The role of sleep quality and grey matter volumes in the prediction of depressive symptoms severity using three large-scale datasets

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Motivation

Sleep disturbance and depressive symptoms are highly prevalent in the general population. Although several studies reported their association, the predictive role of sleep on depressive symptoms and underlying mechanism of their interplay is poorly understood. Hence, we aimed to assess the relationship between sleep quality and depressive symptoms severity (DSS) and neurobiological mechanisms of this relationship, considering gray matter volume (GMV) and anxiety problems (as a shared factor for both sleep quality and DSS). Further, we tested predictability of DSS based on sleep quality, GMV, and anxiety at individual level using three large-scale datasets.

Methods

We included 1101 participants of HCP-Young adult dataset. DSS and sleep quality were assessed using depressive problems section of the Achenbach adult self-report and Pittsburgh sleep quality index (PSQI). Effects of age, gender, and total-GMV were controlled in all analyses.

Materials:

- Sleep quality scores based on PSQI
- DSS based on Achenbach
- Volume of 473 gray matter parcels
- Anxiety problems based on Achenbach

Methods:

- Linear partial correlation between sleep quality, DSS, GMV, and anxiety.
- Mediation analysis using structural equation modeling to clarify whether correlated parcels and anxiety in parallel can mediate the relationship between sleep quality and DSS.
- Prediction of DSS using ensemble decision tree (bagging and LS_Boost) ML models at individual level based on four features categories.
- Out-of-sample validation of ML models in HPC-Ageing and eNKI databases.

Table1. Demographic characteristics

Sample	Subjects	Age	Gender	Questionnaires
HCP	1101	22 – 35 Mean = 28.8 SD = 3.7	598 female (54.3%)	PSQI and Achenbach
eNKI	334	15 – 59 Mean = 37.0 SD = 13.8	210 female (62.9%)	PSQI and Achenbach
HCP-Aging	378	36 – 59 Mean = 47.3 SD = 7.0	219 female (57.9%)	PSQI and Achenbach

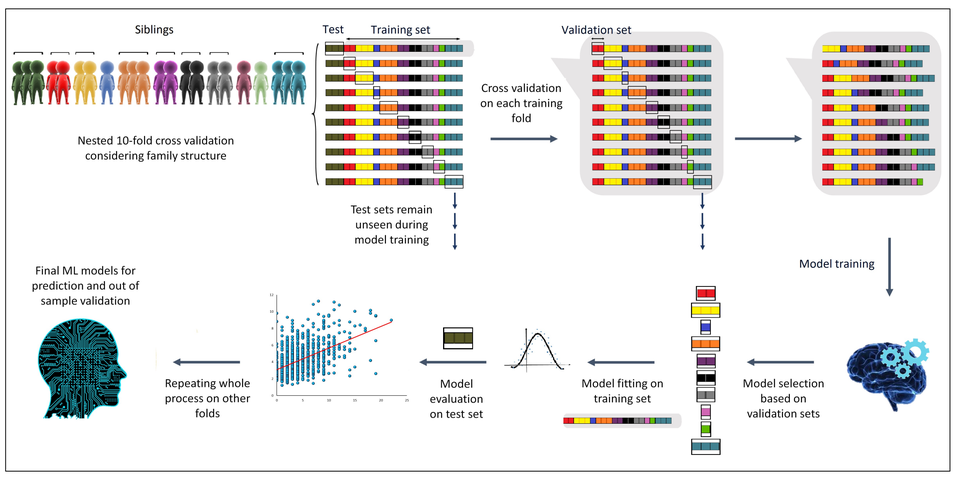

Figure 1. Training process of ML model in HCP-Young adult dataset.

Results

There was strong association between sleep quality and DSS i.e., lower GMVs of the somatosensory area, primary motor cortex, extra-striate cortex, temporal lobe, parahippocampus, and cerebellum are correlated with more DSS and worse sleep quality. Anxiety and GMVs partially mediated (51%) of the relationship between sleep quality and DSS. Sleep and anxiety predicted DSS in HCP dataset and we found similar prediction results in two other databases.

