Wearable headband EEG with pulse plethysmography to assess cortical hyperarousal in individuals with stress-related mental disorders

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INTRODUCTION

- Sleep disturbances, as a **transdiagnostic factor**, are linked to stress-related mental disorders [1]
- Wearable sleep devices are now available to **measure sleep in the home setting**
- Controversy persists about the application and validity of sleep wearables [2]

➢ We **aimed** at investigating whether these devices provide **usable, high-quality data** and identifying which **sleep biomarkers** can be reliably extracted from them.

METHOD

Participants:

- **N = 83** (controls: n = 36; patients*: n = 47), **total nights = 371**
  - ➢ 1–18 nights / participant ($mean_{nights}$ = 4.45)

EEG-headband:

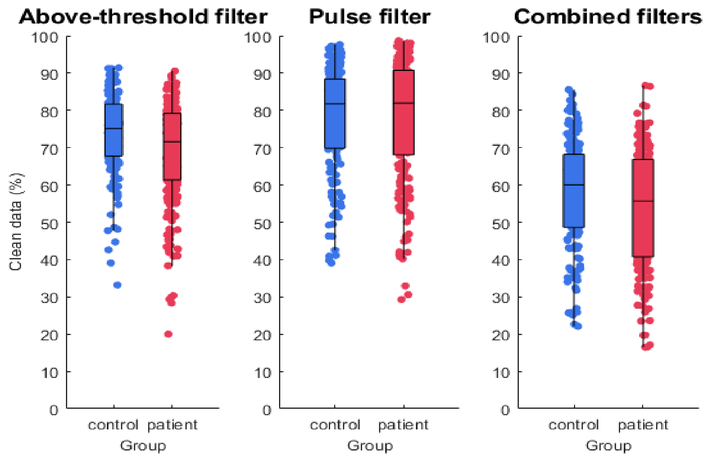
Dreem2 : 6 dry electrodes (Fp1,Fp2,F7,F8,O1,O2) + PPG

- ➢ 4 channels (F7-O1,F8-O2,F8-F7,Fp1-F8)

* non-medicated, with stress-related mental disorders

Sleep analysis:

- **Macrostructure**: Automatic sleep scoring by Dreem[2]
- **Spectral power analysis:**
  - ➢ ***Artifact detection:*** In-house automatized script → combined use of 2 filters: Above – threshold filter, Pulse-filter



  - ➢ ***Spectral slope analysis*** (Bódizs et al.[3]):
    - *Slope & Intercept:* FFT → log transformation of absolute spectrum in 4s windows → interpolation → excluding spindle frequency → linear model fitting = slope + intercept
- **PPG analysis:**
  - ➢ ***Peak detection:*** In-house automatized script: filtering →smoothing → findpeaks→ RR →artifact correction based on EEG = mean HR and RMSSD

Statistical analysis: median of all nights / participant

- **Group comparison:** ANOVA, ANCOVA, rmANOVA, t-test, Mann-Whitney *U* test

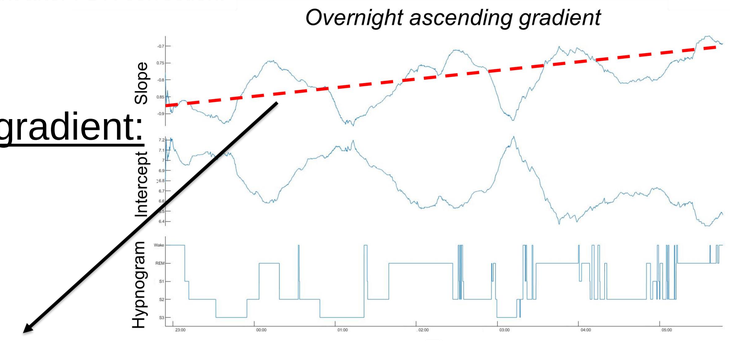
RESULTS

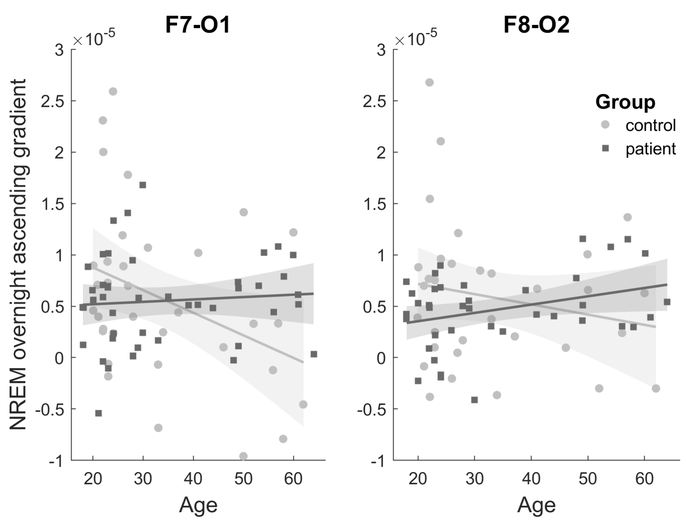
1) Sleep macrostructure:

	Patient (N = 47)		CTL (N = 36)		Independent samples t-test / Mann – Whitney U test	
	Mean	SD	Mean	SD	t_{81} or U value	p value
Sleep latency (min)	20.4	29.9	14.6	9.7	742.5	.413
Sleep efficiency (%)	88.9	7.1	90.8	5.5	1033	.318+
Awakenings (#)	22.8	8.3	20.1	6.6	-1.636	.318+
WASO (min)	29.3	28.1	24.1	19.3	738	.413
NREM stage 2 (min)	190.4	45.9	185.4	44.1	776.5	.526
NREM stage 2 (%)	47.2	7.7	47.2	7.8	877	.748
SWS (min)	90.7	25.9	87.1	22.9	-.671	.748
SWS (%)	23.1	6.9	22.7	5.5	-.331	.748
REM (min)	113.9	31.4	112.5	36.4	-.181	.734
REM (%)	28.5	6.3	29.3	8.7	885.5	.748
Stage transitions (#)	76.7	21.8	70.4	18.2	-1.405	.328
SWS stage transitions (#)	7.4	2.8	7.8	2.7	.663	.748

P values corresponding to one-sided *t*-tests and Mann–Whitney *U* tests are corrected for multiple comparisons (Benjamini–Hochberg correction). WASO = wake after sleep onset, SWS = slow-wave sleep; + significant before at $p < 0.05$, but not significant after FDR correction.

2) Overnight ascending gradient:





Time

ANCOVA

❖ No sign. Group effect:

F7-O1: $F_{1,74}$ = .02, p = .908

F8-O2: $F_{1,68}$ = .90, p = .346

❖ No sign. Age effect:

F7-O1: $F_{1,74}$ = 2.31, p = .133

F8-O2: $F_{1,68}$ = .03, p = .852

❖ **Sign. Group x Age interaction:**

F7-O1: $F_{1,74}$ = 6.71, p = .012

F8-O2: $F_{1,68}$ = 4.13, p = .046

3) Heart rate:

rmANOVA

❖ Sign. Phase effect: (pre-sleep, sleep, post-sleep)

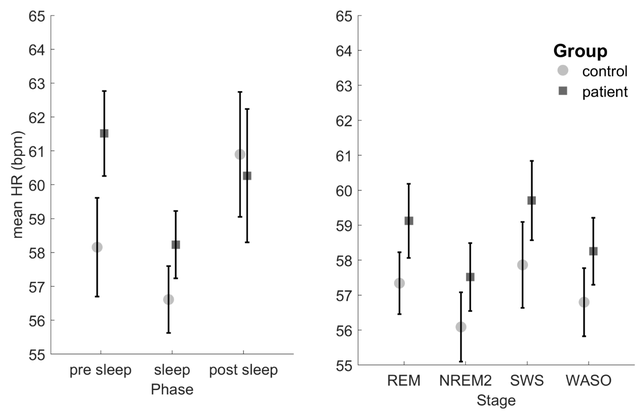
$F_{2,67}$ = 3.67, p = .03

❖ No sign. Group effect:

$F_{1,68}$ = 1.24, p = .27

❖ **Sign. Group x Phase interaction:**

$F_{2,67}$ = 3.12, p = .05



DISCUSSION AND CONCLUSION

- Headband: EEG-headband **well accepted** by patients + **sufficient data quality** for macro- and microstructural analysis of sleep
- Macrostructure: **No** large macrostructural between group **differences**
- Slope analysis: **Reduced age-related decline** in low vs. high freq. power ratio in patients
- PPG: **Higher pre-sleep HR** in patients, that reduced during sleep and dissipated at wakefulness

→ EEG-headband appears to be a meaningful tool for quantifying various sleep biomarkers

→ Future analysis should resolve whether the lack of age-associated dynamicity is due to floor effect in patients

REFERENCES

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CONTACT

Study can be found as a preprint :

Blaskovich, B., et al. "The utility of wearable headband electroencephalography and pulse photoplethysmography to assess cortical hyperarousal in individuals with stress-related mental disorders." *medRxiv* (2023): 2023-06.

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