

New Technology Approaches for Monitoring Sleep & Sleep Disorders



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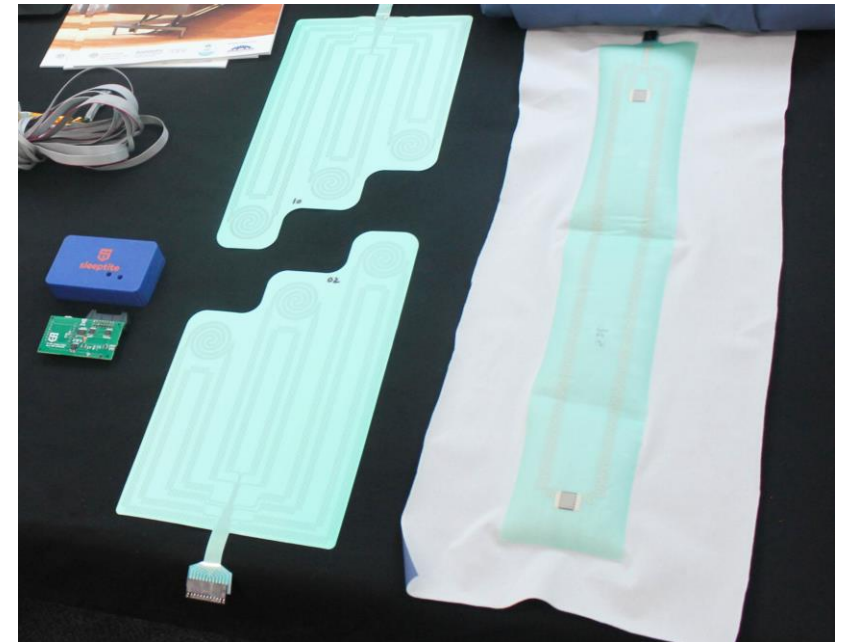
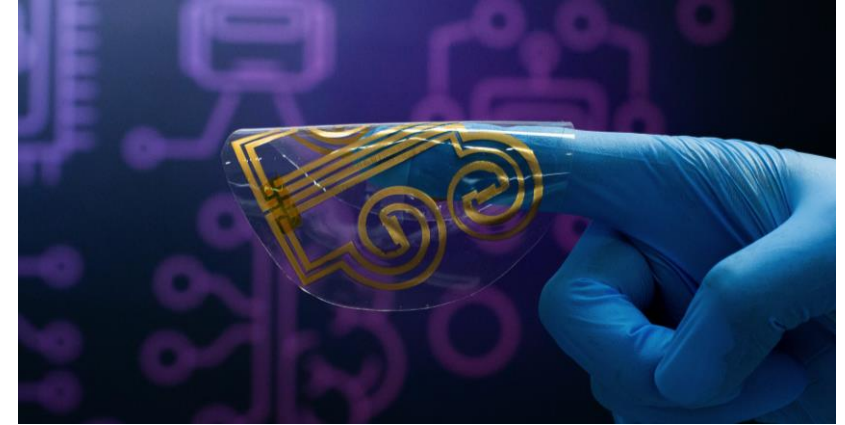


Nearable tech for sleep monitoring

Printable, flexible, stretchable, sensors

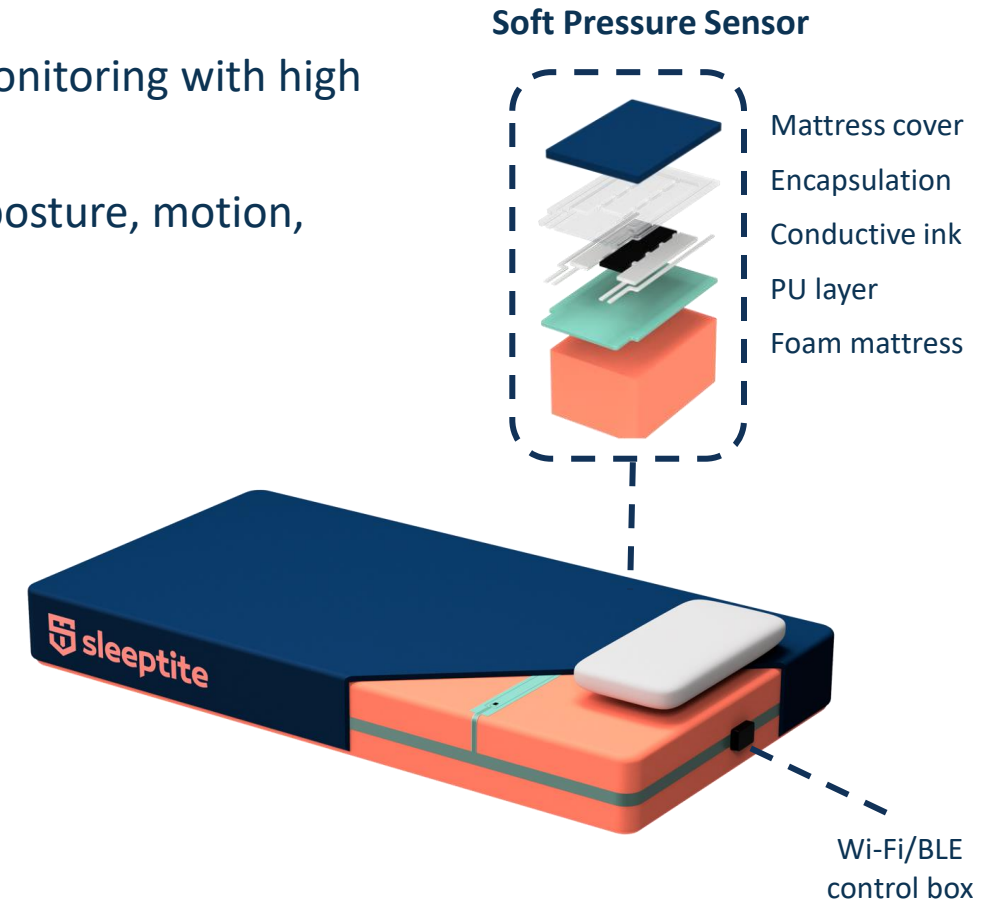
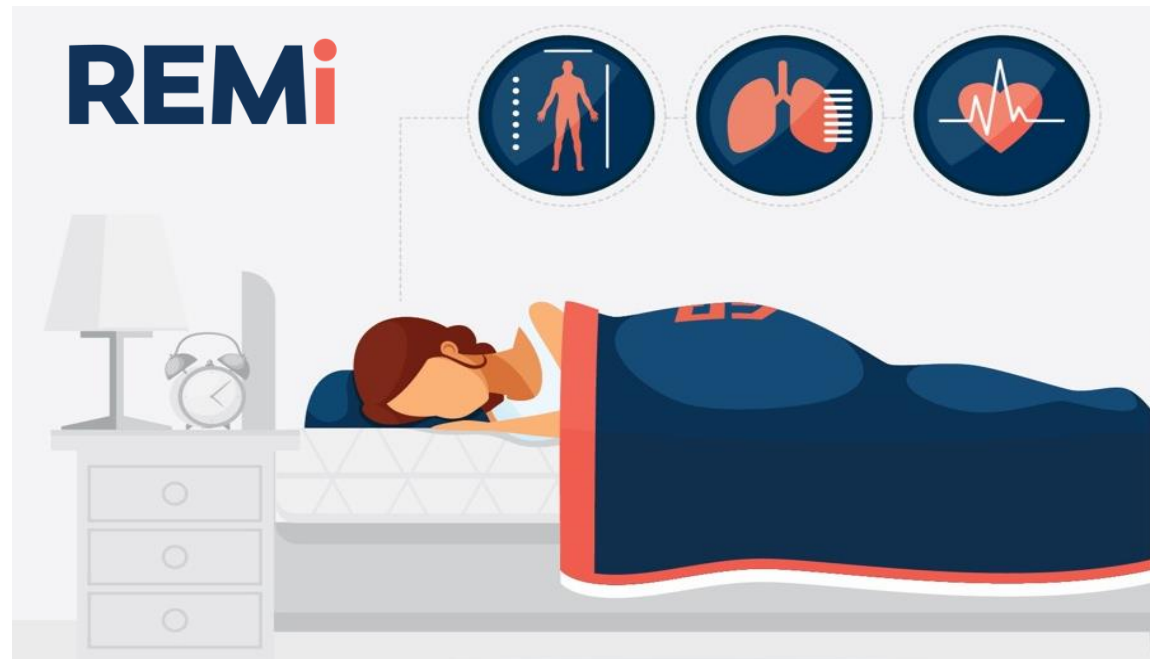
Development of novel low-cost soft electronics on fabric

- Wearables are typically rigid, breakable (eg smartwatches) and require user interaction.
- RMIT & Sleepite developed durable electronics that are conformal, stretchable, flexible and can be embedded onto fabric ^{1,2}
- These new 'nearable' sensors are low-cost and capable of scalable production.

