

Sleep Duration And Sleep Efficiency Show Distinct Associations With Brain Structure And Visceral Adiposity In A Large Preventive Health Cohort

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Introduction

- Sleep duration and sleep efficiency have both been linked to neurodegeneration and metabolic dysfunction.
- However, their independent contributions to neuronal and metabolic health biomarkers remain poorly characterized in large cohorts.
- We examined their independent associations with structural brain MRI measures and visceral adipose tissue in a large preventive health cohort.

Objective

Compare the independent associations of sleep duration and sleep efficiency with structural brain MRI measures and visceral adipose tissue (VAT).

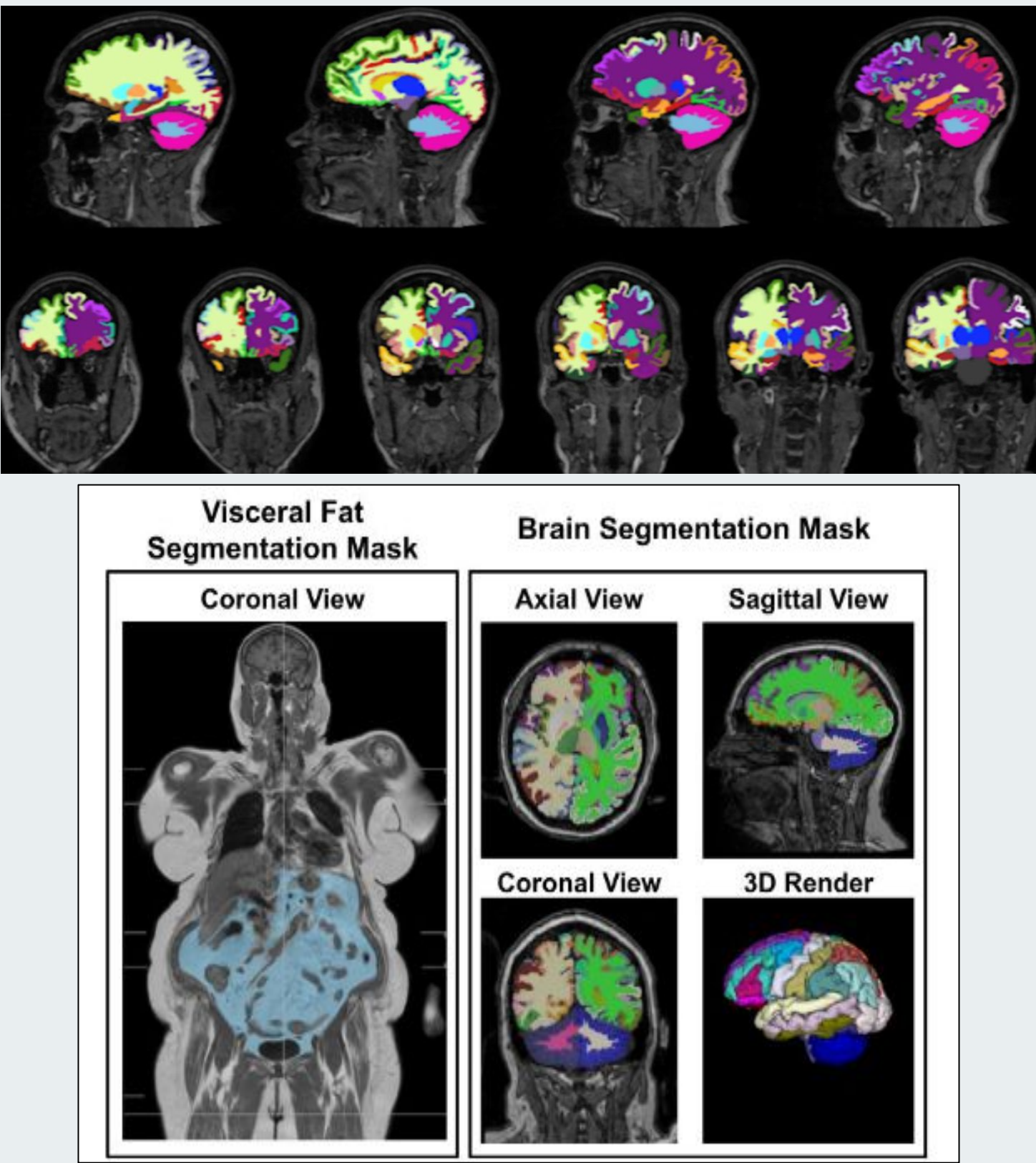
Materials and methods

- Cross-sectional study of 14,031 adults undergoing Prenuvo whole-body MRI.
- Sleep duration and sleep efficiency were derived from the Pittsburgh Sleep Quality Index (PSQI).
- Regional brain volumes were assessed using 3D T1-weighted MRI using Fast Surfer; VAT was segmented from abdominal T1-weighted MRI.
- Outcomes included total and regional gray matter volumes, hippocampal and amygdala volumes, an Alzheimer’s disease signature volume, and VAT.
- Standardized linear regression models adjusted for age, sex, BMI, scanner location, and intracranial volume for brain outcomes. Nested models evaluated the independent effects of both sleep measures.
- Associations were compared using standardized β coefficients, partial R^2 , and FDR-adjusted p-values.

Cohort Characteristics

- Participants reported a mean age of 50.1 $\pm$ 12.6 years (58.4% men), BMI of 28.7 $\pm$ 5.5 kg/m², sleep duration of 6.8 $\pm$ 0.97 hours, and sleep efficiency of 84 $\pm$ 9.0%.

Figure 1: Representative image of visceral fat and brain segmentation on T1 weighted WB-MRI



Results

Graph 1: Forest plot showing association of sleep duration and sleep efficiency with imaging outcomes