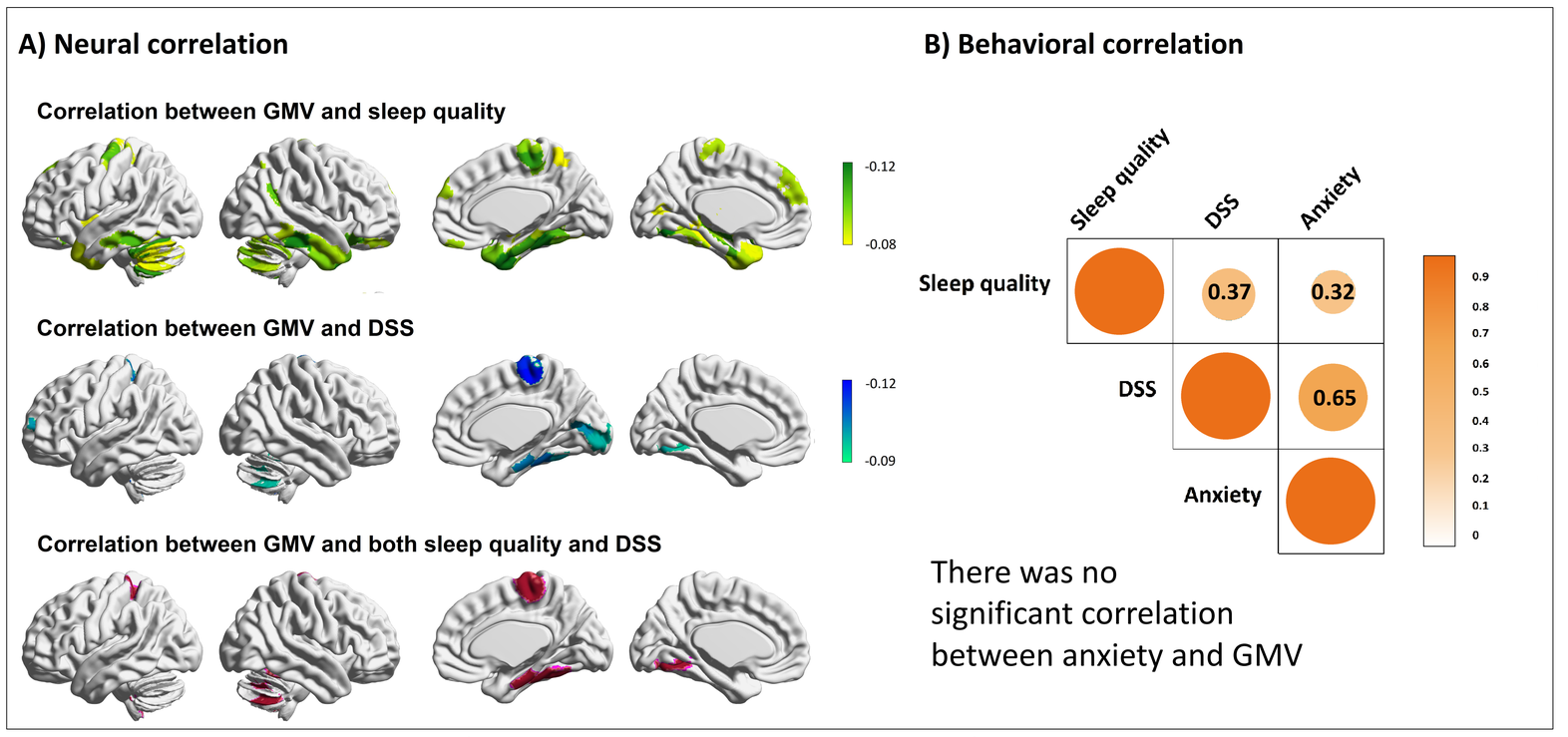

Figure 2. Relationships in HCP-Young adult dataset. A) Patterns of correlation between sleep quality, DSS, GMV ($p < 0.05$ FDR corrected); B) linear correlation between behavioral data.