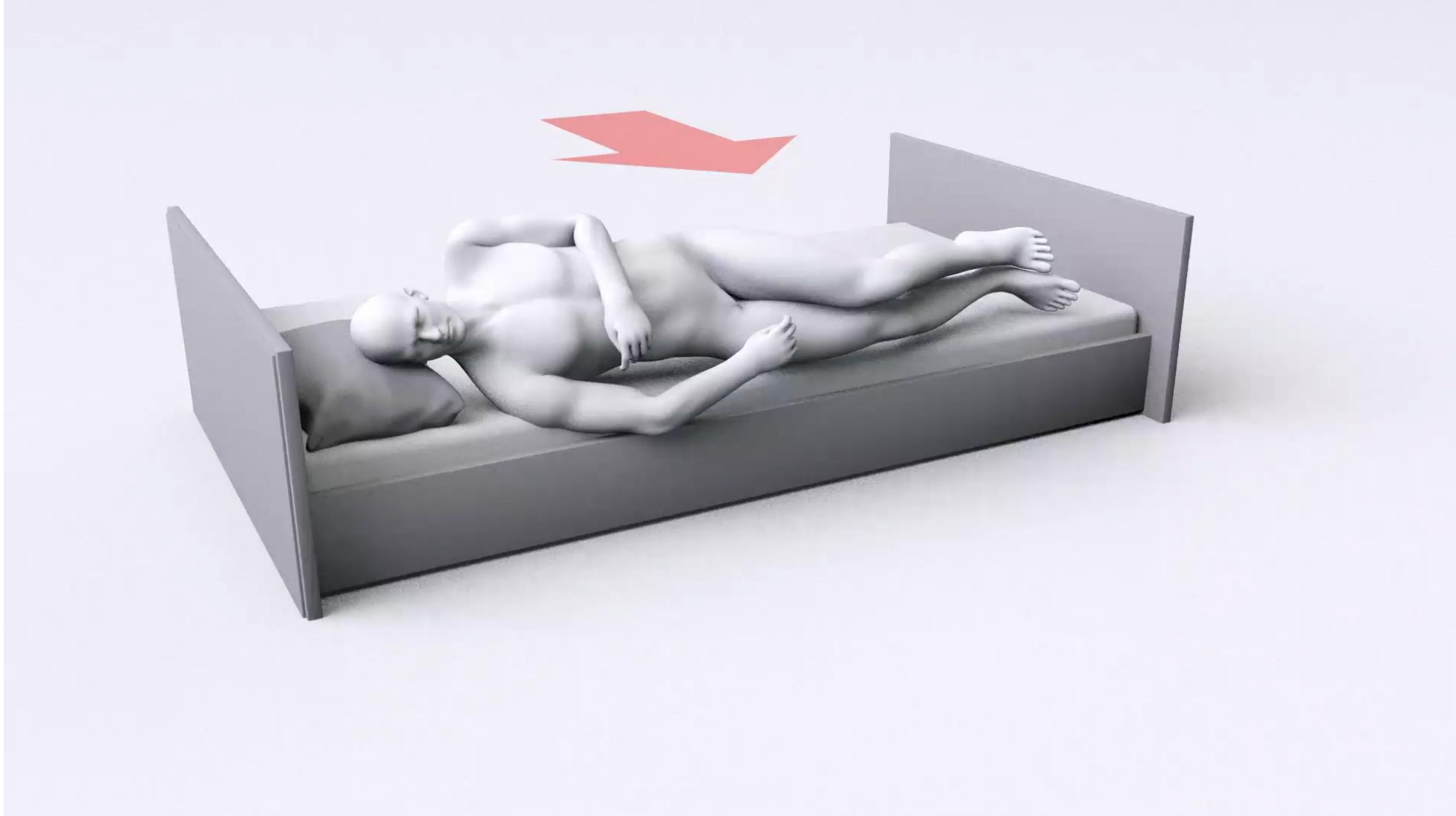


Nearable tech for sleep monitoring | Aged Care - REMi

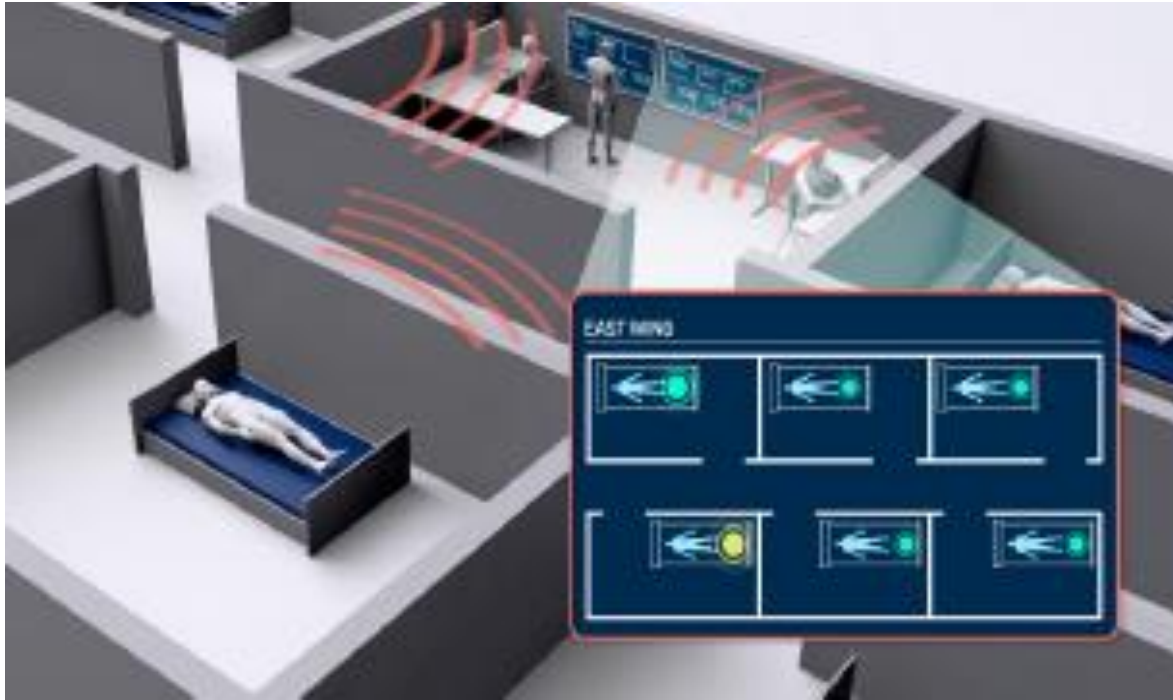
- Developed for the Aged Care sector with sensors embedded onto the mattress protector (underside) and imperceptible to the user³
- Piezo-resistance (pressure) sensor design for real-time biometrics monitoring with high sensitivity.
- The REMi[®] system can wirelessly measure body presence, position, posture, motion, respiration and heart rate- without the need for user interaction.



What is REMi?



REMi | Current device capabilities



Supporting the **aged care workforce** and prioritising provision of **care** through **real time monitoring** of resident status.