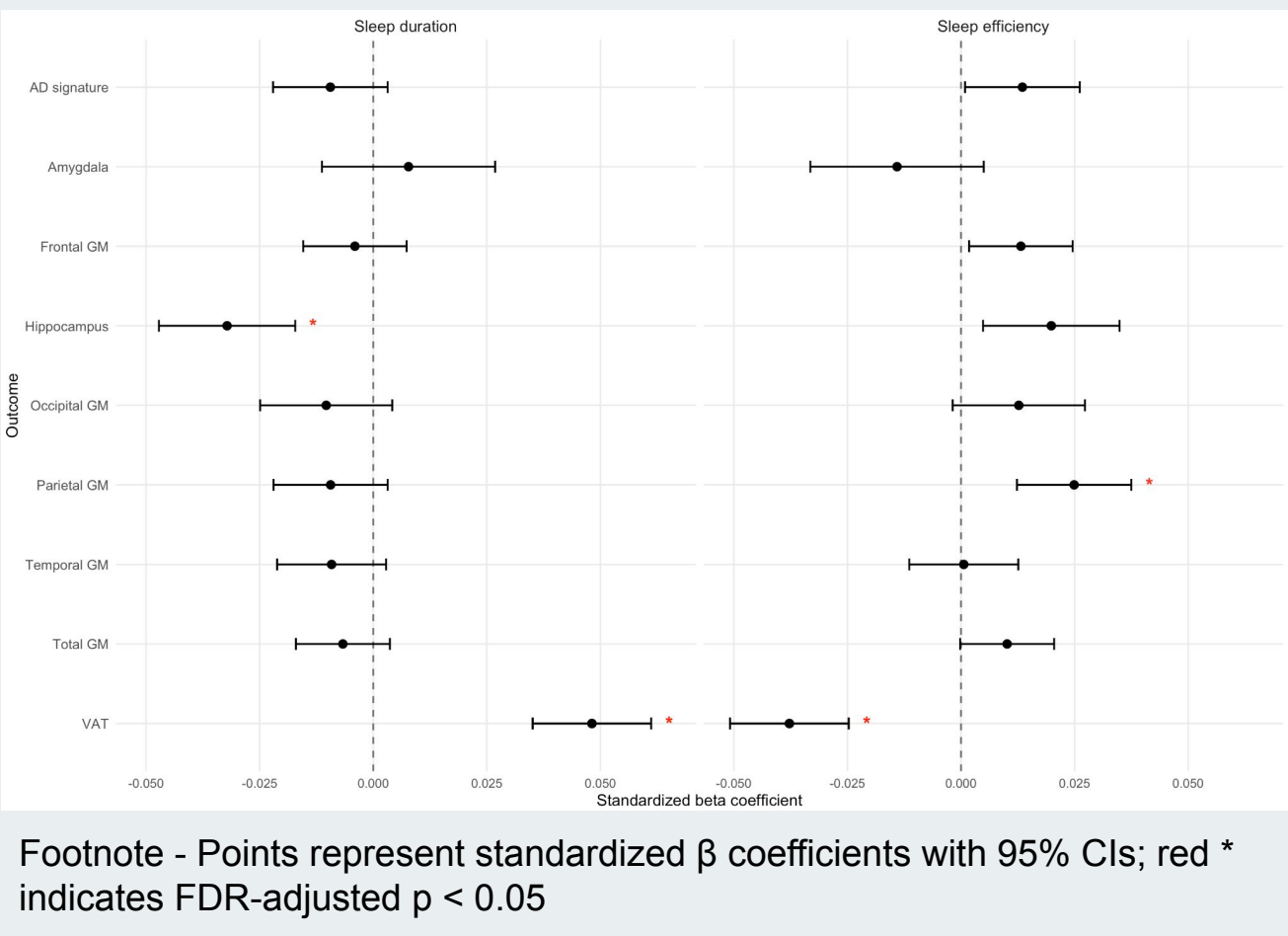
