Sleep Monitoring in Huntington's Disease using Fitbit compared to Polysomnography

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Sleep in Huntington's Disease

- Sleep disturbance is common in Huntington's Disease (HD), and occurs from an early stage in the disease[1]

- Sleep disturbance is linked to neurodegeneration[2,3], and may impact disease progression in HD

- Sleep is not commonly monitored in HD

- Recent advances in wearable technology offer the potential to monitor sleep quality over time in HD

- The **DOMINO-HD study** will examine how sleep, nutrition and physical activity impact HD

- DOMINO-HD will monitor sleep and physical activity in 300 participants with HD over 12 months using a wearable device, Fitbit Charge 4

- This DOMINO-HD sub-study aims to establish the accuracy of the Fitbit Charge 4 sleep metrics compared with polysomnography in 20 participants with HD.

References
1. Herzog–Krzywoszanska and Krzywoszanski, Front Psychiatry, 2019
2. Malhotra, Sleep Med Clin, 2018
3. Musiek and Holtzman, Science, 2016

Sleep monitoring

- **Polysomnography (PSG):** Gold standard hospital or sleep lab based supervised overnight test

- EEG and EOG to measure electrical activity of the brain and eyes, used to categorise sleep stages

- ECG to measure electrical activity of the heart, and calculate heart rate

- Wearable sleep monitor: **Fitbit Charge 4**

- Optical sensor to measure heart rate

- Accelerometer to measure movement
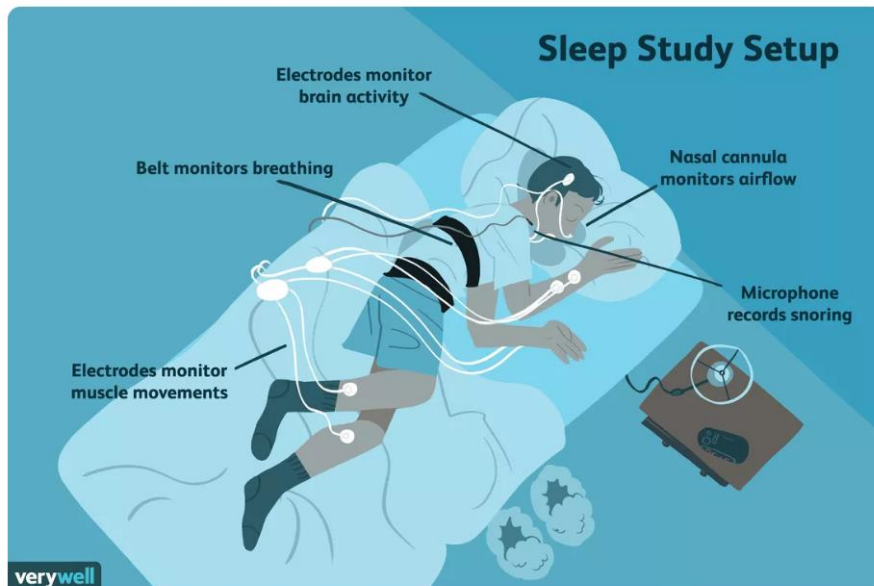
- Heart rate and movement used to estimate sleep stages

Illustration by Emily Roberts, Verywell

Protocol

- Participants wore a Fitbit Charge 4 during overnight PSG, followed by 7 nights at home.

- PSG sleep stages were scored by an expert sleep physiologist, at 30 s epochs. Fitbit sleep data were extracted every 30 s.

- Emerging data for **2 participants** (1 male) with early-stage HD (UHDRS total motor scores 5 and 26) are reported.

