Remote sleep monitoring: a statistical perspective on challenges and opportunities

Vadim Zipunnikov, PhD

Department of Biostatistics

JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH

SMART
Johns Hopkins University
STATISTICAL
METHODS AND
APPLICATIONS FOR
RESEARCH IN
TECHNOLOGY

Remote sleep monitoring: challenges

- Current studies/results are contingent on device/algorithm
- Proprietary hardware/algorithms
  - may prevent generalization of results
  - harmonization of data across studies
- Need for a common language/rules
  - resting HR is different in fitbit/apple watch
- Setup uniform standards for validation
  - require companies to publish evidence/validation for claims
  - require external validation/replication/critical assessment
  - currently, post-release validation by interested researchers

Remote sleep monitoring: challenges

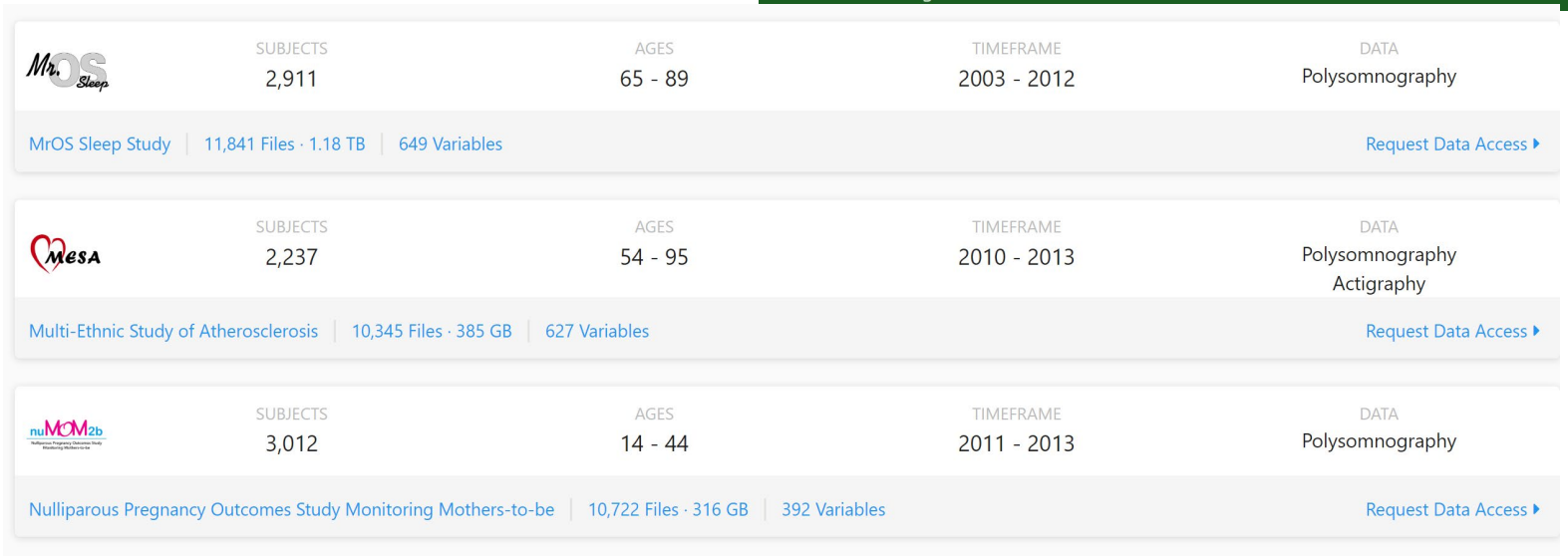
- Ownership/privacy of data
- Device/algorithm independent solutions
  - platforms/devices dropped by manufactures (what if Fitbit is off the market?)
  - legacy data in longitudinal studies (Phillips Actiwatch, switching platforms/devices)
- Need for open-source platforms/software/algorithms
- Need for harmonization and collaborative work.
- Integration across PSG/Actigraphy/HR/Oxygen

Remote sleep monitoring: opportunities

- Create normative population level references for sleep patterns
  - by age, gender, clinical group
- Establish patient-level normative values and longitudinal trajectories
- Account for day-to-day variability, weekly and seasonal patterns
- Improve reliability of assessment
- Account for state (now) vs trait (past)
- Explore/improve specificity of sleep phenotypes/signatures
- Integrate sleep with daytime motor activity and circadian rhythm
- Account for social schedules/encounters/experiences and environmental context (temperature, light)