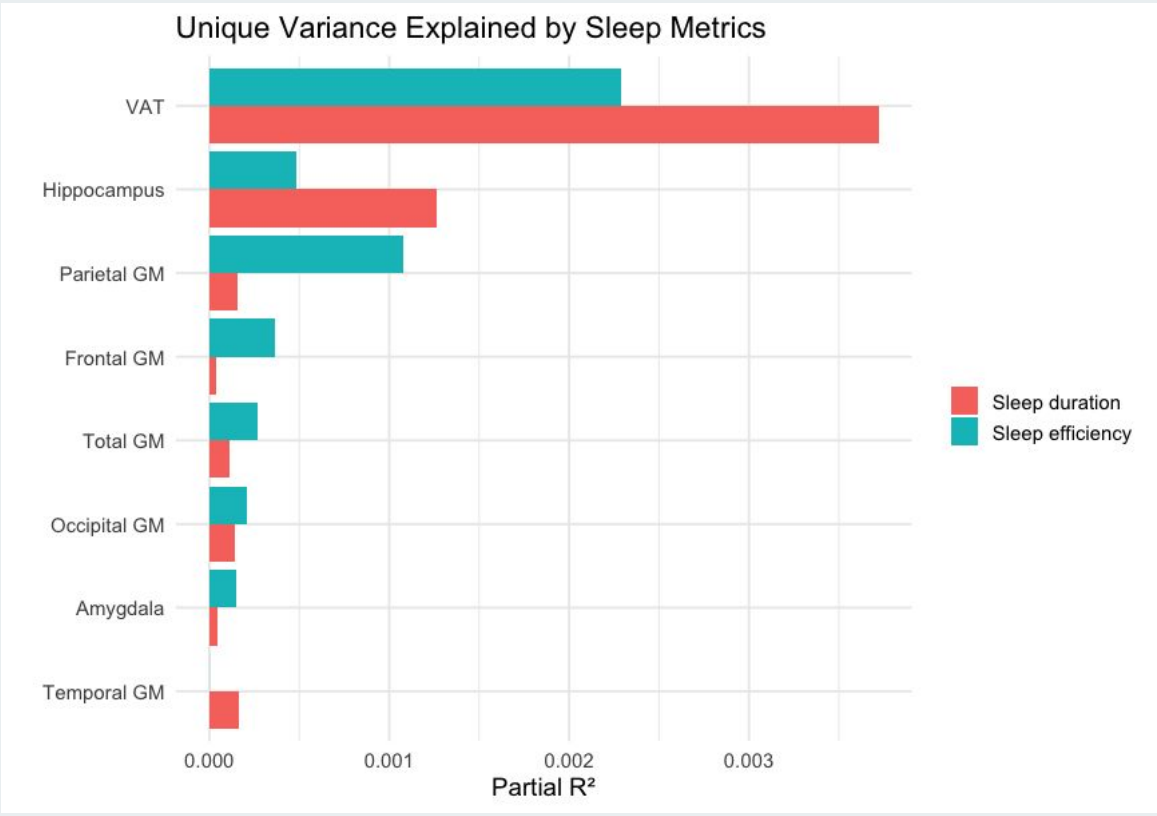


