STRUCTURAL MRI CORRELATES OF HAND MOTOR PERFORMANCE IN PATIENTS WITH MULTIPLE SCLEROSIS

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INTRODUCTION

Multiple Sclerosis (MS) is characterized by alterations in brain structural integrity and worsening of motor performance. Several MRI studies have shown diffusion-weighted MRI abnormalities in the white matter (WM) and regional gray matter (GM) atrophy in these patients [1-4]. The correlation between regional WM and GM damage and motor performance has been only marginally evaluated [5].

OBJECTIVE

We applied structural MRI techniques in a large cohort of healthy controls (HC) and MS patients to evaluate the correlation between variations of regional brain GM volumes and WM architecture and measures of manual dexterity (9 Hole Peg Test and Finger Tapping) and EDSS.

METHODS

Subjects:134 right-handed HC [64 men and 70 women; mean age=37 years, SD=14 years] and 366 right-handed MS patients [140 men and 226 women; mean age=42 years, SD=16 years; mean EDSS=3, SD=2; mean disease duration (DD)=13, SD=8 years] were recruited from San Raffaele Hospital, Milan, Italy.

Clinical assessment:

- EDSS;
- 9 Hole Peg Test (9HPT);
- 30 seconds maximum finger tapping rate (FT).

MRI acquisition (3.0 T scanner):

- 3D T1-weighted: regional GM volume modifications;
- DTI: WM architecture assessment;
- Dual-echo: assessment of brain T2-hyperintense lesion load (Jim 6.0).

Mapping modifications of GM volumes:

- Voxel-Based Morphometry (VBM) (SMP12, DARTEL): Transformation of GM maps to MNI space, non-linear deformation of GM maps to match the final customized template, modulation to keep original volume unchanged, and smoothing (8 mm gaussian kernel) [6] after T1-hypointense lesion refilling.

Mapping modifications of WM architecture:

- Tract-based Spatial Statistic (TBSS) (FSL): fractional anisotropy (FA), mean (MD), axial (AD) and radial diffusivity (RD) input images; permutation testing with 5000 permutations, randomised program within FSL skeleton, before applying voxelwise cross-subject statistics [7].

Statistical analysis:

- Comparison of demographic and clinical data between study groups (SPSS);
- Correlations between clinical measures and MRI changes: linear regression analysis ($p<0.001$ uncorrected).

RESULTS

Clinical assessment: HC and MS patients did not differ for demographic data. MS patients had a worse motor performance in clinical tests.

Table 1 summarizes demographical and clinical data of the two study groups.

Variables	HC	MS	p
Age	37 (14)	42 (16)	0.07
Sex (F/M)	70/64	226/140	0.06
Disease duration	-	13 (8)	-
EDSS	-	3.0 (2.0)	-
R z9HPT	0 (1)	-1.5 (1.2)	<0.001
L z9HPT	0 (1)	-1.4 (1.2)	<0.001
R zFT	0 (1)	-1.2 (1.4)	<0.001
L zFT	0 (1)	-1.1 (1.2)	<0.001
T2 lesion load	-	9.5 (11)	-

Table 1.

Variables are expressed as mean and standard deviation (SD).
Z-scores were obtained using HC group as reference population.

VBM: widespread GM atrophy pattern in MS patients compared to HC, involving fronto-parieto-temporal lobes and deep GM nuclei ($p<0.001$, uncorrected); **Figure 1.**

Figure 1.

