Abstract No 1195
Poster ID P217

27th Congress of the European Sleep Research Society

Seville, Spain I 24 – 27 September 2024

Assessing the effects of total and partial sleep deprivation on glymphatic indices using the ENIGMA-Sleep cohorts

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INTRODUCTION

Background

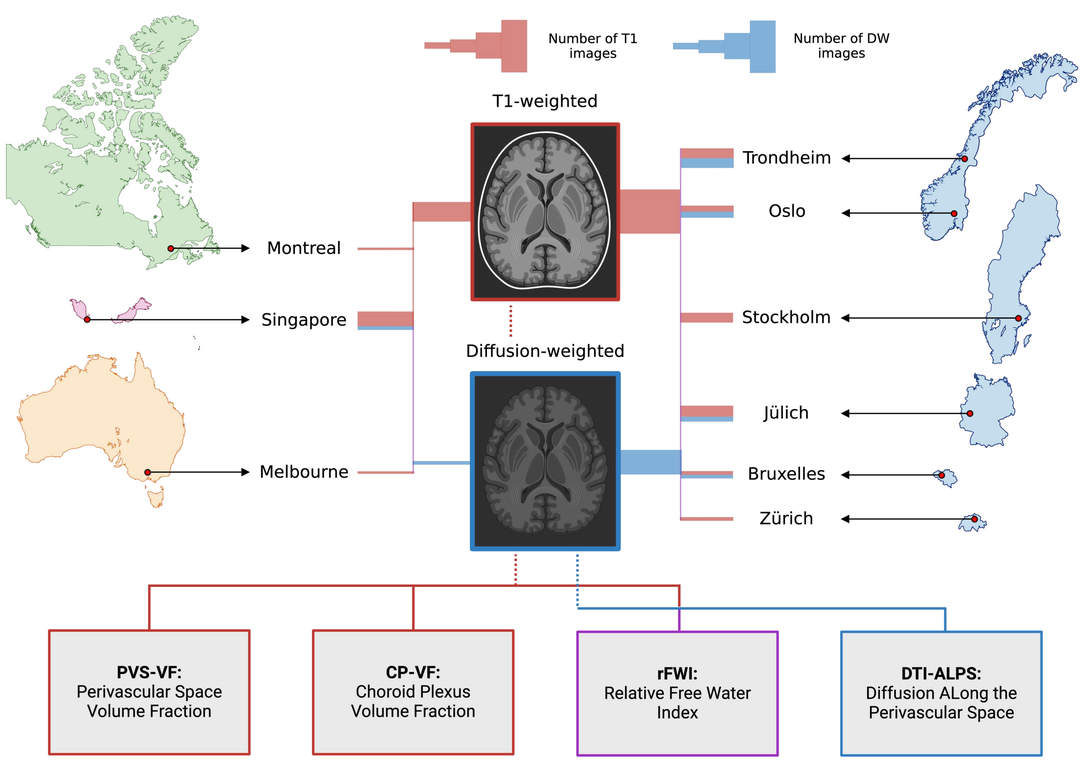
- Tracer studies in humans have shown that **sleep deprivation** has long-lasting adverse effects on **waste clearance** by the **glymphatic system [1].**
- This is reflected by major changes in multiple **glymphatic MRI indices [2].**
- Using a large, multi-site dataset (n = 678) provided by ENIGMA-SLEEP, we aim to assess the effect of **partial** (ca. 4 hr) and **total** (24 hr) **sleep deprivation** (SD) on 4 glymphatic MRI indices.

Hypotheses

- One night of SD significantly impairs **glymphatic function:** exhibited by increased **PVS-VF**, **CP-VF**, and **rFWI**; decreased **DTI-ALPS**.
- Abnormalities are more severe in **total SD** compared to **partial SD**.

DATA

Figure 1: Trajectory of the ENIGMA-Sleep Data



METHODS

Anatomical

- T1 scans were preprocessed using SMRIPrep **[3]**.
- Choroid plexus and intracranial volume was obtained during Freesurfer reconstruction.
- PVS volume was obtained using the pretrained SHIVA-PVS U-net by *Boutinaud et al.* **[4].**

Diffusion

- DTI scans were preprocessed using QSIPrep **[3]**.
- Free water indices were calculated using Dipy's FW elimination model and Freesurfer's WM mask
- DTI-ALPS was calculated in MNI space using the *Liu & Barisano et al.* pipeline **[5].**

Statistics

- A **mixed linear model** was used to assess the changes in glymphatic indices between normal sleep and the SD condition.
- Indices were **harmonized** using neuroCombat **[6]** and **corrected** for age, sex, BMI, and chronotype.