Night 1
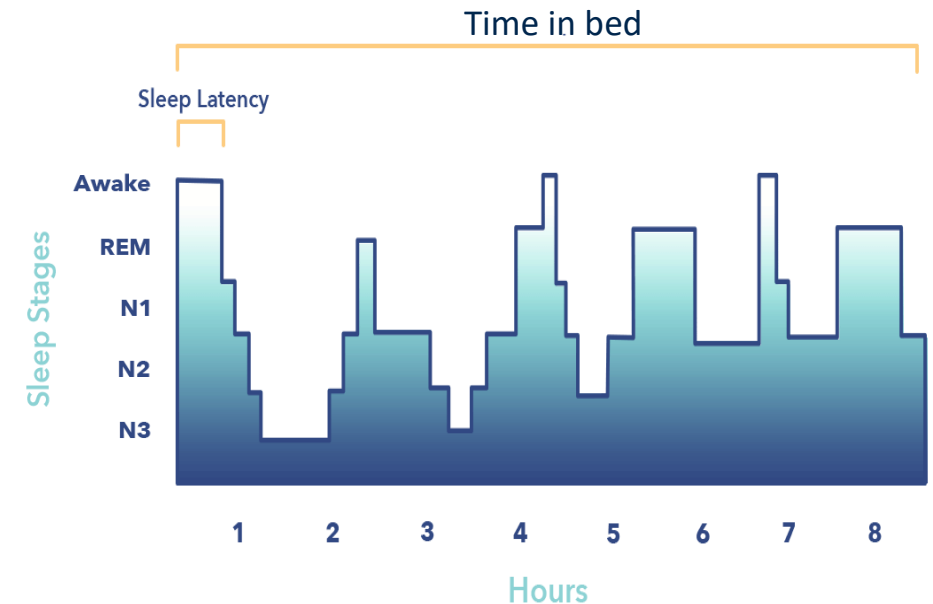**Location:** Hospital sleep laboratory
Sleep measurement: PSG and Fitbit

Nights 2-8
Location: Home
Sleep measurement: Fitbit

Analysis

- Sleep metrics examined for each night (Fitbit and PSG)
  - Total sleep time (TST)
  - Total wake time (TWT)
  - REM sleep time
  - Deep sleep (stage N3) time
  - Light sleep (stages N1 and N2) time
 - Wake after sleep onset (WASO)