- REMi data transmitted to cloud-based dashboards to be viewed by care staff
- Continuous monitoring a of a resident's **presence**, **position** and **posture** in bed
- 'Nearable' sensors embedded in mattress cover are imperceptible to the user
- REMi system has the capability to integrate with other systems/dashboards
- REMi can be used in both Aged care facilities and Aging in place



Flinders
University

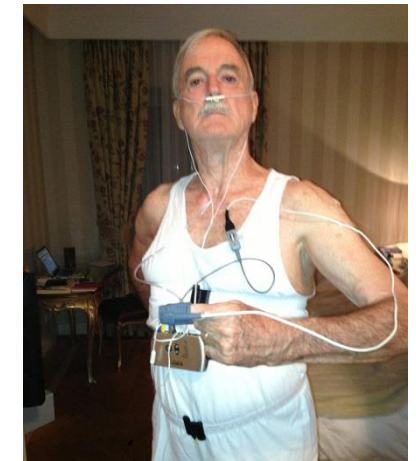
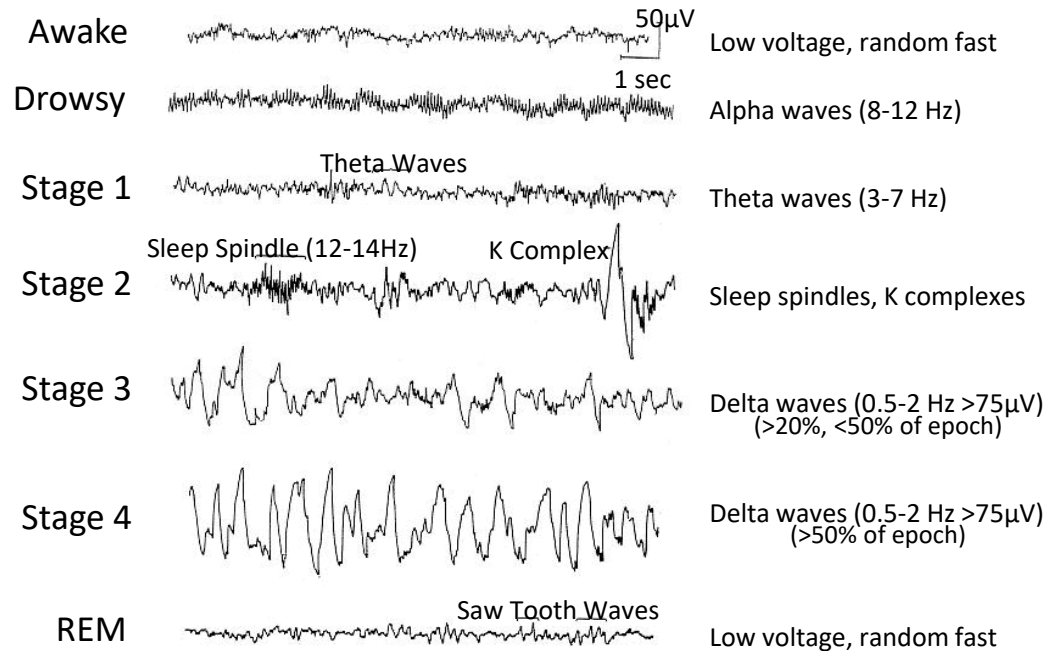
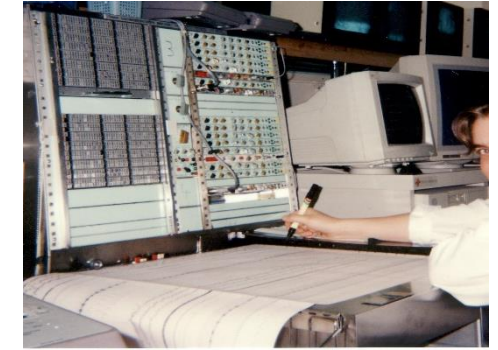
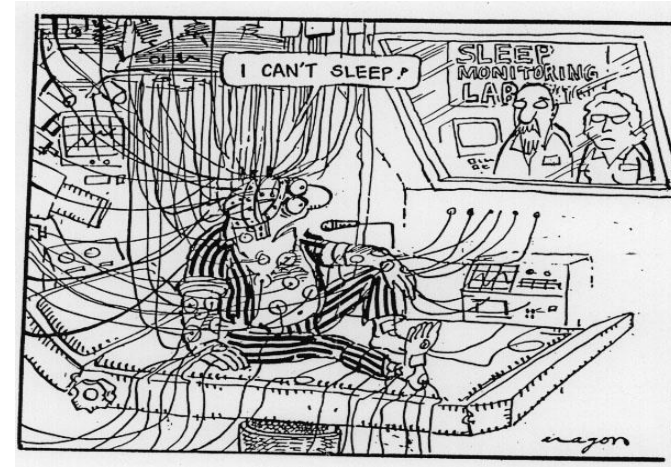
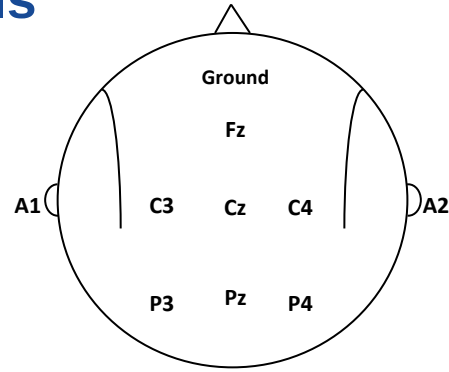


Kaurna m

Clinical sleep study polysomnography (PSG) is complex!

- **Multiple physiological signals**

- Direct EEG markers of sleep
- EOG and EMG
- Oximetry
- Breathing
- Body position & movements



<http://www.dailymail.co.uk>

Better use of physiological data

CURRENT APPROACHES

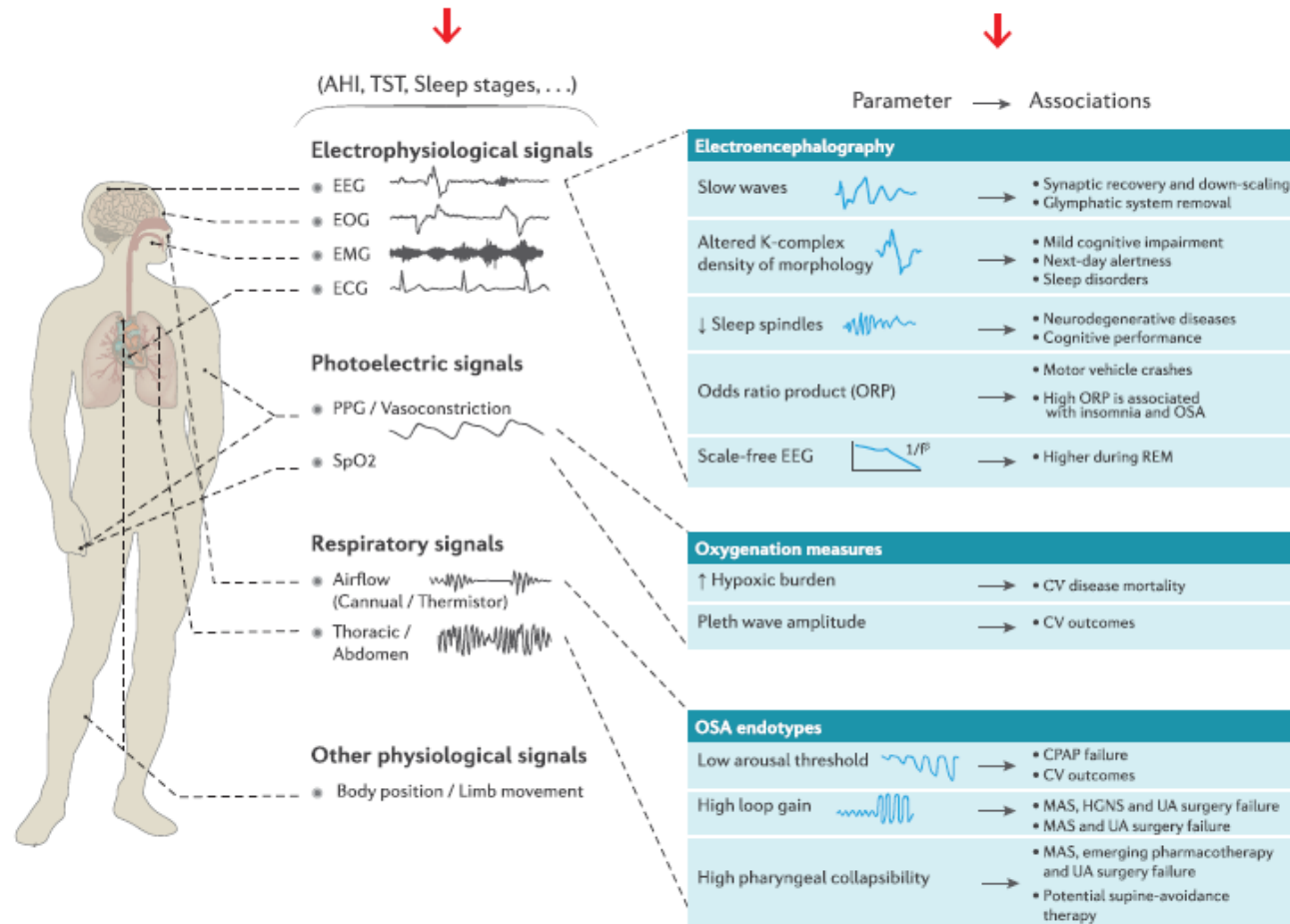
Advantages: Lots of detailed rich neurophysiological data collected.