Table 1: Regression results

Outcome	Sleep measure	Std β	FDR p
Parietal gray matter	Efficiency	+0.025	<0.001
Hippocampal volume	Duration	-0.032	<0.001
Visceral adipose tissue	Duration	+0.048	<0.001
Visceral adipose tissue	Efficiency	-0.038	<0.001

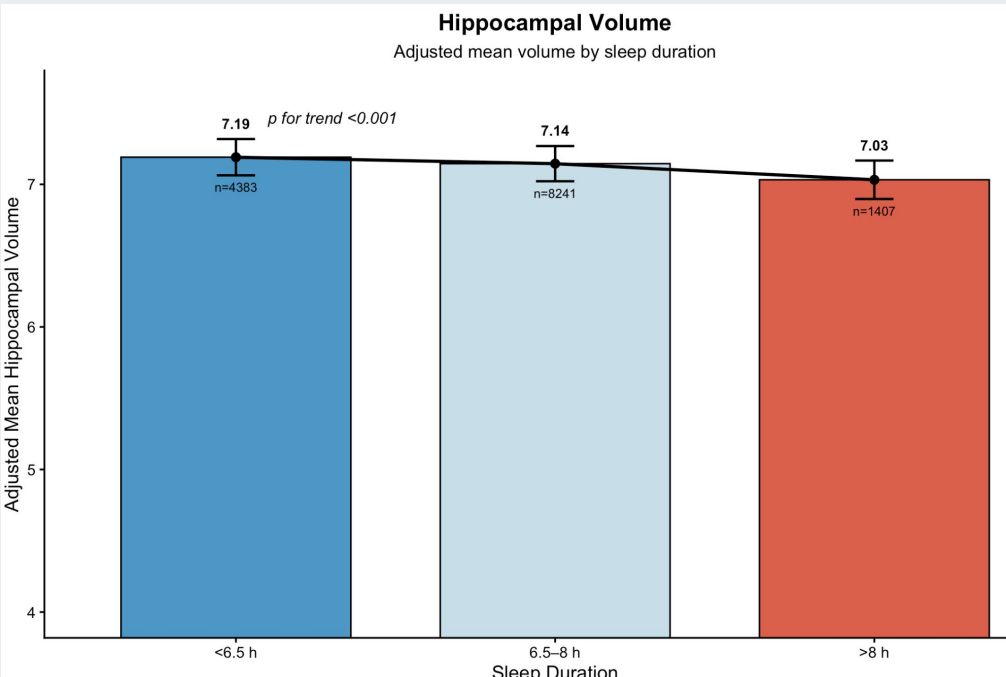
Clinical interpretation: A 10-percentage-point lower sleep efficiency was associated with ~96 mL greater VFAT and 0.03 mL lower hippocampal volume, while each additional hour of sleep was associated with ~113 mL greater VFAT and 0.05 mL lower hippocampal volume. All four displayed associations met the FDR-adjusted significance threshold.