- Epoch by epoch analysis: Sensitivity (true positive rate) and specificity (true negative rate) of Fitbit to each sleep stage
  - Sensitivity is the percentage of 30 s epochs identified as X using PSG, which are also identified as X using Fitbit
  - Specificity is the percentage of 30 s epochs not identified as X by Fitbit, which are also not identified as X by PSG
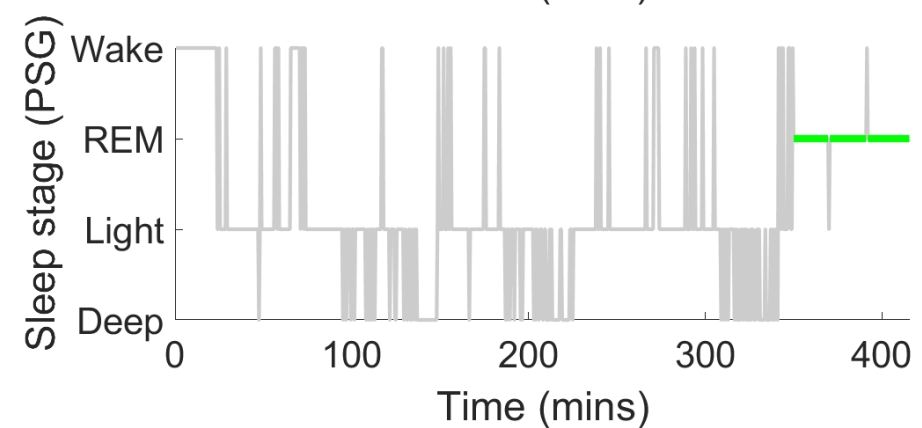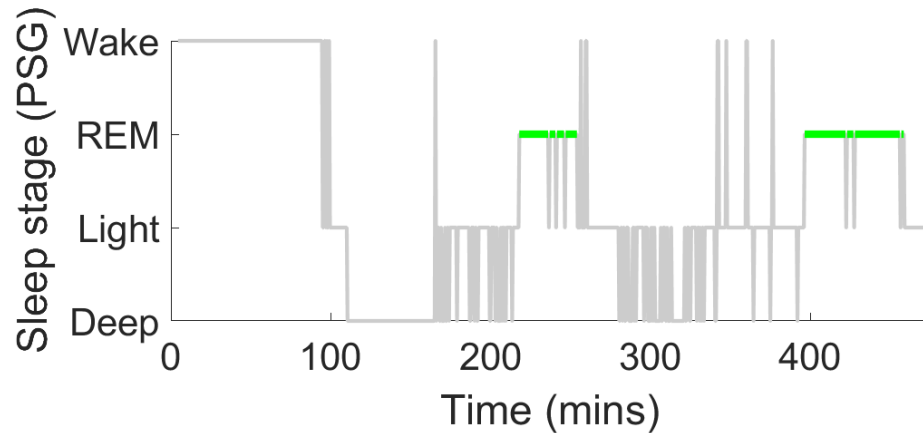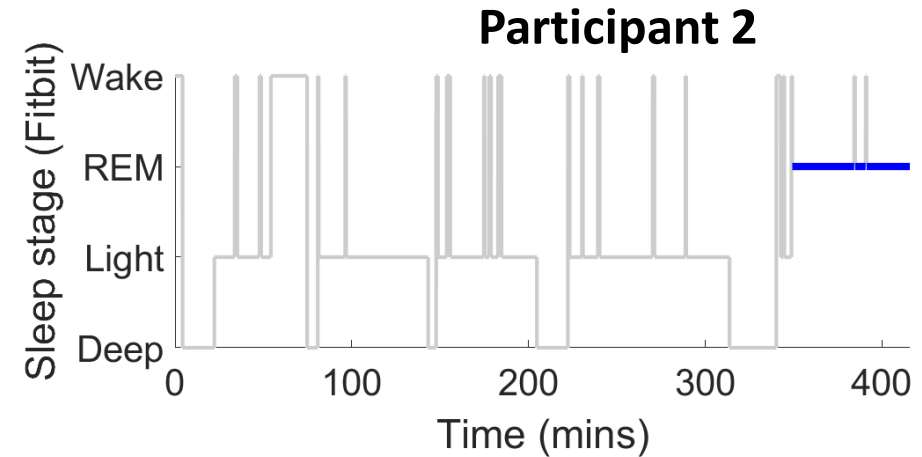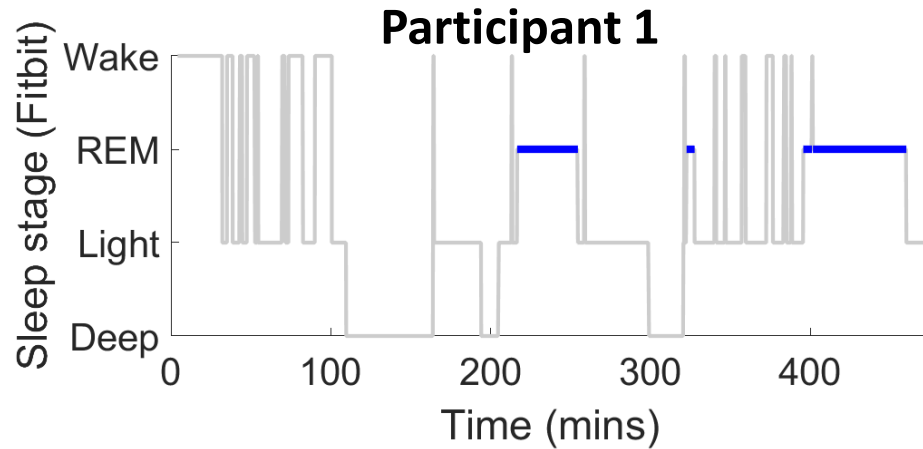 - … where X is sleep (any sleep stage), light sleep, deep sleep or REM sleep