Disadvantages: Most of the collected information is currently ignored, traditional metrics are imprecise and do not predict treatment response or relate well to key clinical and health outcomes.

EMERGING APPROACHES

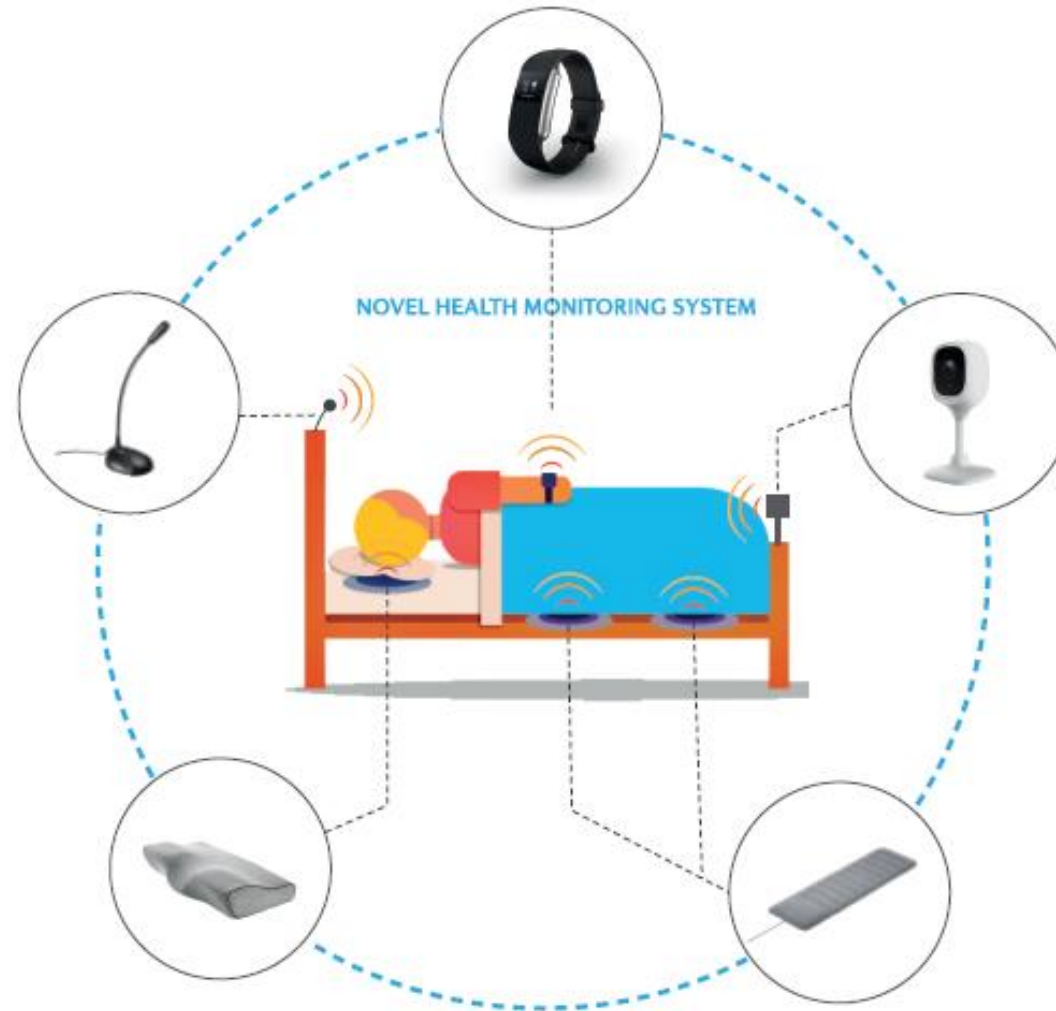
Advantages: Makes use of routinely collected data to provide novel insight into sleep neurobiology and treatment prediction to better link with key clinical and health outcomes.

Disadvantages: Most approaches are still at the research and development phase and are not currently available for clinical use at scale.



Lechat et al. Front Neurosci. 2021 Oct 7;15:751730. doi: 10.3389/fnins.2021.751730. eCollection 2021

Bedroom of the Future – New technology to monitor sleep and health outcomes



Lechat et al. Front Neurosci. 2021
Oct 7;15:751730. doi:
10.3389/fnins.2021.751730.
eCollection 2021

New Technology

Under mattress sensors to quantify sleep and disorders

EarlySense - under mattress, respiration, HR, movement

- AHI validation – $AHI > 15$ – Sensitivity = 88%, Specificity = 89% (Davidovich et al, DOI:10.22489/CinC.2016.246-183)



FullPower AI Sleep Monitor – under/in mattress, respiration, HR, movement

- AHI validation – $AH \geq 15$ – Sensitivity = 82%, Specificity = 93% (Ding et al, <https://doi.org/10.1016/j.sleep.2022.04.010>)

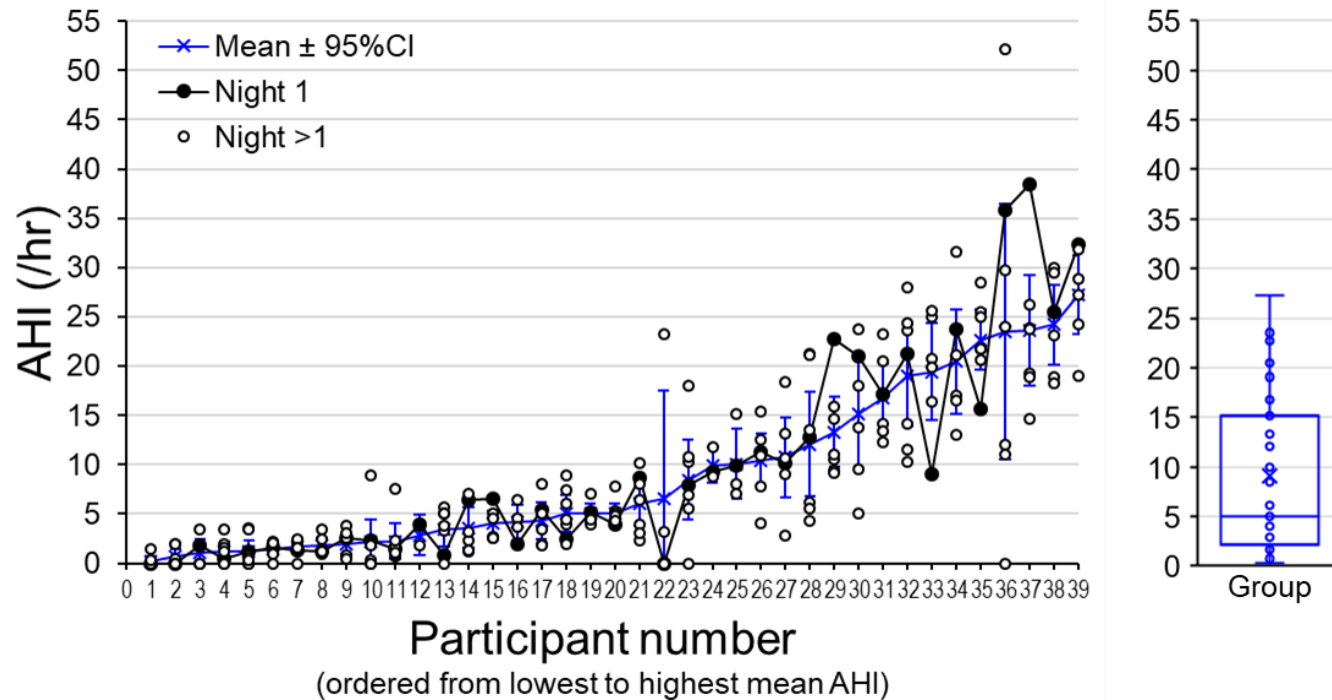


Withings Sleep Analyser – under/in mattress, respiration, HR, movement

- AHI validation – $AHI \geq 15$ – Sensitivity = 88%, Specificity = 89% (Edouard et al, J Clin Sleep Med 2021 doi: 10.5664/jcsm.9168, independent AISH validation verified)



