Measuring Structural Connectivity In Migraine: The Impact Of Correcting For Region Volumes

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INTRODUCTION

One way of assessing the structural wiring of the brain is using **diffusion weighted imaging (DWI)**. It allows estimating a **tractogram** which represents the fibre pathways in the brain. Using a brain atlas, one can define **regions of interest (ROI)** and calculate a **connectivity matrix to characterise the connections between these regions**.

However, there is **no consensus on whether this matrix should be normalized** by the regions' volumes to avoid possible bias towards increased connectivity in bigger regions[1,2]. As such, in this study we evaluated the impact of applying such a normalisation in the context of **migraine** when measuring **global and nodal graph theory metrics**.

GOAL: *Study the impact of correcting for region volumes when measuring structural connectivity*

METHODS

DWI Data Acquisition:
- 15 healthy controls in the midcycle phase
- 14 migraineurs without aura in the interictal phase
- 3T Siemens Vida Scanner, with 64-channel receiver head coil
- b = 400, 1000, 2000s/mm2 along 32, 32, 60 gradient directions, respectively
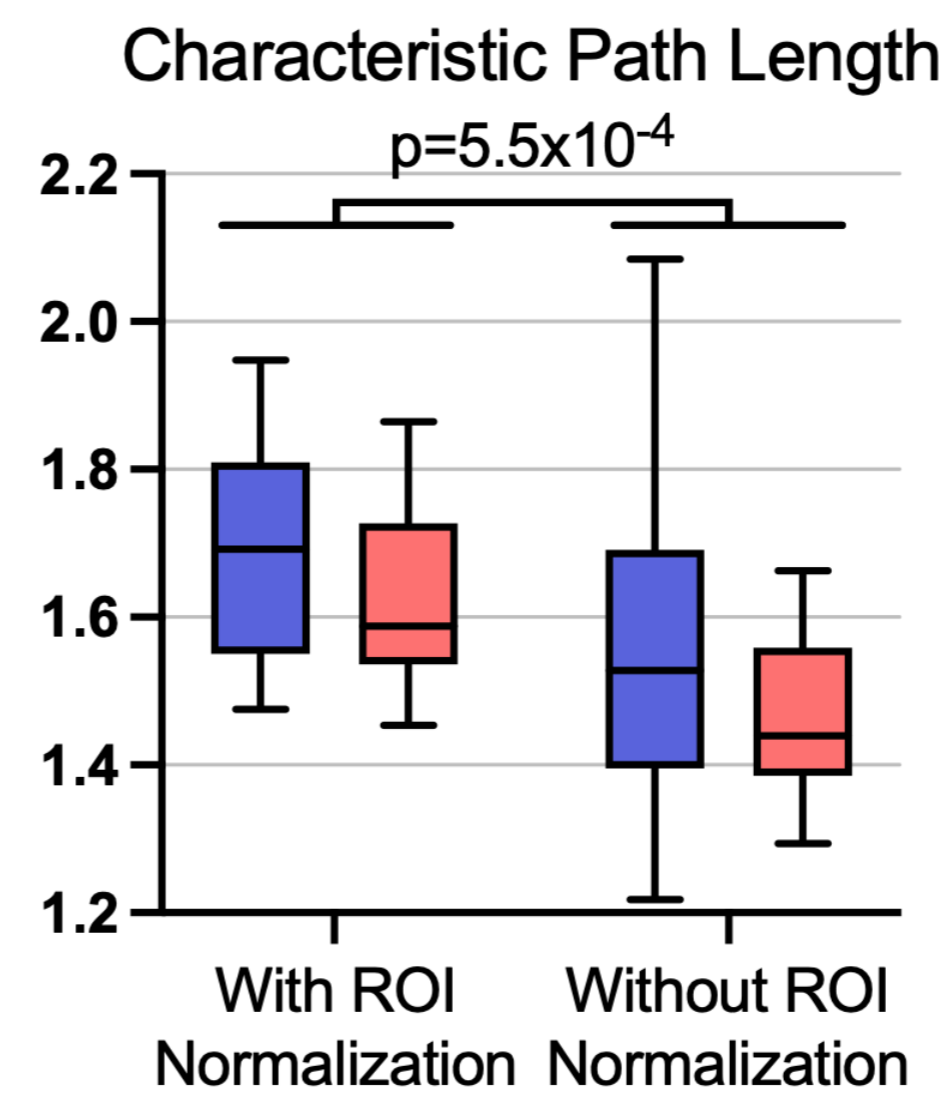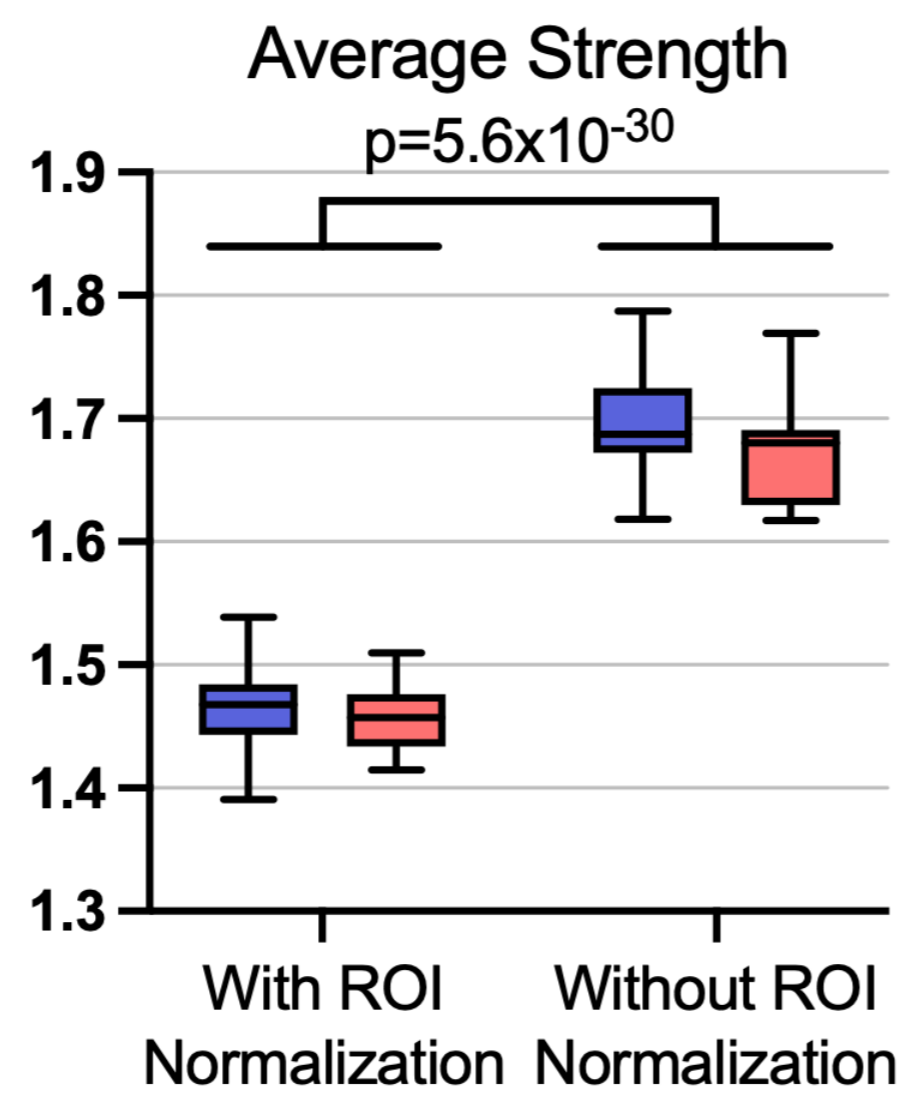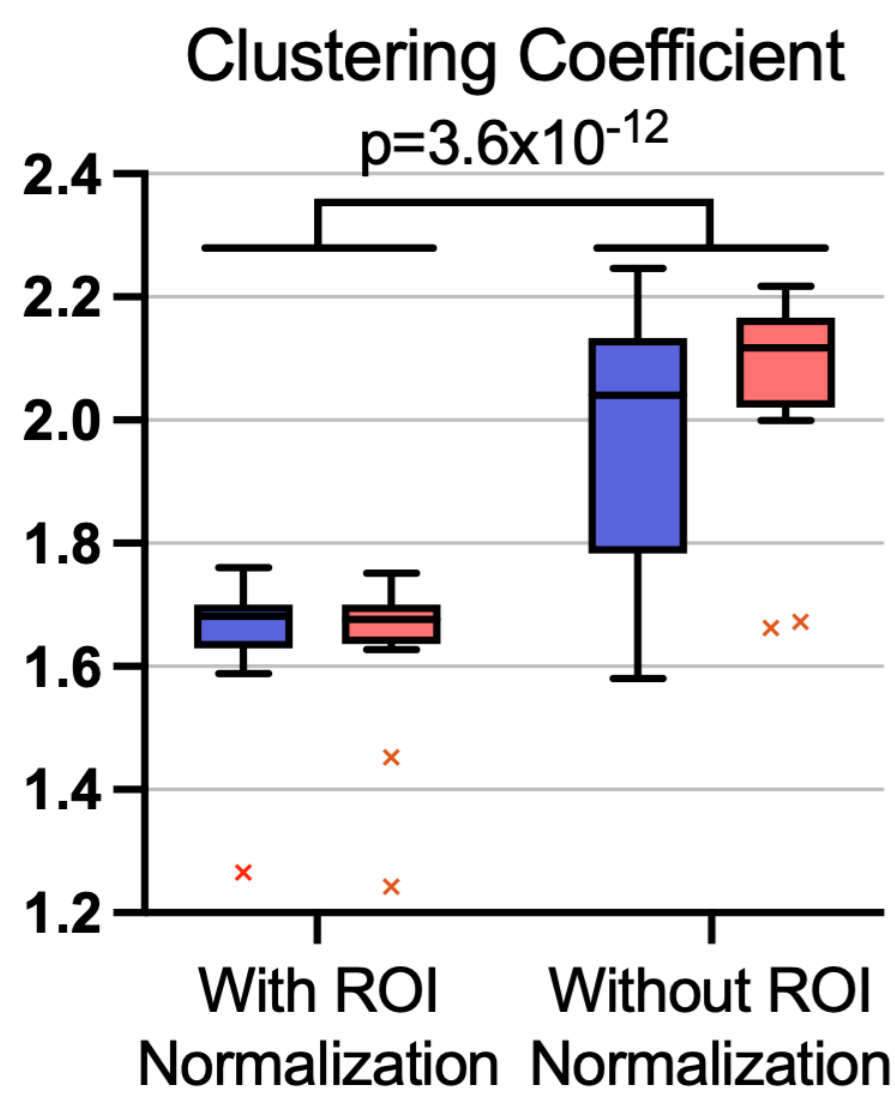- Preprocessing according to the DESIGNER pipeline[3]