- Home sleep metrics (Fitbit) compared to PSG
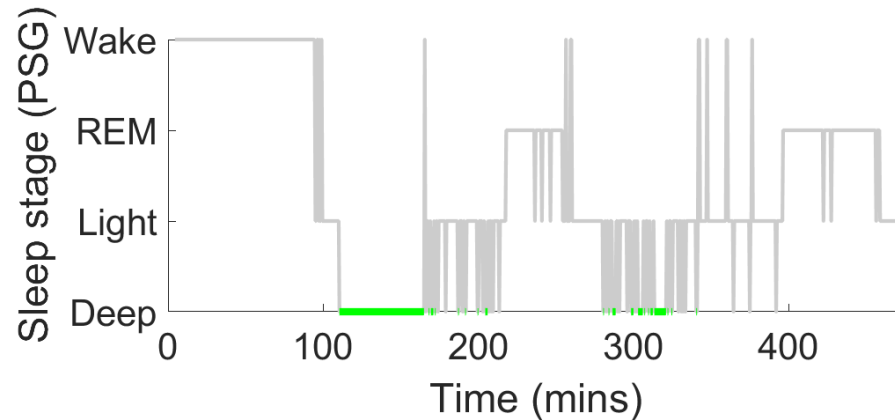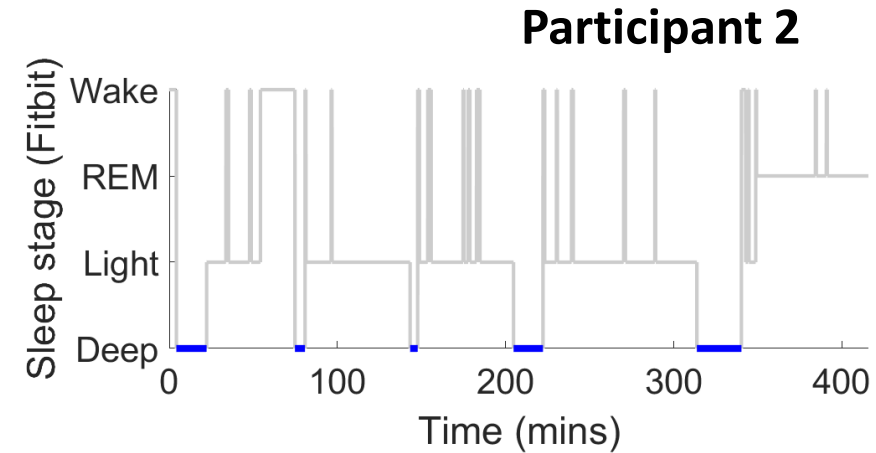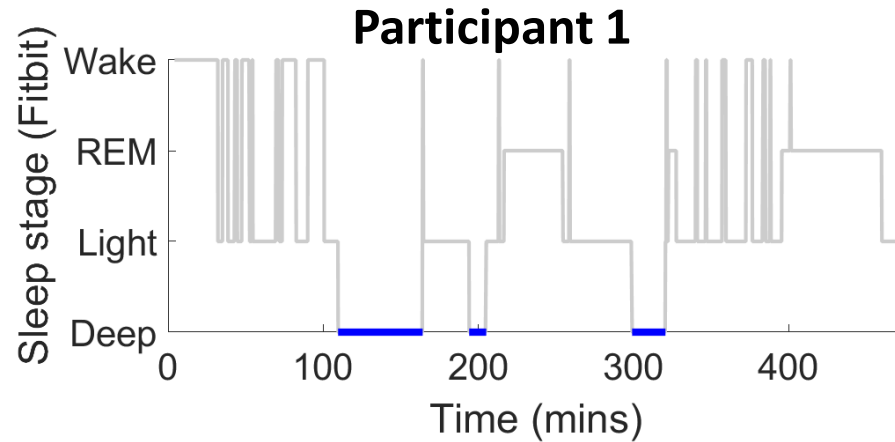
Results: Sleep detection
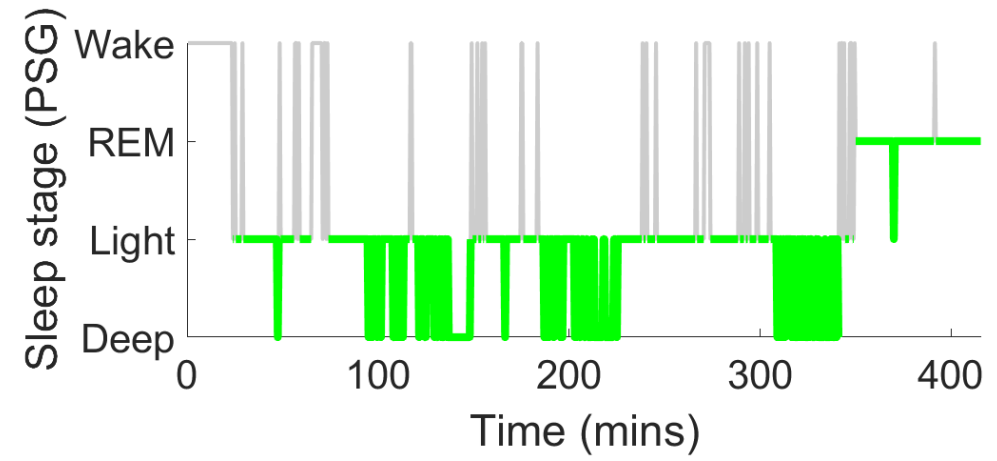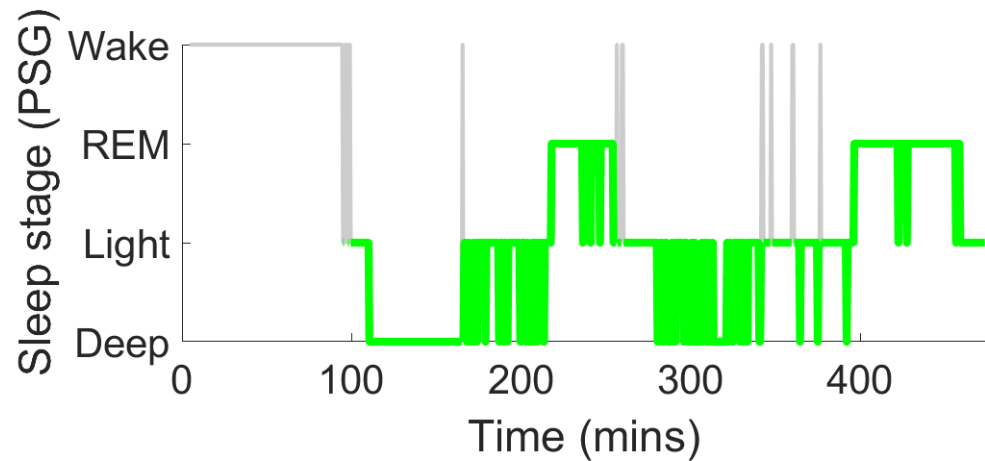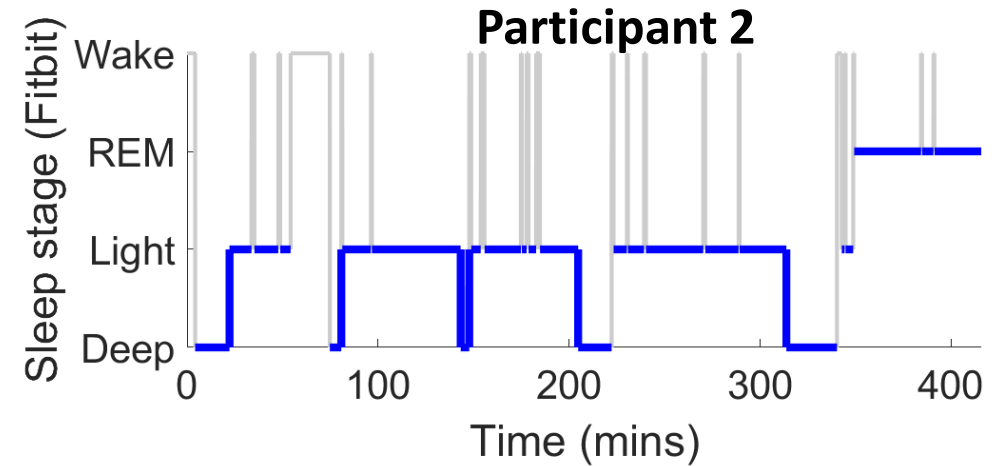