Night to night variation in sleep apnea

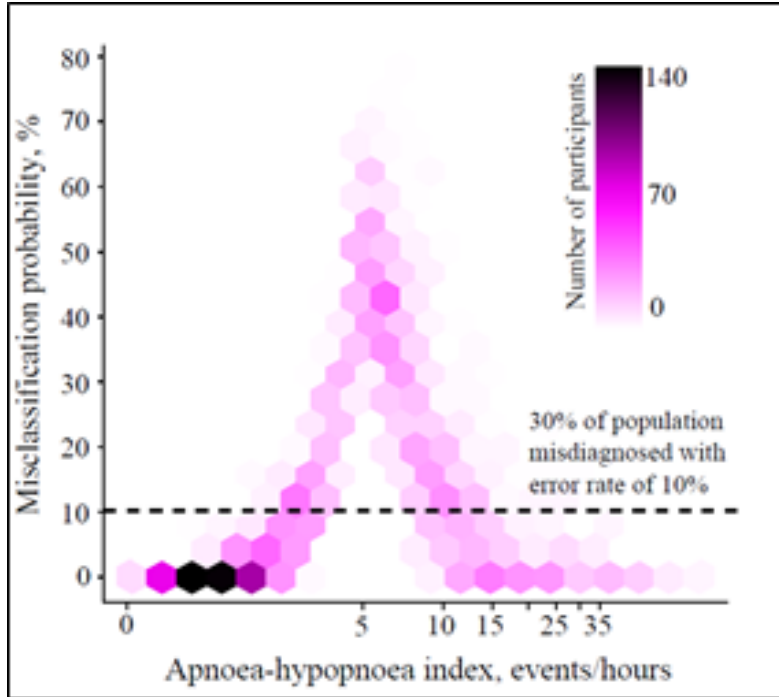


	Night 1	Best Night	Worst Night	Mean
AHI (/h)	6.4 [1.7-14.3]	2.0 [0.0-8.0]	8.9 [4.8-23.3]	5.0 [2.2-14.3]
Normal	26 (67%)	32 (82%)	20 (51%)	24 (62%)
Mild	5 (13%)	7 (18%)	6 (15%)	9 (23%)
Moderate	5 (13%)	0 (0%)	9 (23%)	6 (15%)
Severe	3 (8%)	0 (0%)	4 (10%)	0 (0%)

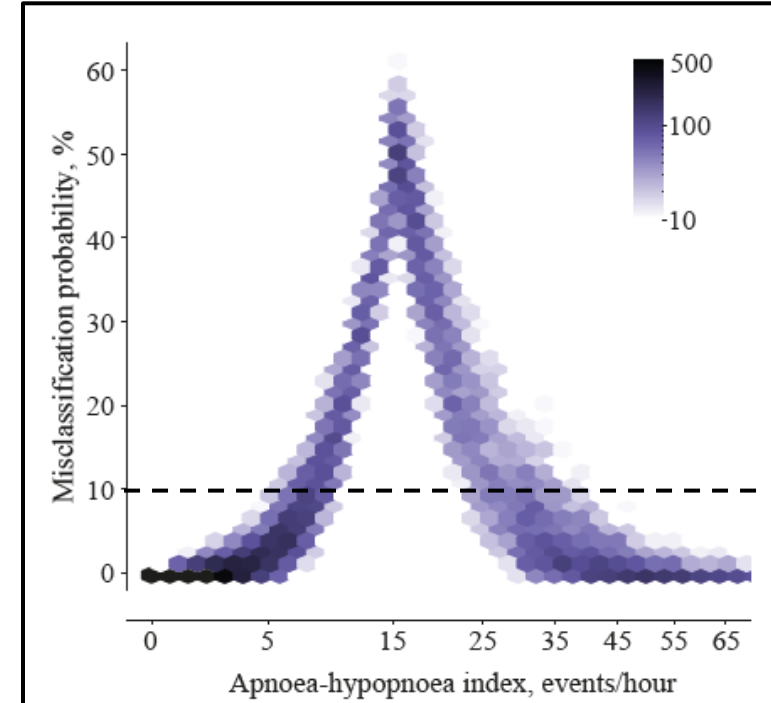
Median and interquartile range AHI and the number (%) of participants classified as normal (AHI ≤ 10 /h) or mild (AHI 10-20 /h), moderate (AHI 20-30 /h) or severe (AHI > 30 /h) OSA based on their night 1, best night (lowest AHI), worst night (highest AHI) and mean AHI across all available nights from N=39 participants.

Probability of OSA mis-classification

FullPower AI Sleep Monitor



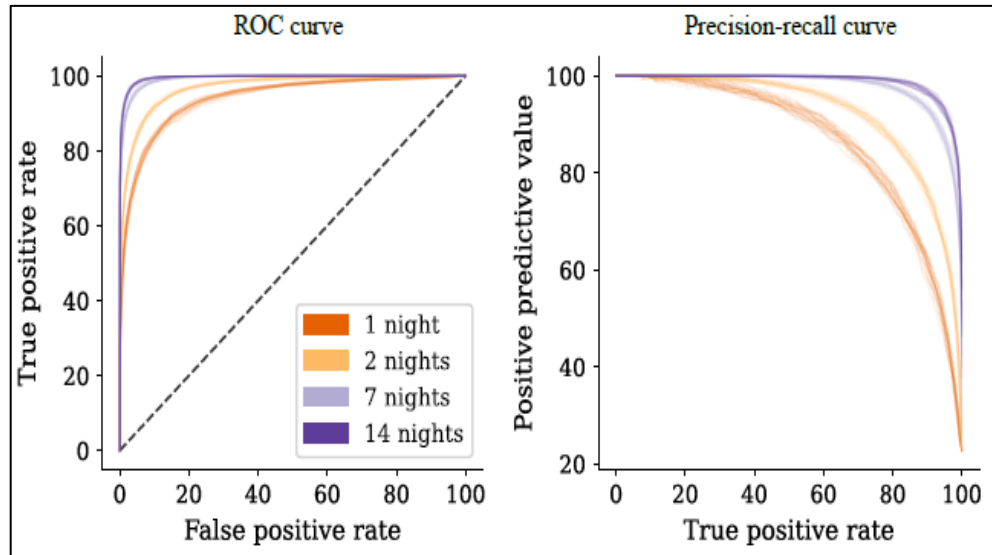
Withings Sleep Analyser



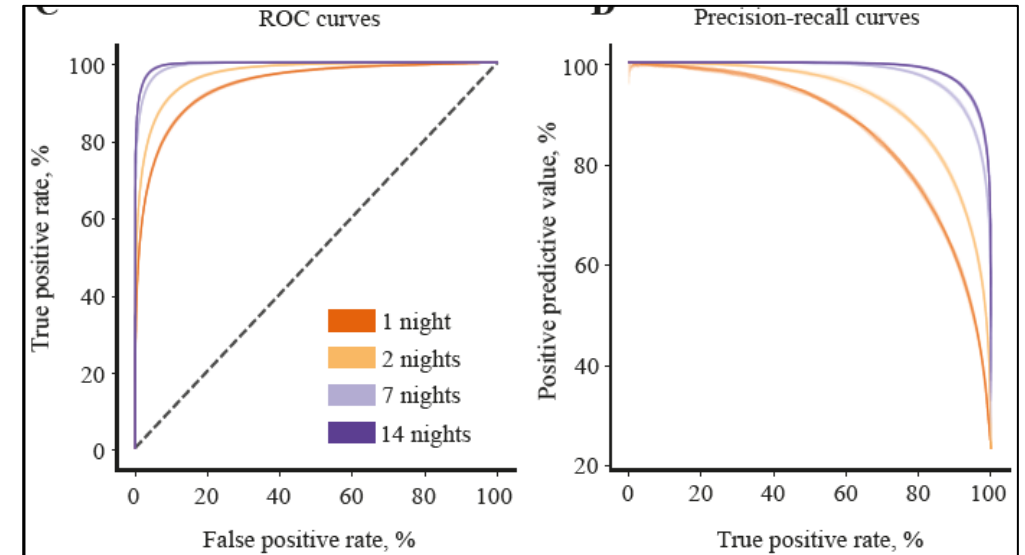
Misclassification probability based on a single night study, which ranged from approximately 0 to 60%. If 10% is used as the maximally acceptable error rate (i.e. 90% probability of correct classification), up to 30.5%-33% of the population would get an inconclusive/misclassified result from a single night study. Furthermore, the misclassification rate was significantly more prevalent in individuals with a 28 night average AHI indicative of OSA compared to those without OSA (62 – 62.6% versus 21-25%).

How many nights monitoring is enough?