Graph 2: Partial correlation coefficients of sleep variables with brain and visceral fat volume



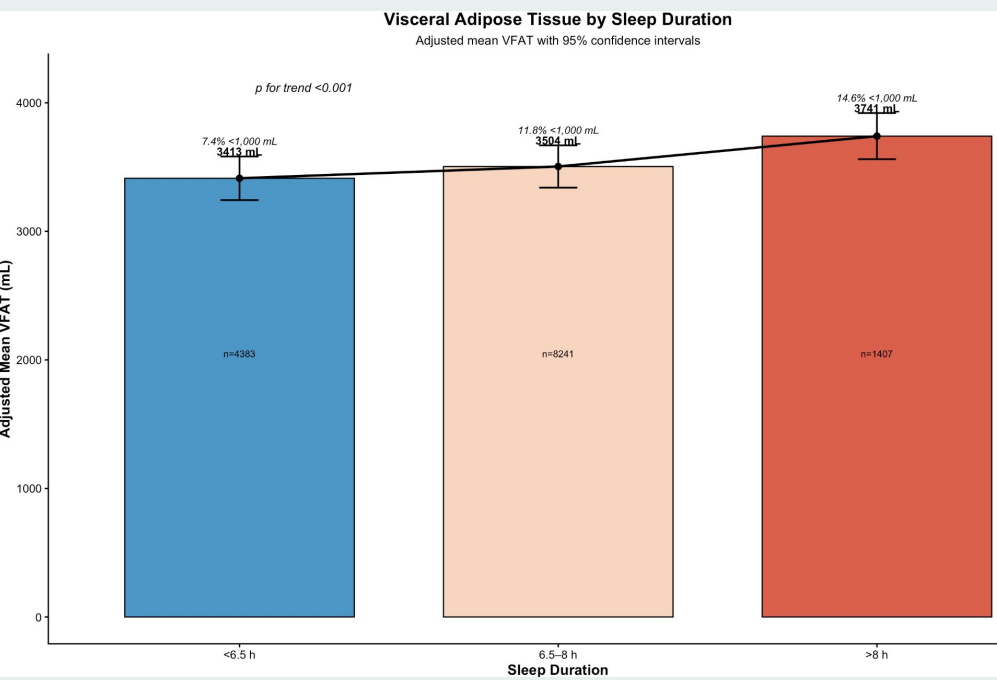
Sleep duration explained more unique variance in VAT and hippocampal volume, whereas sleep efficiency contributed more to cortical gray matter volumes, particularly parietal gray matter; however, the absolute contributions of both sleep measures were small (partial R^2 < 0.004)

