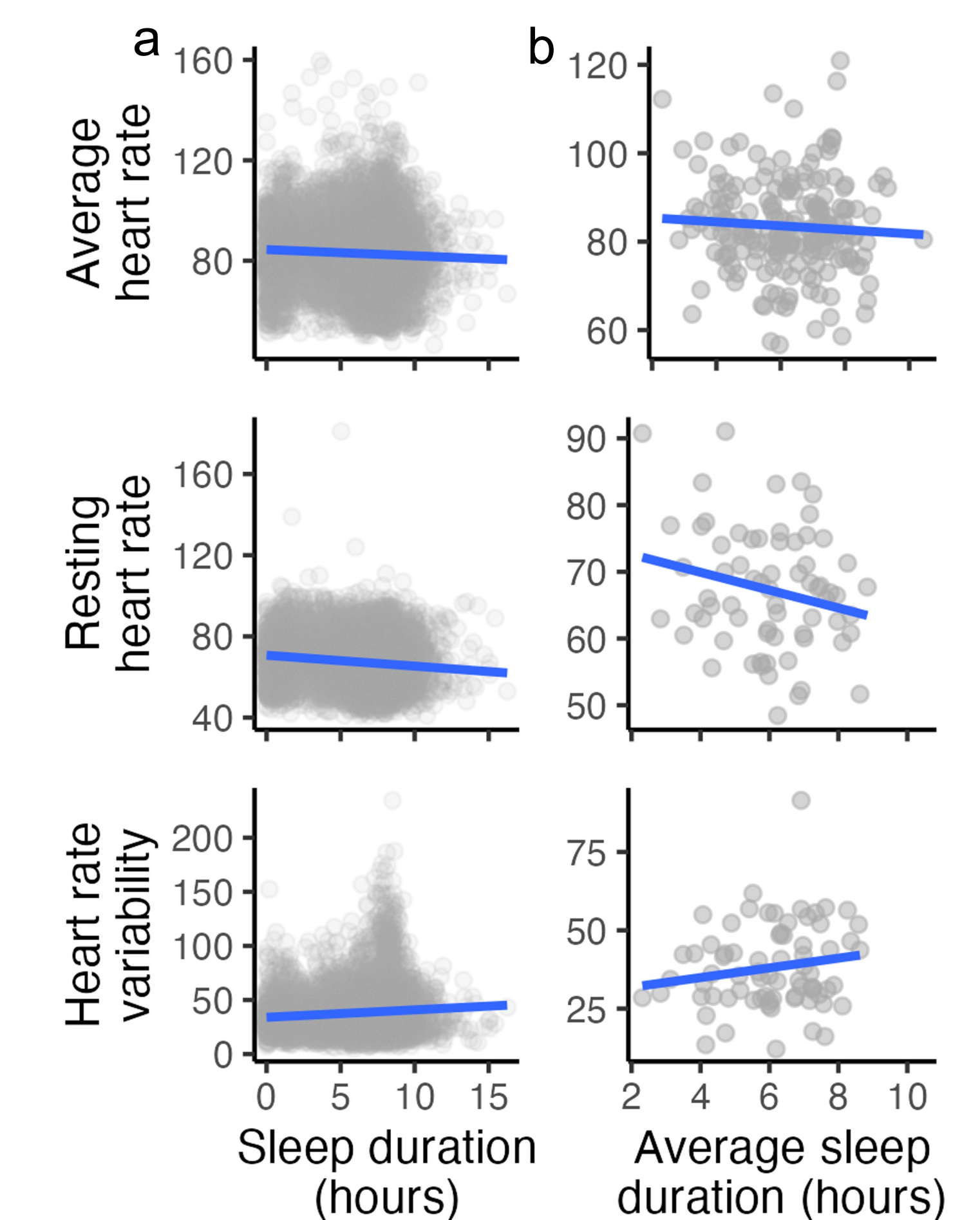


Figure 5. Association between passive sleep and cardiac measures. (a) Nights with less sleep are associated with significantly higher (resting) heart rate and lower heart rate variability (Pearson correlation $p = 6e-8$ or lower). (b) Patients with less sleep on average tend to have higher heart rate and lower variability (Pearson $p = 0.38, 0.07, 0.15$).