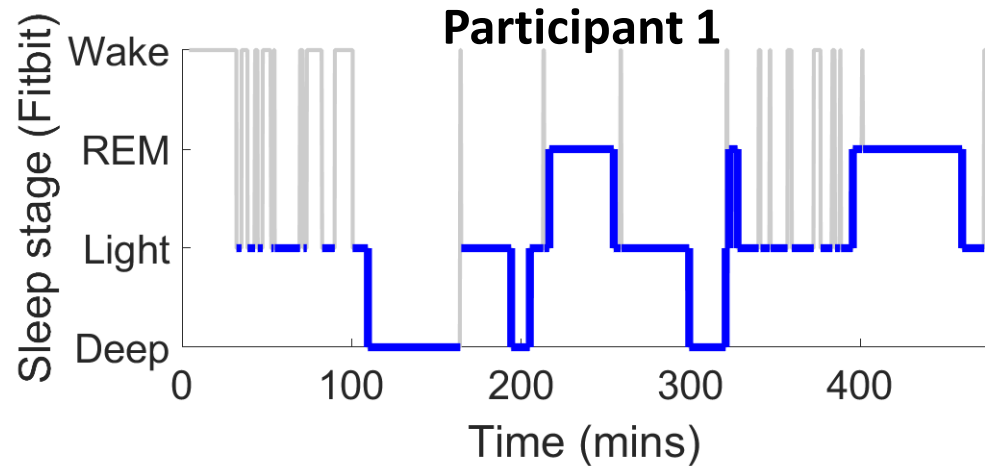
- Compared to PSG, Fitbit overestimated total sleep time by 15.25 ± 10.96 mins (4.1 %)
- Fitbit sensitivity to sleep was 93.6 ± 2.6 %
- Fitbit specificity to sleep was 48.8 ± 17.7 % (Note: *Specificity to sleep = Sensitivity to wake*)

