Association of sleep quality and diffusion MRI derived interstitial fluid content – insights in cerebral waste clearance

Merel M. van der Thiel[1,2], Walter H. Backes[1,2,3], Gerhard S. Drenthen[1,2], Paulien H.M. Voorter[1,2], Thorsten Feiweier[4], Inez H.G.B Ramakers[2,5], Jacobus F.A. Jansen[1,2,6]

[1]*Department of Radiology & Nuclear Medicine, Maastricht University Medical Center, Maastricht, the Netherlands*

[2]*School for Mental Health & Neuroscience, Maastricht University, Maastricht, the Netherlands*

[3] *School for Cardiovascular Disease, Maastricht University, Maastricht, the Netherlands*

[4] *Siemens Healthcare, Erlangen, Germany*

[5] *Department of Psychiatry & Neuropsychology, Maastricht University, Maastricht, the Netherlands*

[6] *Department of Electrical Engineering, Eindhoven University of Technology, Eindhoven, the Netherlands*

Background

IntraVoxel Incoherent Motion (IVIM) MRI can detect the diffusion of cerebral interstitial fluid (ISF) (D_{int}) and its volume fraction (f_{int}). The ISF plays a crucial part in the cerebral clearance system, as it washes waste products through the parenchyma.

Cerebral clearance is most active during sleep. ISF expands during sleep, which facilitates the clearance of waste products from in-between the cells, while the ISF-volume reduces again in awake states. Previous MRI-studies have observed alterations in general diffusivity measures dependent on sleeping patterns. However, no previous studies have examined the effects of long-term subjective sleep deprivation on cerebral diffusivity using an ISF-specific diffusion measure.

The current exploratory study investigates whether alterations in a proxy of ISF-volume (f_{int}) are related to hours of sleep or self-reported sleep quality.

Method

Twenty neurotypical elderly subjects (mean age ± standard deviation: 65.1 ± 7.7 years, 35% male) underwent high-field MRI (7T research system, Siemens).

The intermediate diffusion components (D_{int}) in the range $1.5*10^{-3}$<Diffusivity<$4.0*10^{-3}$ mm^2/s were calculated using spectral analysis. The relative signal contribution of D_{int} was quantified by f_{int}. Median f_{int} values were extracted from the white matter (WM) and gray matter (GM).

In addition to the clinically used total PSQI (sum of all 7 components), two specific PSQI components were examined: Subjective sleep quality (PSQI1) and Sleep duration (PSQI3).

Pearson correlations were computed between the PSQI scores and f_{int} for WM and GM. To check for potential confounding influences, partial correlations were performed adjusting for age and time of MRI-acquisition.

Results

A significant negative association was found between PSQI1 and WM f_{int} (R=-.454, p=.045), where a worse reported sleep quality significantly relates to lower WM f_{int}. After adjusting for potential confounding influences, a trend towards significance remained (R=-.437, p=.061).

Conclusion

The current explorative study identified a lower diffusion MRI-derived proxy of ISF-volume in the WM of subjects who reported a subjective feeling of long-term sleep deprivation. A reduction in ISF-volume may leave less space for waste products to be cleared from in-between the cells. Thereby, our findings highlight the potential of the IVIM-derived ISF-fraction as a non-invasive method to measure ISF alterations related to sleep disturbances.

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