FullPower AI Sleep Monitor

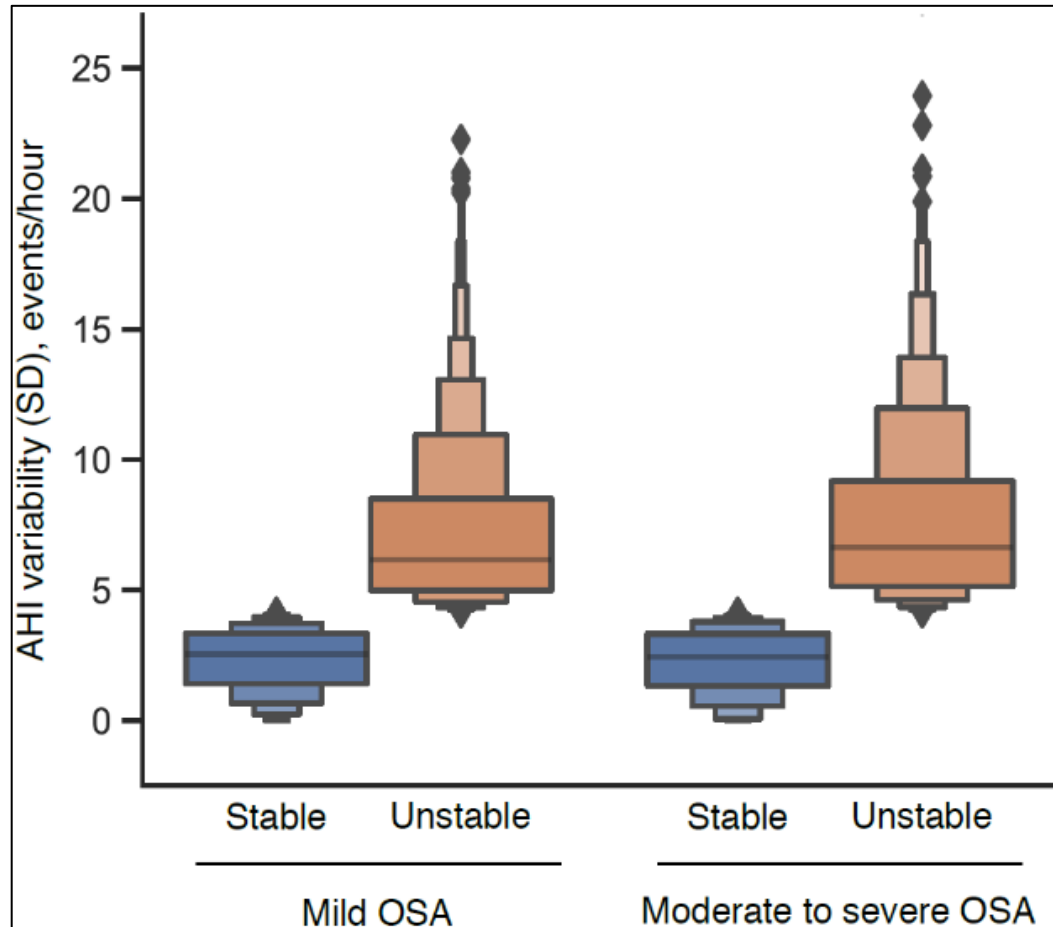


Withings Sleep Analyser



Receiver operator characteristic (ROC) and precision-recall (PR) curves show that the likelihood of misclassification of OSA depends on the number of nights used for AHI evaluation. **7 or preferably 14 nights substantially decrease the likelihood of misclassifying patients that truly have OSA as a non-OSA patient**

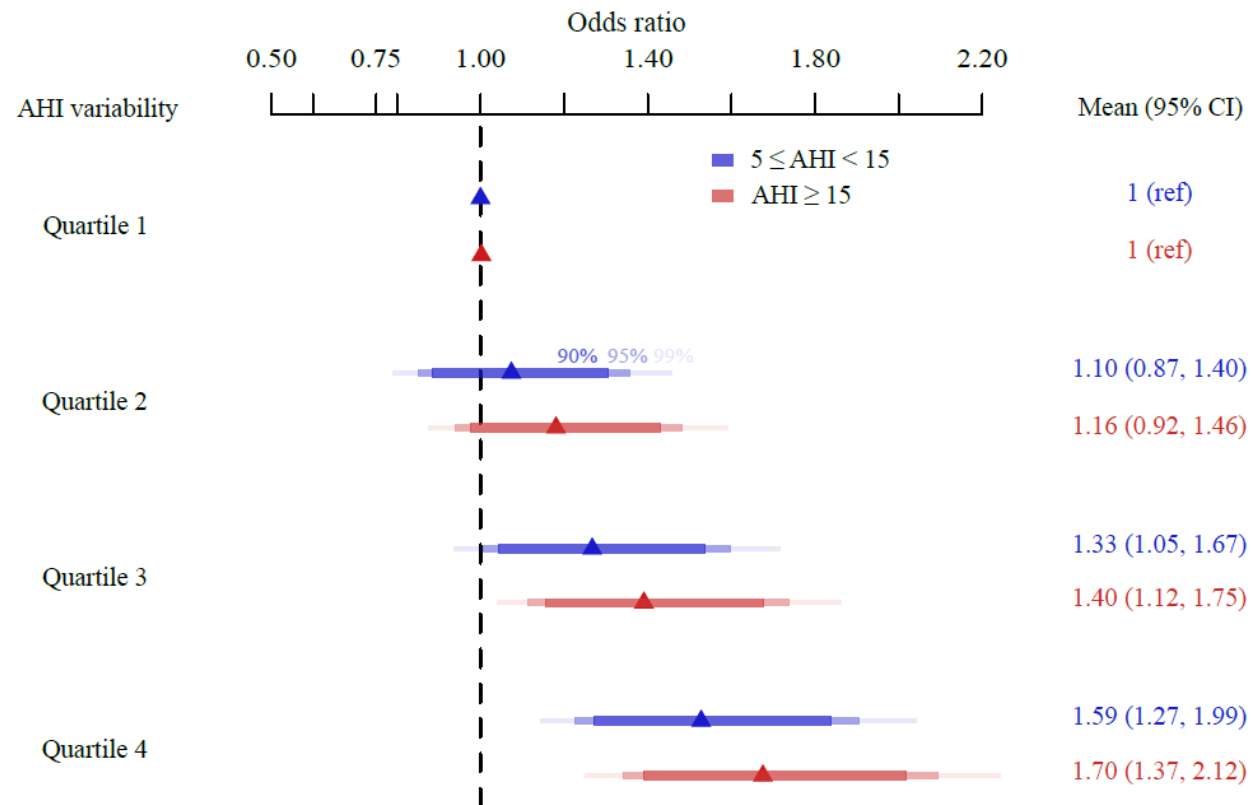
Clusters/phenotypes of AHI N2NV



Median split of AHI standard deviation across all nights showing both mild (AHI 5-15) and moderate to severe OSA (AHI >15) categories have distinct clusters of people with low (Stable) AHI and high (Unstable) AHI variability