Results: REM detection

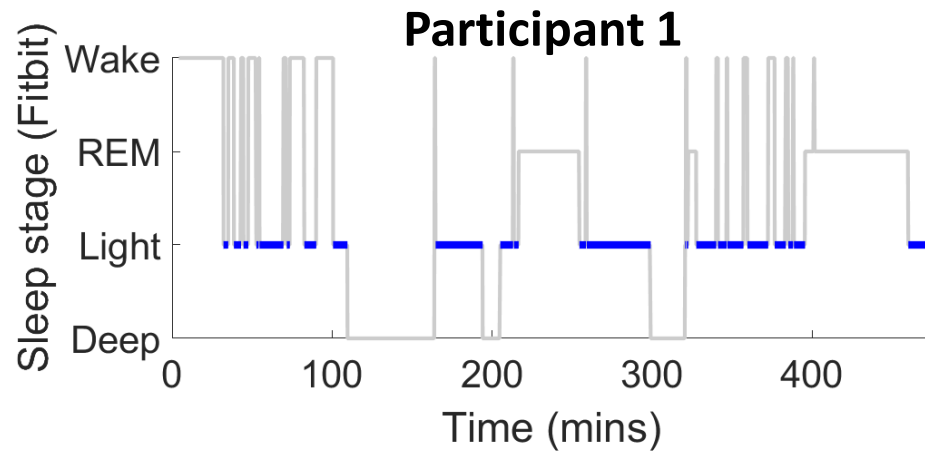- Compared to PSG, Fitbit overestimated REM sleep by 6.75 ± 6.71 minutes (8.4 %)
- Fitbit sensitivity to REM sleep was 98.2 ± 1.8 %
- Fitbit specificity to REM sleep was 98.3 ± 1.9 %

Results: Deep sleep detection
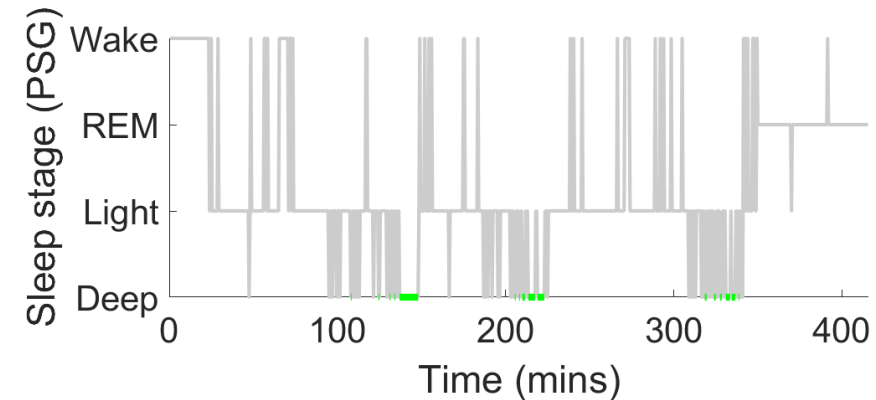
- Compared to PSG, Fitbit overestimated Deep sleep by 2.25 ± 20.86 minutes (2.8 %)
- Fitbit sensitivity to Deep sleep was 65.2 ± 13.1 %
- Fitbit specificity to Deep sleep was 92.8 ± 5.4 %