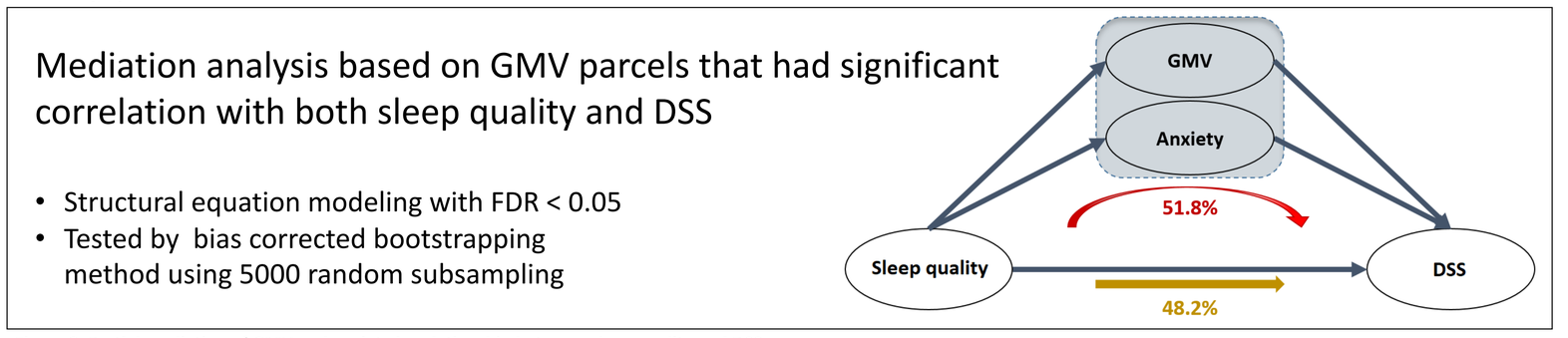

Figure 3. Partial mediation of GMV and anxiety in relationship between sleep quality and DSS.

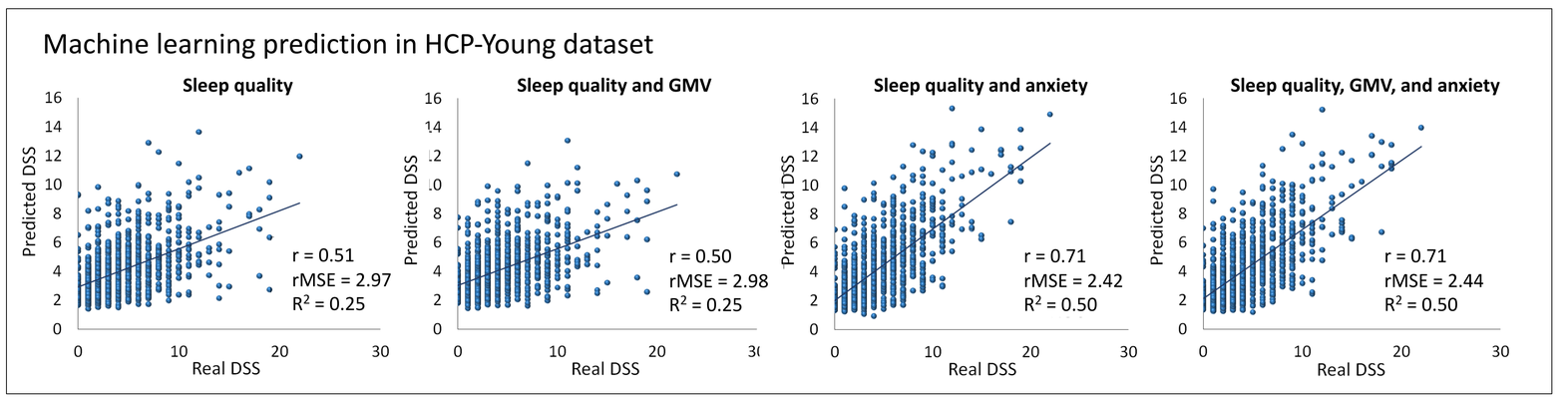

Figure 4. Results of ML in DSS prediction based on five feature categories in HCP-Young adult dataset .