Withings dataset

Association between nightly variation in sleep apnea severity and hypertension



Lechat et al. under review - Confidential

Normal sleep reduces with age

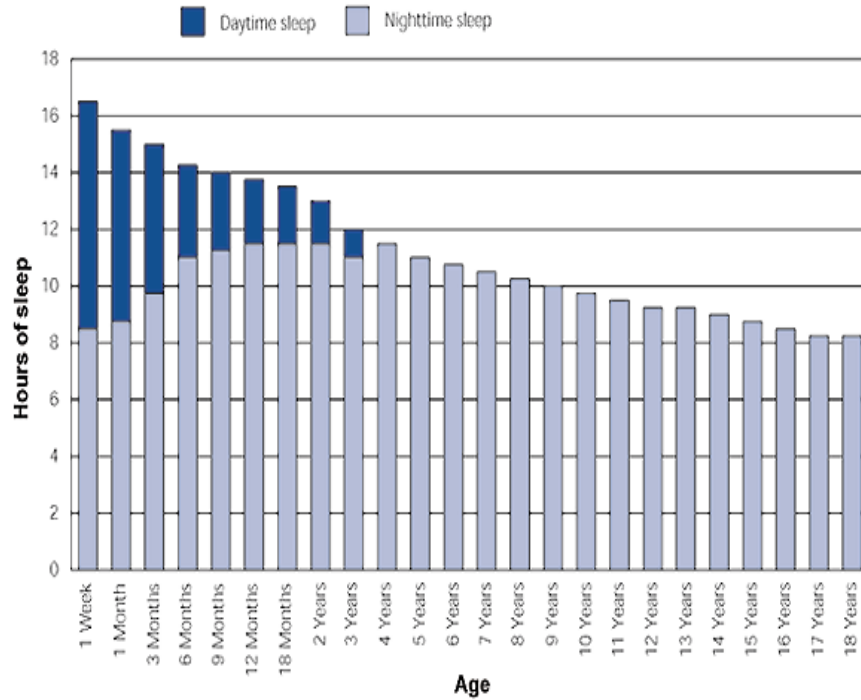
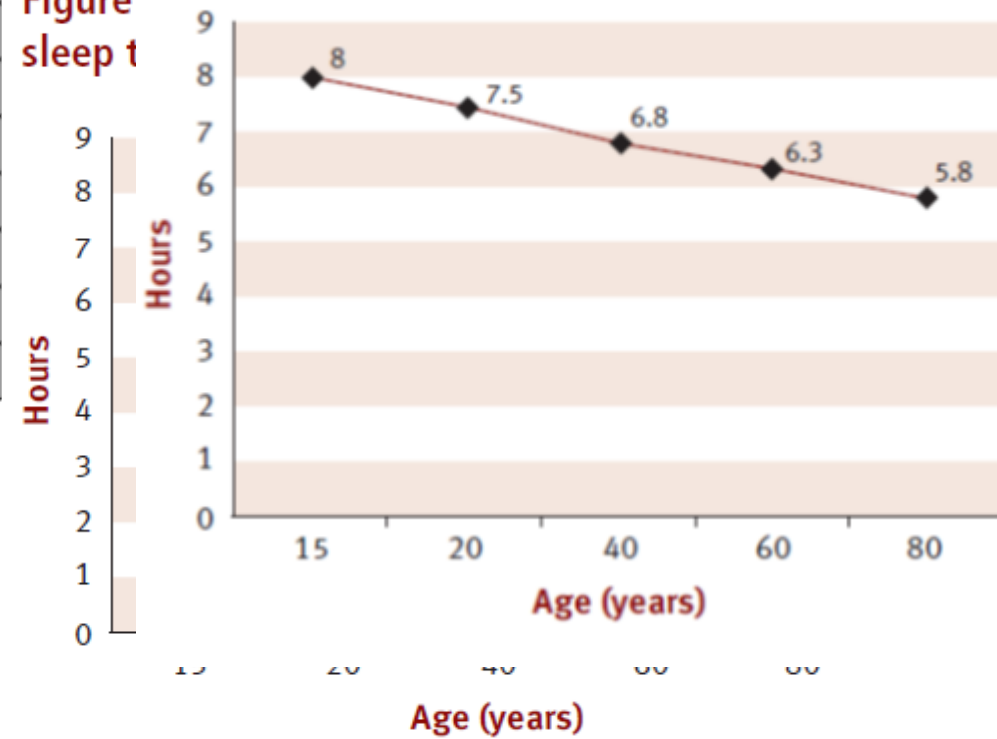
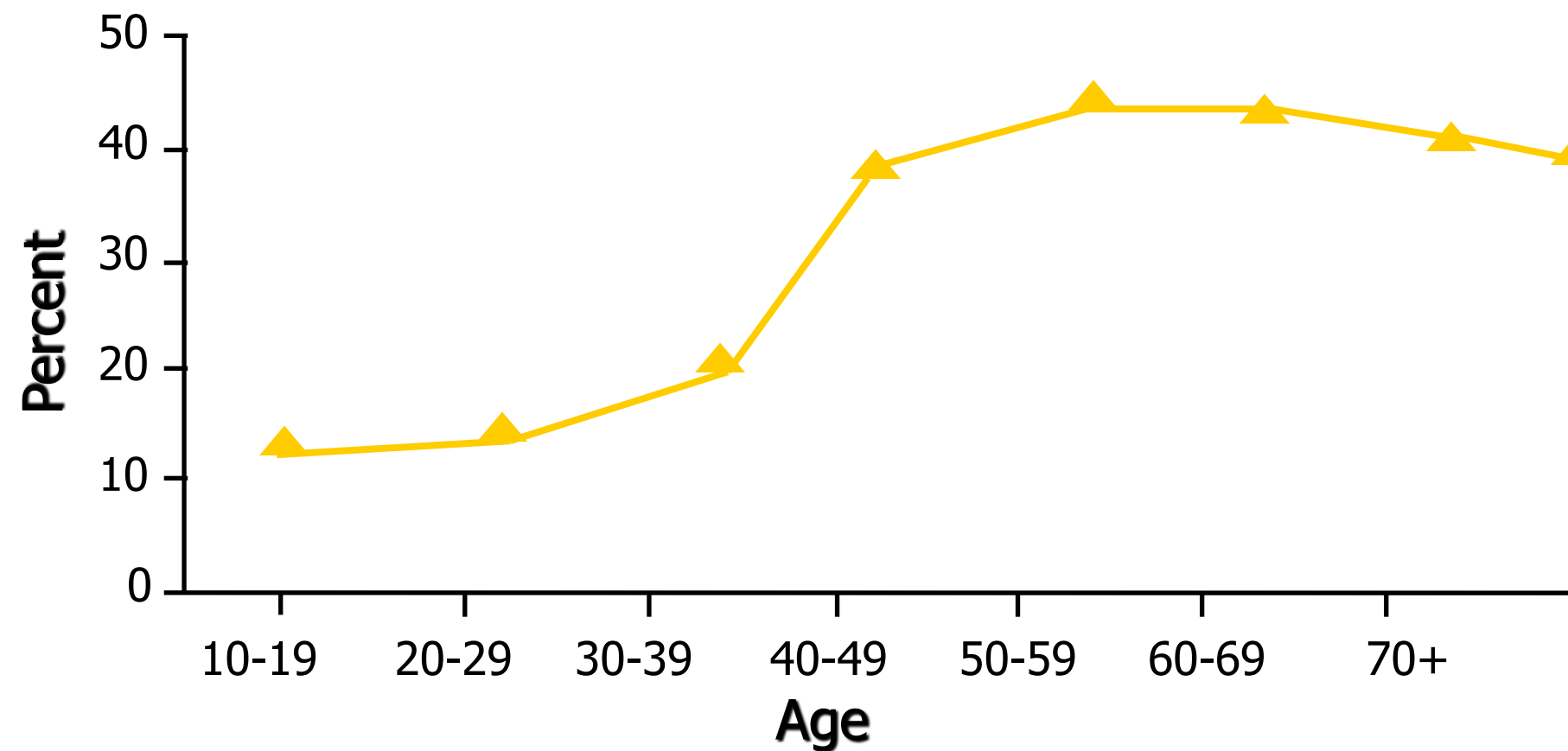


Figure 1: Age-related trends for average total sleep time/night ¹⁶

Figure sleep 1



Sleep Complaints as we Age



Karacan et al, 1976; Vitiello et al, 2004

Prevalence of Sleep Disorders with ageing

<u>Condition</u>	<u>All Adults</u>	<u>Elderly</u>
Insomnia	10-20%	40-50%
Sleep Apnea	10%-25%	24%-40%
Periodic Limb Movements	2-5%	30%-45%
Restless Leg Syndrome	2%-15%	12%-30%
REM Sleep Behavior D/O	0.5%	0.5%-2%