RESULTS

Main Findings

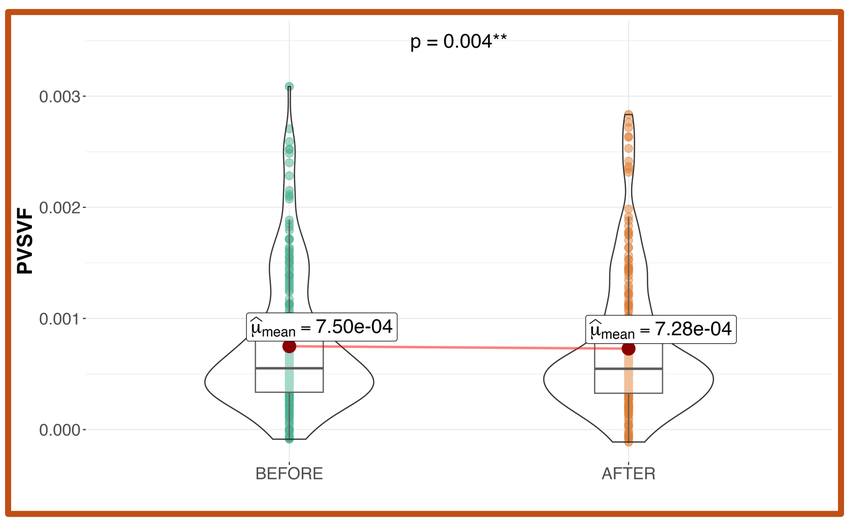
- Sleep deprivation was associated with a **significantly reduced PVS volume (**p = 0.004) and **FW index (**p = 0.047).
- There was no significant change in the **CP volume** or the **DTI-ALPS index** following sleep deprivation.
- **Total sleep deprivation** was associated with a more pronounced **PVS volume reduction** when compared to **partial sleep deprivation** (p = 0.001).

Additional Findings

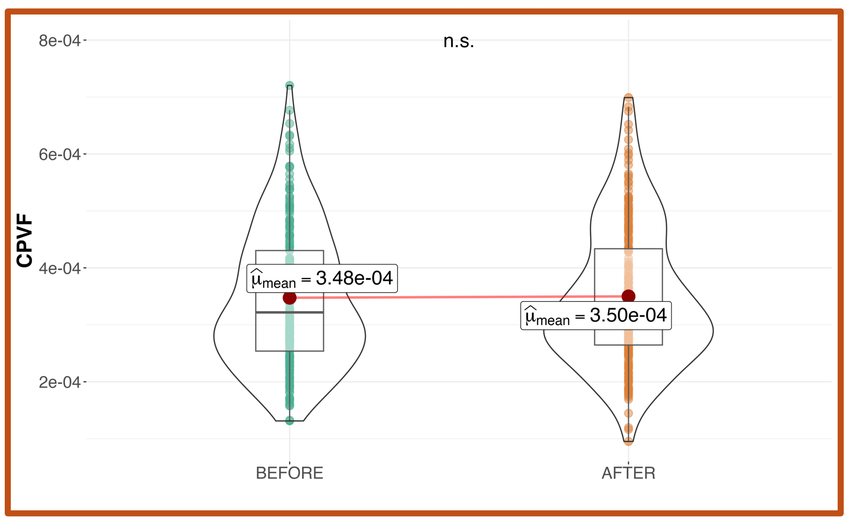
- **Age** was associated with increased PVS volume (p < 0.000), increased CP volume (p < 0.000), and a decreased DTI-ALPS index (p = 0.022).
- **Male sex** was associated with a higher FW index (p < 0.000)
- **Chronotype 1** ("Morning Person") was associated with increased PVS volume (p = 0.002)
- **Chronotype 2** ("Evening Person") was associated with a reduced FW index (p = 0.028)