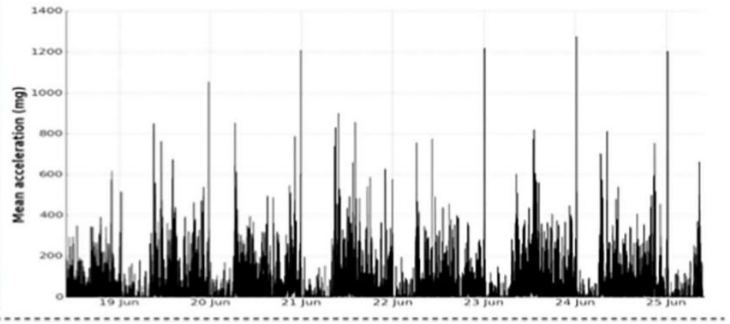
Data repositories

- NHLBI initiative
- Replication exiting results/algorithms
- Development/validation novel algorithms
- Cohort-based normative data



Large national cohorts

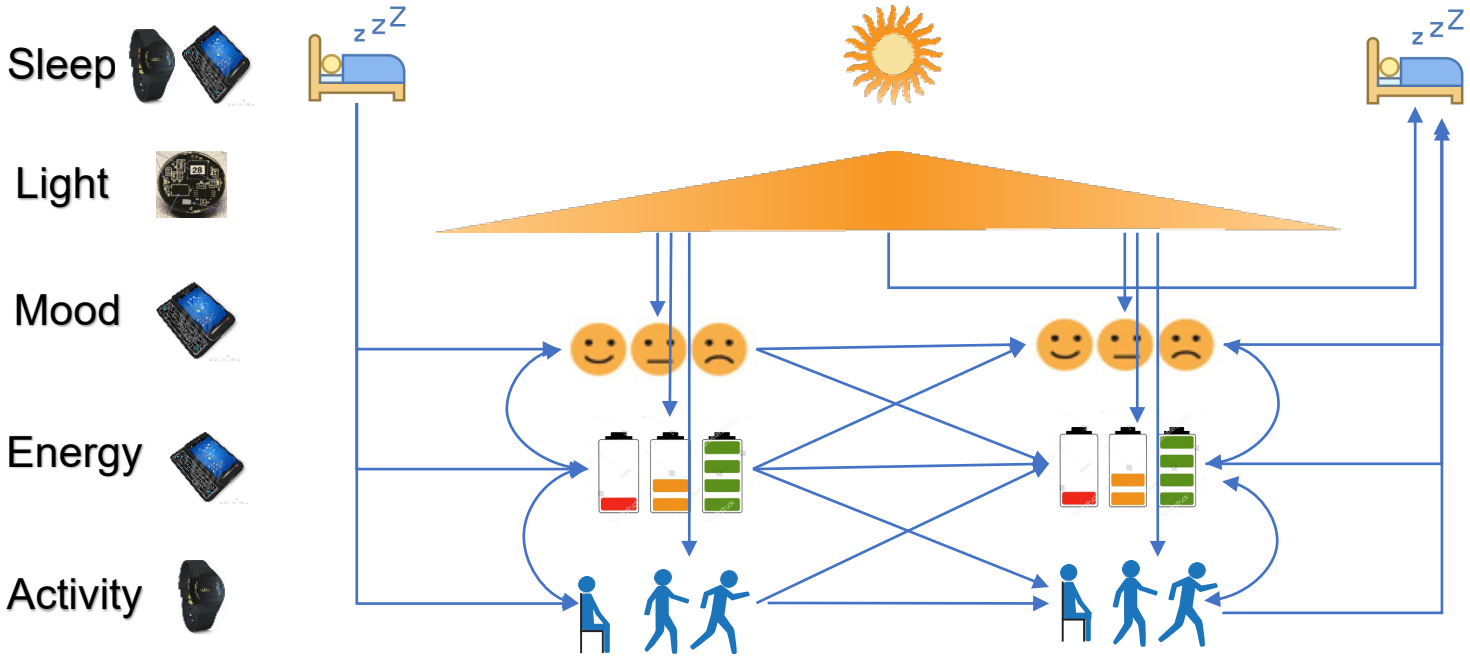
- UK Biobank (45-79 y.o, ~100K participants with wrist actigraphy)



- All of US (fitbit, ~17K, self-selected adults 18-82 y.o)