Data Analysis (MRTrix[4] and MATLAB):
- Estimation of fibre density functions (using spherical deconvolution)
- Tractography (using anatomically contrained framework and SIFT)
- Determination of the connectome (with the AAL116 atlas)
- Normalization of the connectivity matrix
- Calculation of the graph theory metrics
- Statistical Analysis

Data Acquisition → Fibre Modelling (MSMT-CSD) → Fibre tracking (with ACT, SIFT) → Connectivity Matrix → Normalization → Graph Theory Metrics[5] → Statistical Analysis

RESULTS AND DISCUSSION

Global Metrics

Clustering Coefficient — p=3.6x10^{-12}

Average Strength — p=5.6x10^{-30}
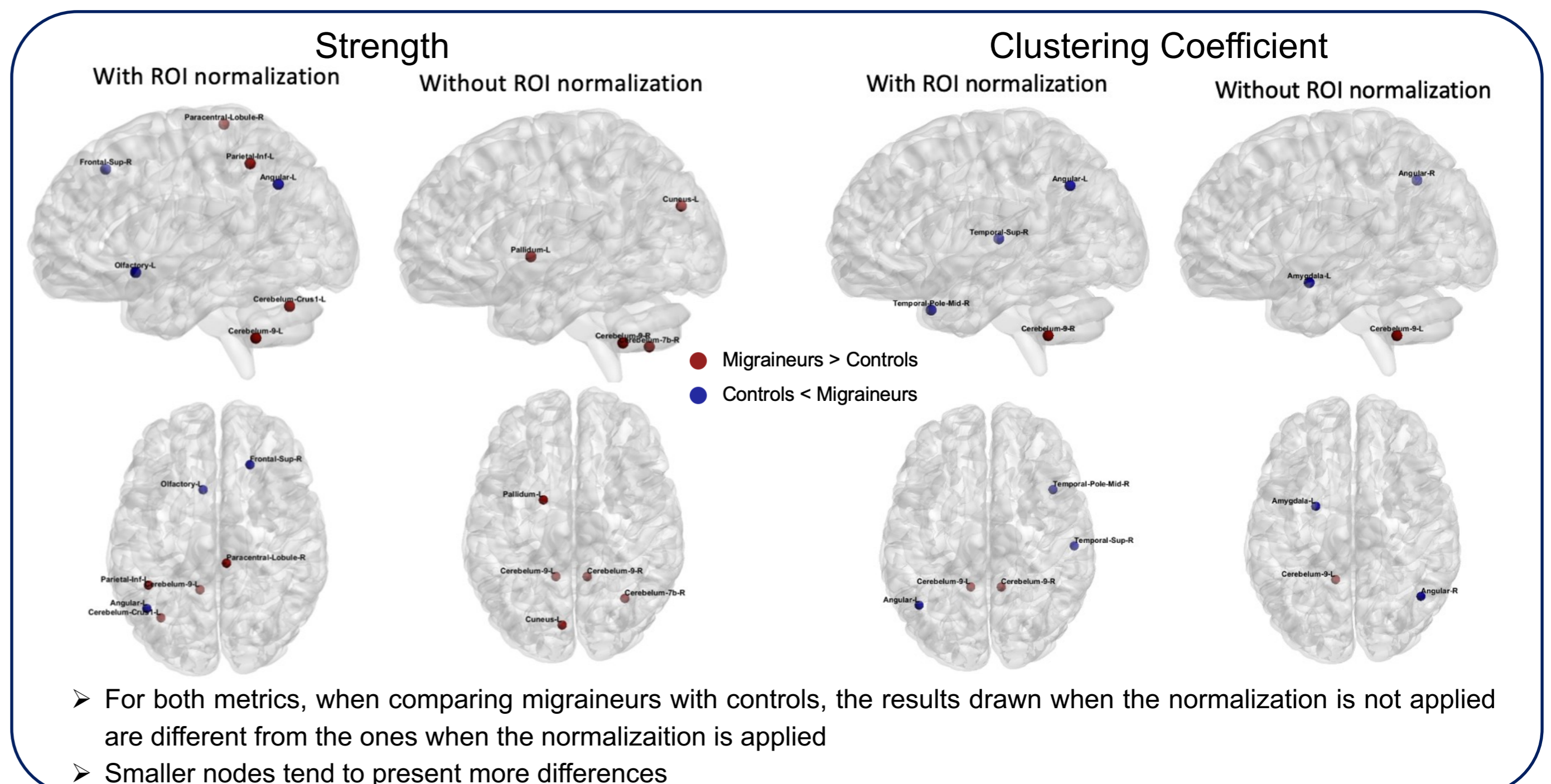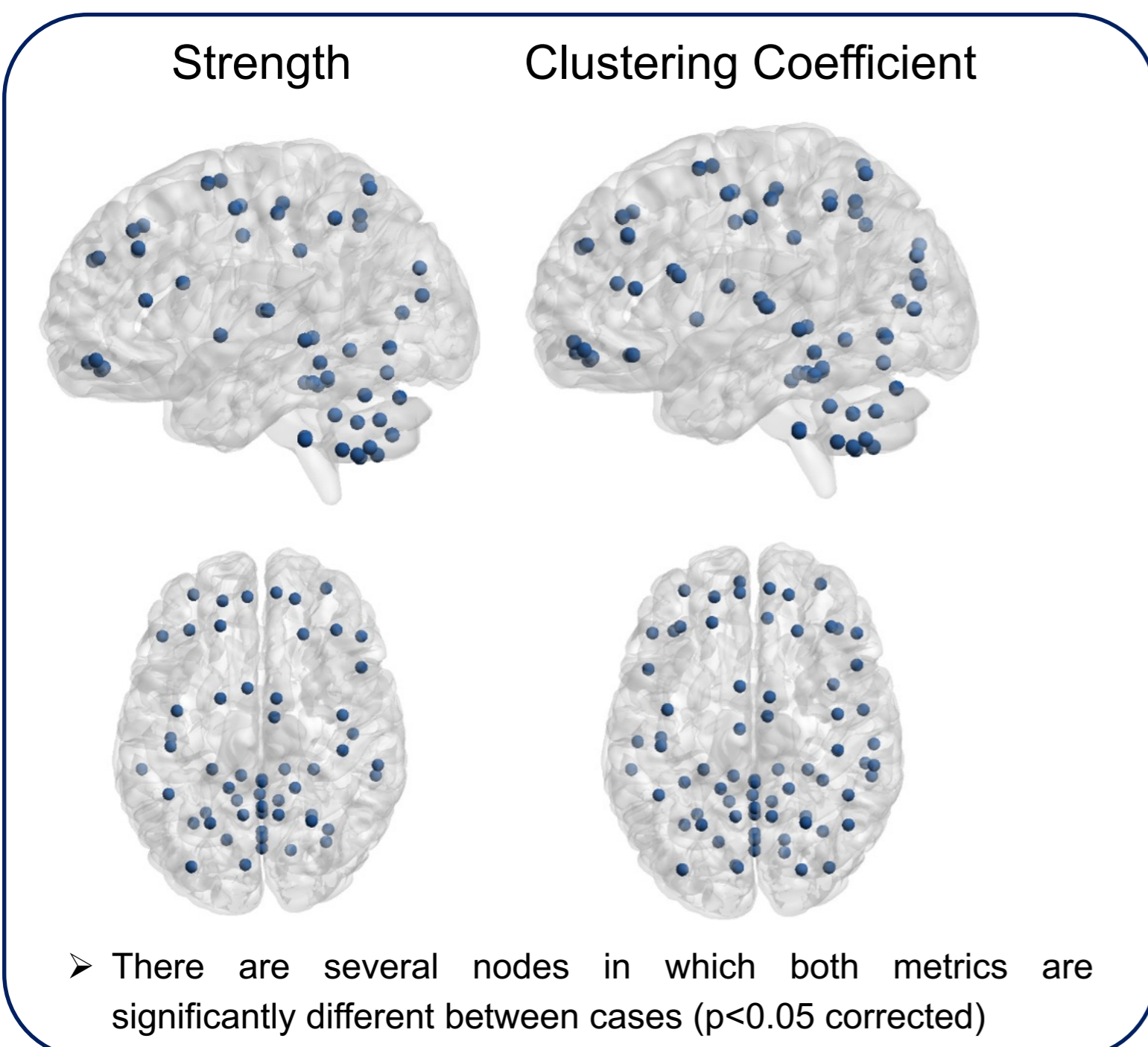
Characteristic Path Length — p=5.5x10^{-4}