Figure 2: Glymphatic Indices Before and After Sleep Deprivation

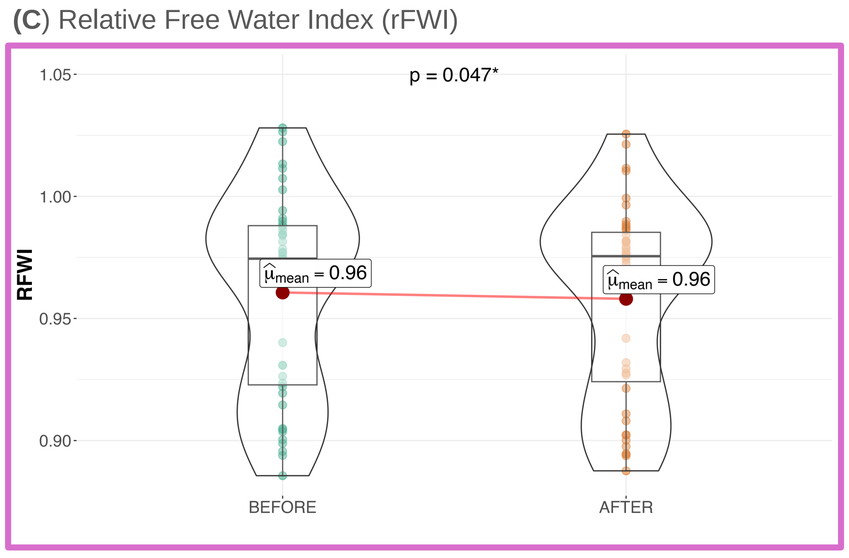
(**A**) Perivascular Space Volume Fraction (PVS-VF)



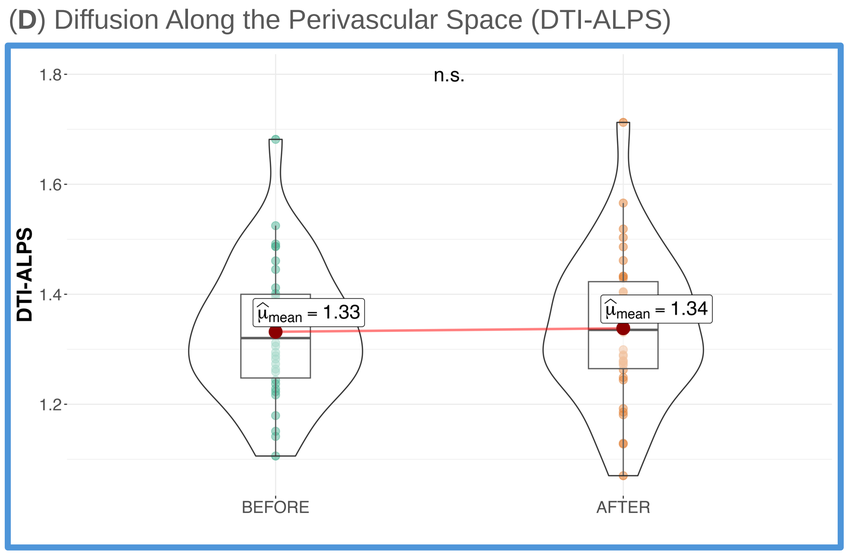
(**B**) Choroid Plexus Volume Fraction (CP-VF)



(**C**) Relative Free Water Index (rFWI)



(**D**) Diffusion Along the Perivascular Space (DTI-ALPS)



CONCLUSIONS

- The absence of concurrent abnormalities across 4 glymphatic indices suggests that **glymphatic function is not significantly altered.**
- The observed reduction in PVS volume may be due to **attenuated CSF influx** associated with prolonged wakefulness **[7]**.
- A reduction in the FW index is likely related to **microstructural changes** in the **WM** following sleep deprivation **[8]**.

REFERENCES

1. Eide, Per Kristian, et al. *Brain* 144.3 (2021): 863-874.
2. Kamagata, Koji, et al. *Journal of Magnetic Resonance Imaging* 59.5 (2024): 1476-1493.
3. Botvinik, In. "NeuroImaging PREProcessing toolS (NiPreps)."
4. Boutinaud, Philippe, et al. *Frontiers in neuroinformatics* 15 (2021): 641600.
5. Liu, Xiaodan, et al. *Alzheimer's & Dementia* 19 (2023): e073378.Botvinik, In. "NeuroImaging PREProcessing toolS (NiPreps)."
6. Richter, Sophie, et al. Neuroimage: Reports 2.4 (2022): 100136
7. Shih, Nien-Chu, et al. *Sleep Medicine* 111 (2023): 170-179.
8. Elvsåshagen, Torbjørn, et al. *PloS one* 10.5 (2015): e0127351

Figure 1 was made with Biorender (https://biorender.com)

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