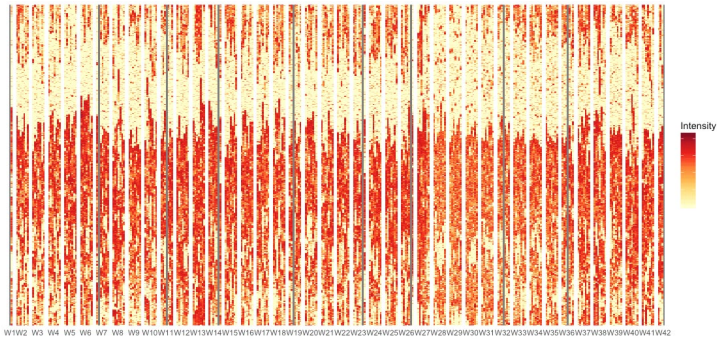
Sleep and beyond

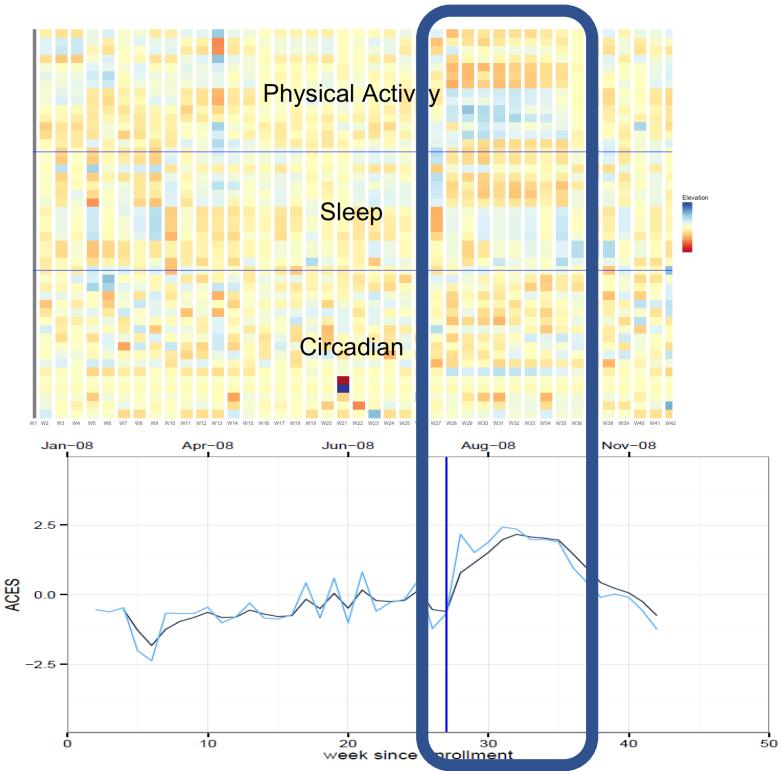
- Sleep is a part of 24-hour cycle
- What about physical activity and circadian rhythmicity?
- How to account for social (schedules, experiences, stressors) and environmental context (light, temperature, seasons)

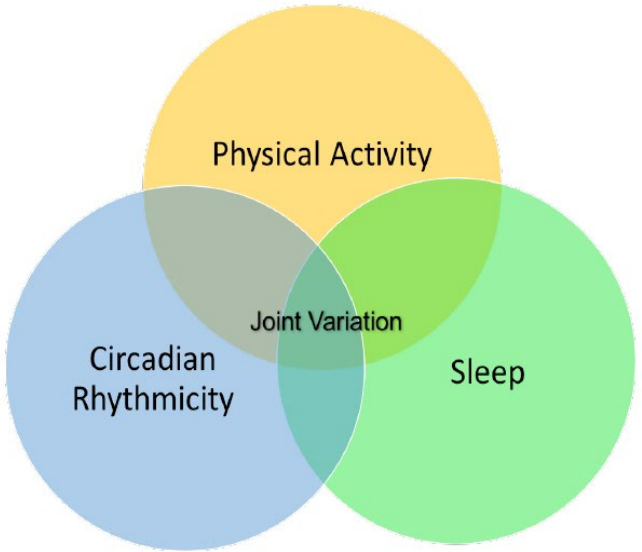


- **Advantages of using EMA and light sensors**
  - Self-perceived sleep quality, energy, mood,
  - Social context (current location, immediate experiences, social encounters)
  - Environmental context (temperature, weather, light exposure, light at night)
  - Real-time recalls that can be integrated with ambulatory actigraphy/PSG
  - Natural environment (home, work)

Multi-week monitoring CHF patients







BYOD (Bring your own device)

- Jonhs Hopkins patients can “donate” their fitbit data (5 mins)
- Automated report on prior trajectories of sleep & physical activity
- Train clinician to interpret in a consistent fashion
- Informs about current functional status of a patient
- More accurate placement of a patient in a risk category
- Tracking post-surgery recovery

- **Thank you!**