Aging Worsens the Effects of Sleep Deprivation on Postural Control

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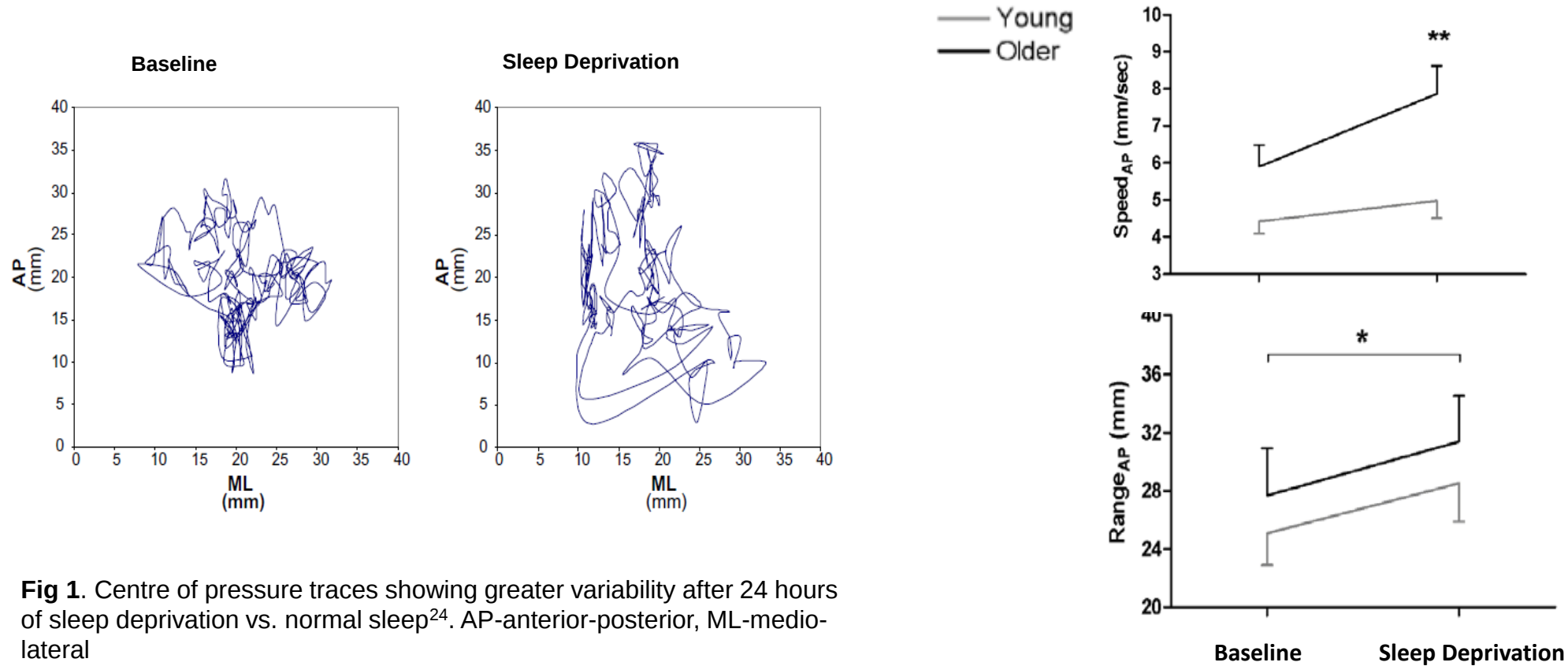
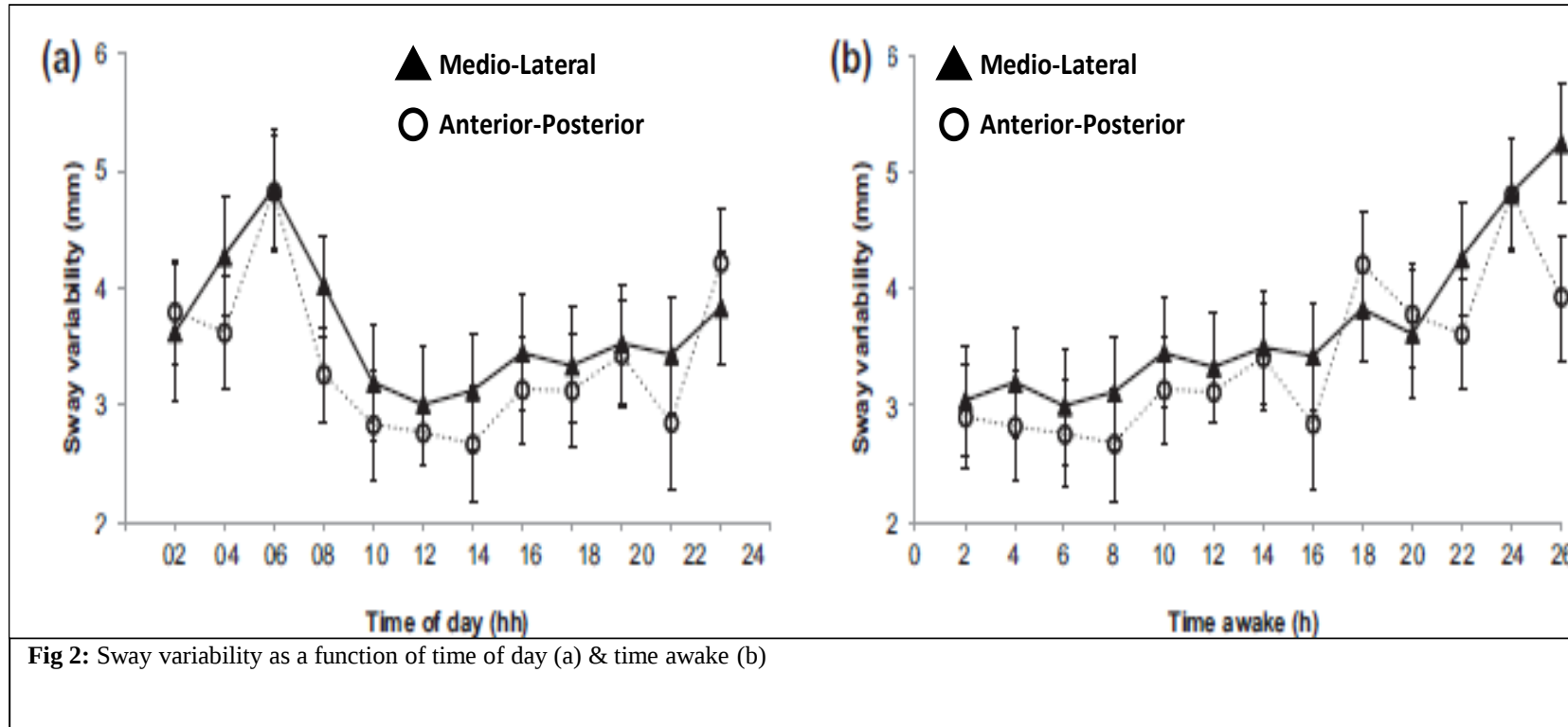


Fig 1. Centre of pressure traces showing greater variability after 24 hours of sleep deprivation vs. normal sleep²⁴. AP-anterior-posterior, ML-medio-lateral

Sway variability as a function of time of day & time awake



Effect of 6 months CPAP on Physiological Profile Assessment Falls Risk Score

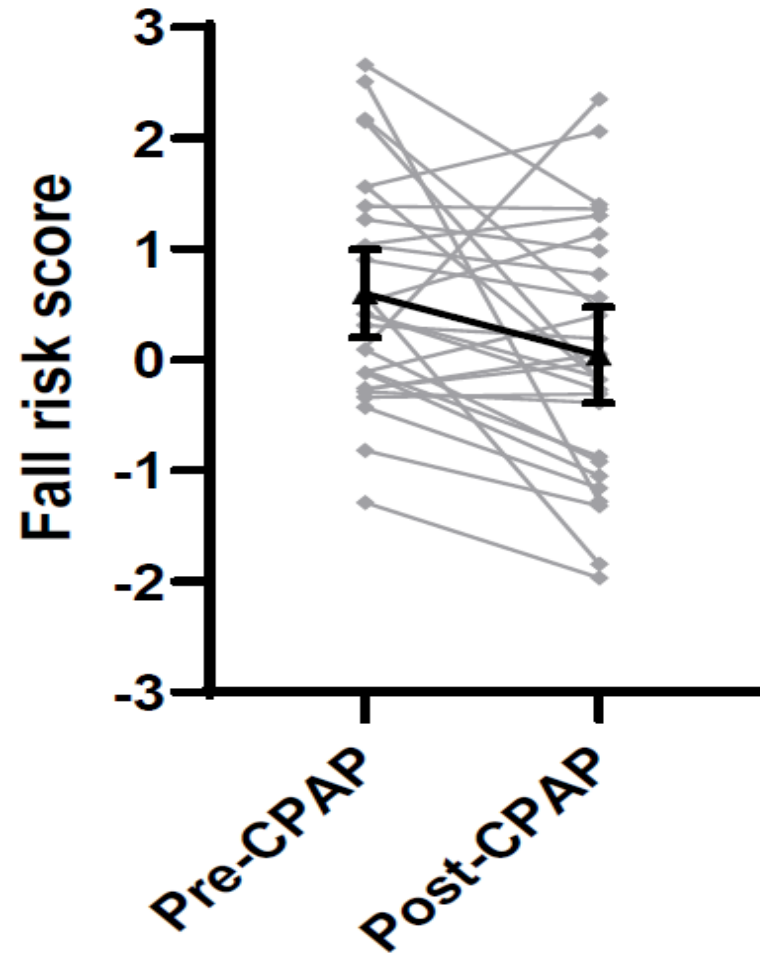


Figure 1. Changes in fall risk score pre- to post-CPAP treatment. Dark line represents average change in fall risk score for the group. Grey lines represent individual changes for participants. CPAP – continuous positive airway pressure.

Summary and Conclusion

- Sleep and breathing vary significantly from night to night
- New and emerging technologies allow for multi-night sleep measurement
- Quantifying night to night sleep and sleep disorders likely relate to important health outcomes
- Provides unique opportunity for unintrusive in-home sleep health monitoring in older people towards
 - Sleep disorder screening and monitoring
 - Preventative strategies
 - Healthy ageing



THANK YOU!

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