Results: Light sleep detection
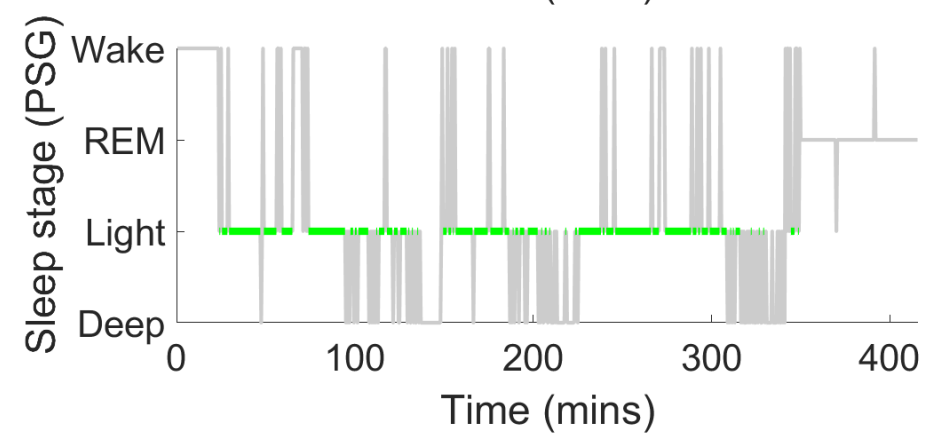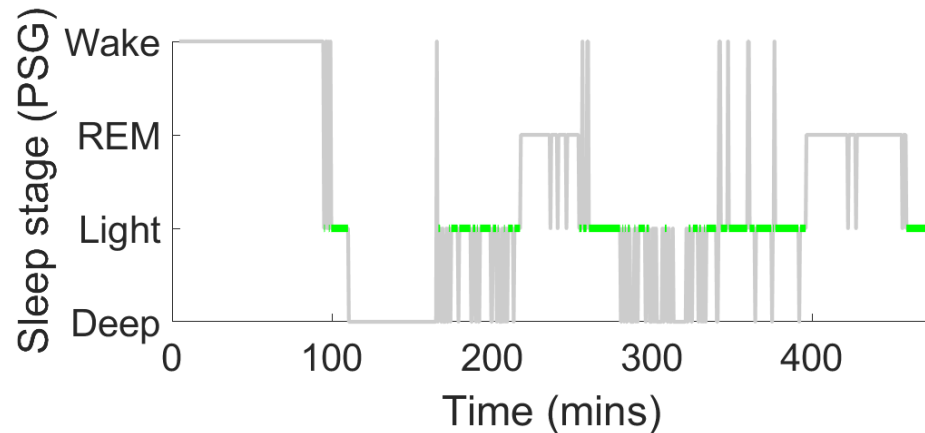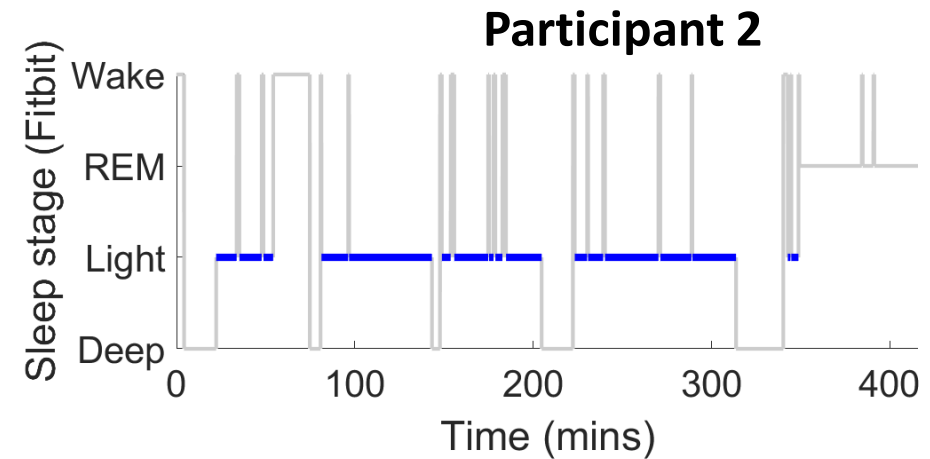
- Compared to PSG, Fitbit overestimated Light sleep by 22.5 ± 21.21 minutes (10.8 %)
- Fitbit sensitivity to Light sleep was 79.1 ± 0.1 %
- Fitbit specificity to Light sleep was 77.9 ± 1.1 %