Graph 3: Hippocampal volume by sleep duration



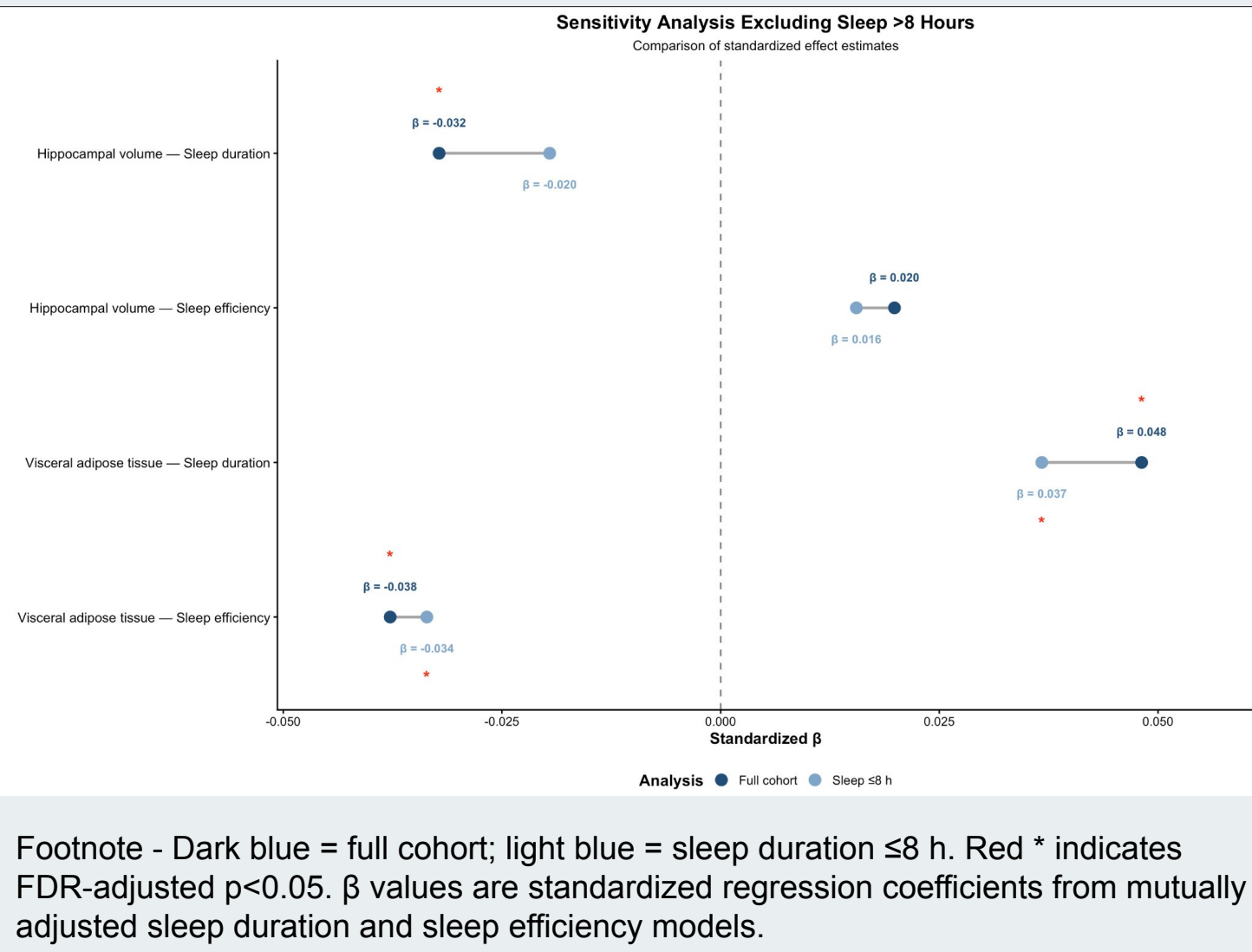
Adjusted mean hippocampal volume (95% CI) across participants reporting <6.5, 6.5–8, and >8 hours of sleep. Hippocampal volume decreased across increasing sleep-duration categories (p for trend <0.001).

Graph 4: VFAT volume by sleep duration



Adjusted mean visceral adipose tissue (VFAT; 95% CI) increased across <6.5, 6.5–8, and >8 hours of reported sleep (p for trend <0.001), with the highest adjusted VFAT observed among participants sleeping >8 hours.

Graph 5: Sensitivity analysis excluding participants reporting >8 hours of sleep



Excluding >8-hour sleepers weakened the association between sleep duration and hippocampal volume (β –0.032 to –0.020; no longer FDR-significant), while VFAT associations remained robust, suggesting that the hippocampal finding was more sensitive to long sleep duration than the metabolic findings.

Strengths and limitations

- Large preventive health cohort with brain and body imaging
- Nested models estimated independent associations for both sleep measures
- Cross-sectional design cannot establish direction or causality
- Self-reported sleep may differ from objective sleep measures

Conclusion

- Sleep efficiency showed the strongest association with parietal cortical structure.
- Longer sleep duration was associated with smaller hippocampal volume, although this relationship was attenuated after excluding >8-hour sleepers.
- Sleep duration and efficiency showed independent, opposing associations with visceral adiposity that remained robust after excluding >8-hour sleepers.

Future Directions

- Evaluate longitudinal changes in sleep, brain structure, and visceral adiposity using repeat MRI.
- Examine whether associations differ by age, sex, BMI, sleep disorders, or cardiometabolic health.
- Determine whether these imaging differences predict subsequent cognitive decline or metabolic disease.

References

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2. Henschel L, et al. FastSurfer: A fast and accurate deep learning based neuroimaging pipeline. NeuroImage. 2020;219:117012. doi:10.1016/j.neuroimage.2020.117012.

Conflict of Interest Statement

Madhurima Datta, Saurabh Garg, Nasrin Akbari, Ahmed Gouda and Alex Exuzides are paid employees of Prenuvo Inc.