Legend: Controls, Migraineurs

> Global metrics are significantly different between normalizations
> Similar trends are observed when comparing groups in each case

Nodal Metrics

Nodes significantly different between normalizations

Strength — Clustering Coefficient

> There are several nodes in which both metrics are significantly different between cases (p<0.05 corrected)

Nodes significantly different between groups

Strength — With ROI normalization / Without ROI normalization

Clustering Coefficient — With ROI normalization / Without ROI normalization

Migraineurs > Controls
Controls < Migraineurs

> For both metrics, when comparing migraineurs with controls, the results drawn when the normalization is not applied are different from the ones when the normalizaition is applied
> Smaller nodes tend to present more differences

CONCLUSION

- The normalisation greatly affects the values of the connectivity metrics
- When comparing groups, global metrics follow the same trends in both normalizations
- Nodal metrics seem to be greatly affected by the normalizations and therefore, one needs to be aware of its potential impact on the results drawn when comparing groups

References: 1. M Silvestro et al, Headache Pain, 2021, 22(1): 1-11; 2. A Planchuelo-Gómez et al, Cephalalgia, 2019, 40(4), 367-383; 3. B Ades-Aron, Neuroimage, 2018, 183,532-543; 4. JD Tournier et al, Neuroimage, 2019, 202,116137; 5. M Rubinov et al, Neuroimage, 2010, 52(3), 1059-1069