Results: At-home sleep vs PSG
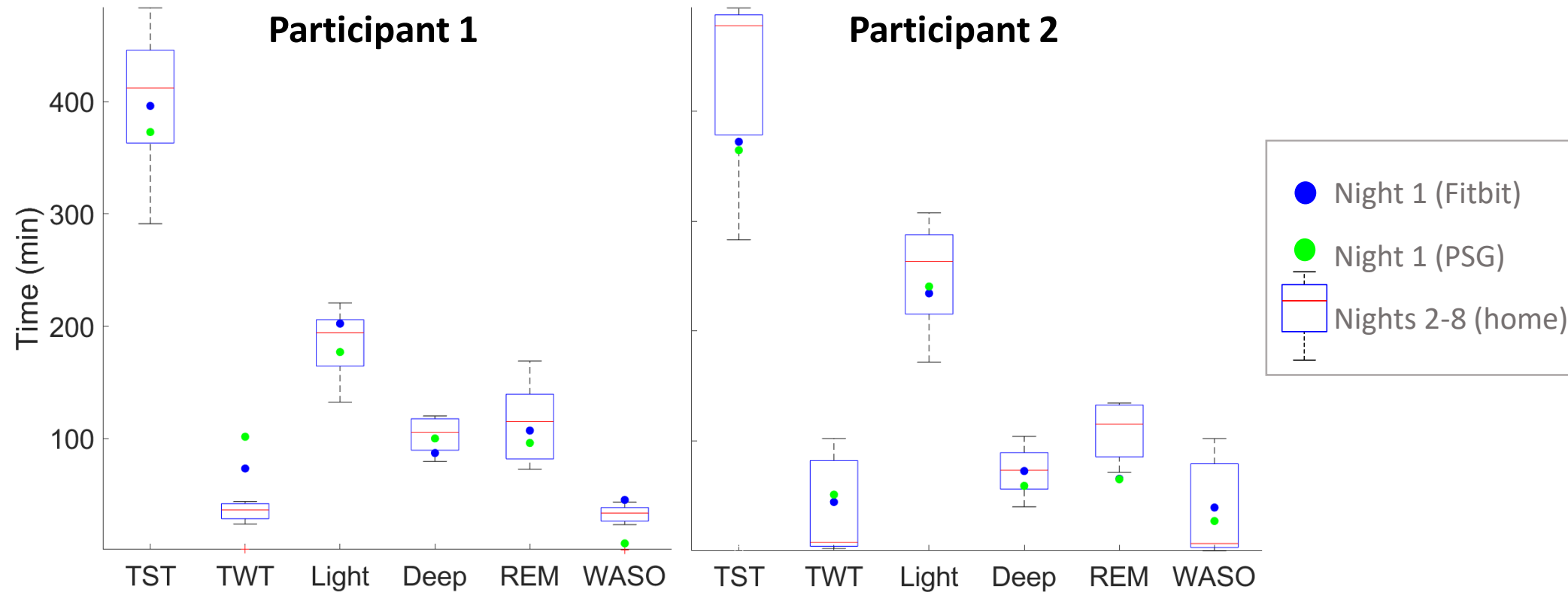
- For both participants, TST, TWT, Light and Deep sleep times on Night 1 (Hospital PSG) were within the range observed at home, suggesting consistent sleep patterns.
- Reduced REM sleep time observed in Participant 2 on Night 1 (Hospital PSG) compared with Nights 2-8 (Home), likely due to shorter TST.
- Greater TWT on Night 1 (Hospital PSG) compared to Nights 2-8 (Home) for Participant 1, likely due to earlier bedtime in hospital compared to home.

Discussion and Conclusion

- Initial results (N=2) suggest that Fitbit Charge 4 may be suitable to monitor sleep stages patterns in HD

- Results are particularly encouraging for:
    - REM sleep detection: sensitivity 98%, specificity 98%
    - Total sleep time estimation: 4% overestimation
    - Total deep sleep time estimation: 2.8% overestimation

- However, lower sensitivity to wake (48%), deep sleep (65%) and light sleep (78%) were observed

- Preliminary results suggest that Fitbit Charge 4 performance is improved relative to previous Fitbit models
    - Previously[1], Fitbit One was compared to PSG in 7 HD patients (3 pre-symptomatic, 4 early-stage symptomatic), with Fitbit overestimating total sleep time by 88 mins compared with PSG, and sensitivity to sleep and wake were 99% and 27%
    - In the current study (N=2) using the Fitbit Charge 4, Fitbit overestimated total sleep time by 15 mins compared with PSG. Sensitivity to sleep and wake were 94% and 49% in this study

1. Maskevich et al, J. Huntington Dis, 2017

- Hospital-based sleep metrics (PSG and Fitbit) were within the range observed at home

- Trends in sleep stage patterns over time will be examined in future work

- Data collection is ongoing, aim to examine 20 participants in total

Thank you