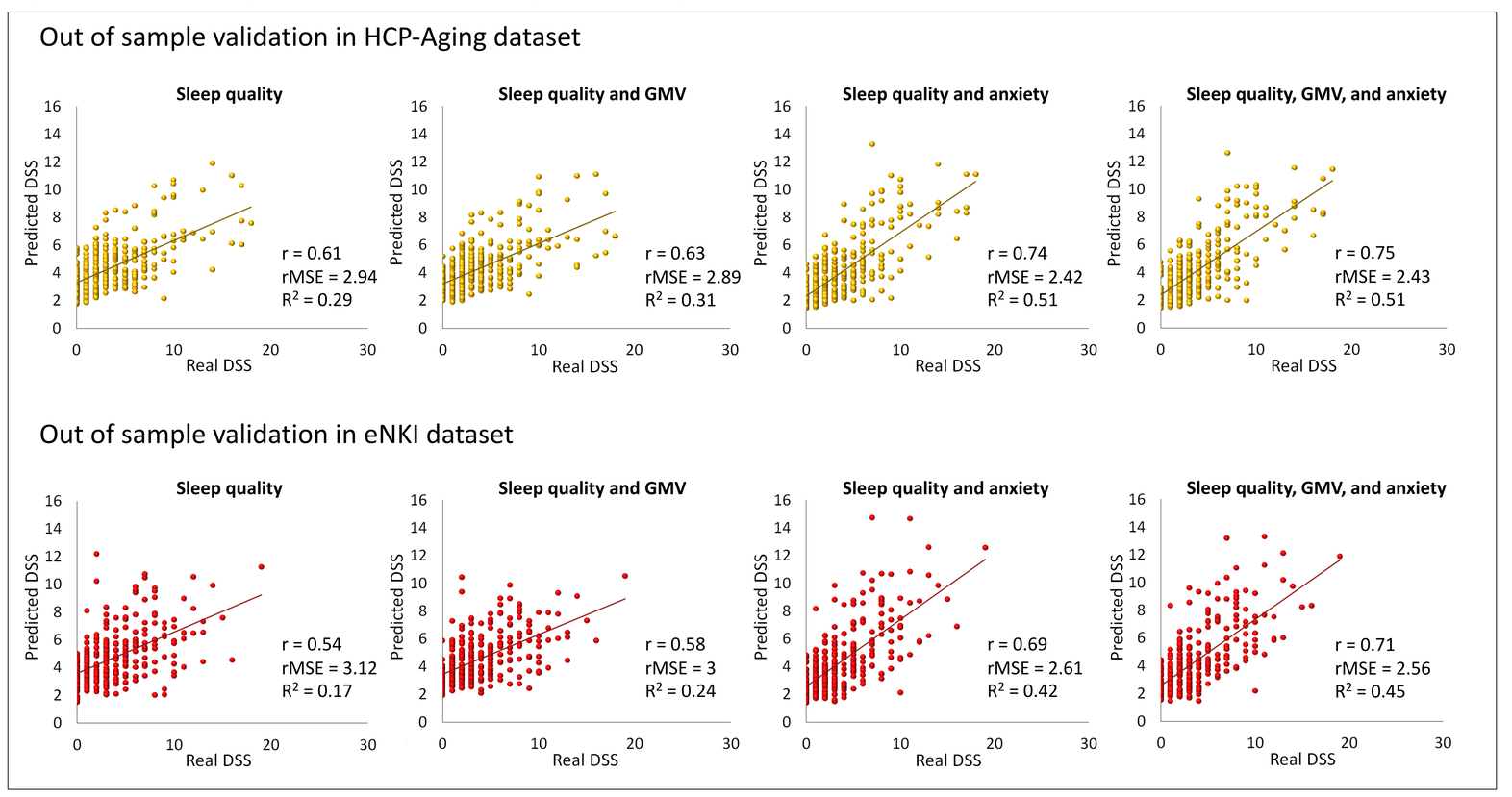

Figure 5. Out of sample validation of pre-trained models in eNKI and HCP_Aging datasets.

Conclusion

We found that sleep quality can predict DSS using ML models in three large-scale databases and anxiety can strengthen this prediction. Further, GMV and anxiety mediates the link between sleep quality and DSS in the general population.

INM & IBI Retreat 2022, *Email: m.tahmasian@fz-juelich.de