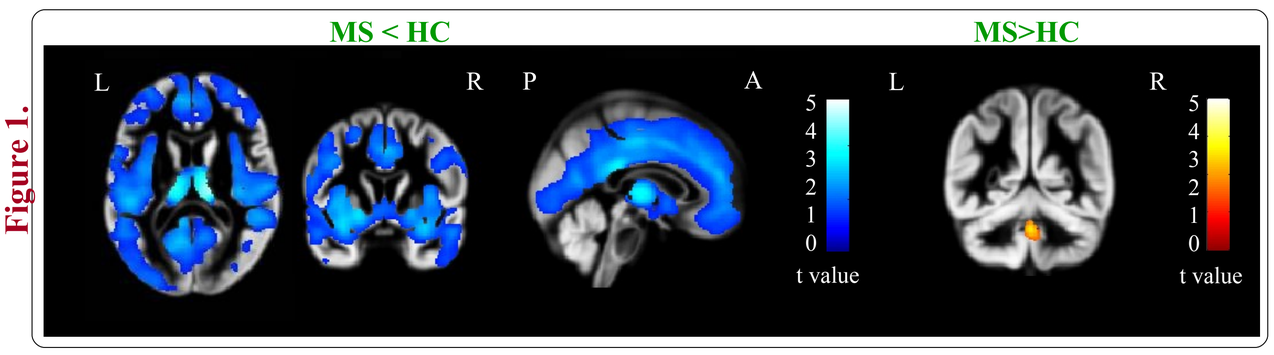
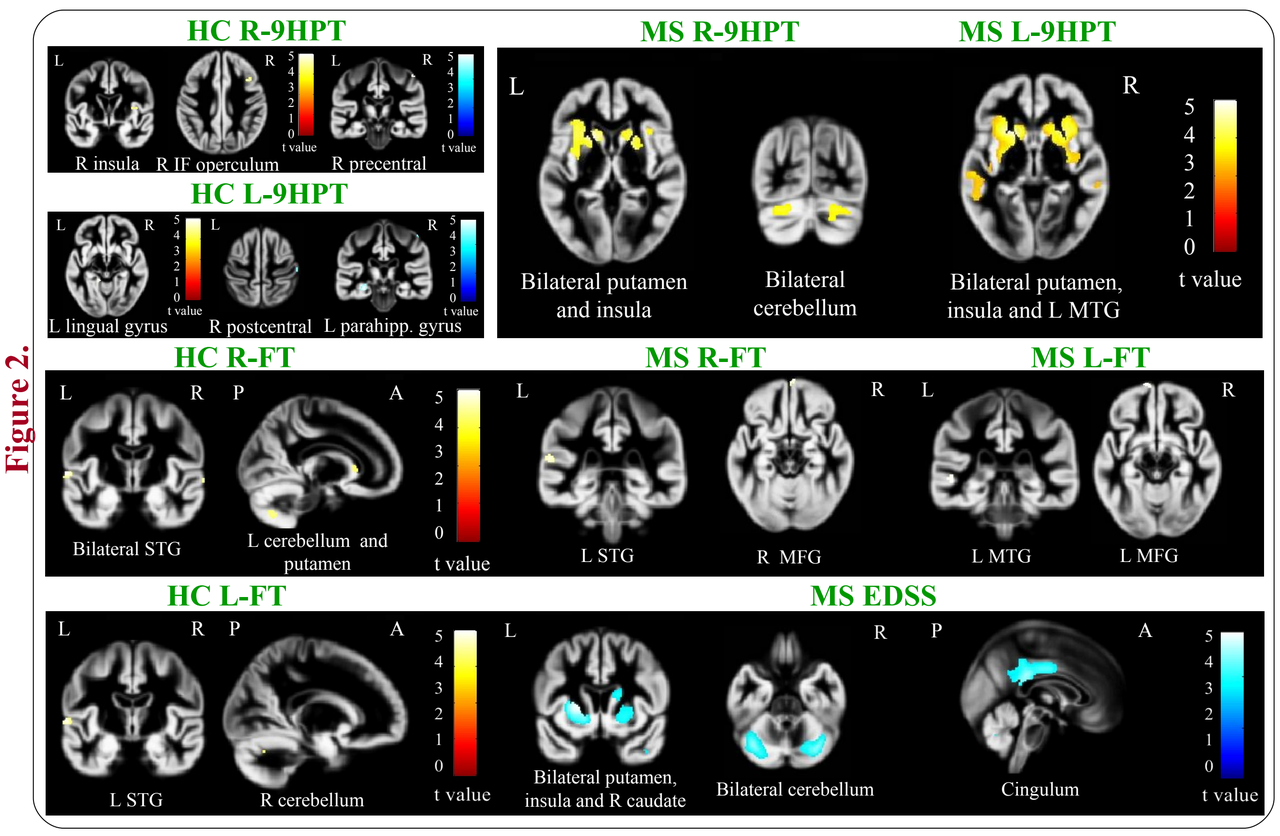


Figure 2 shows correlations between GM modifications and clinical measures (positive correlations encoded in red-yellow, negative in blue-light blue, $p<0.001$, uncorrected).

Figure 2.



TBSS: **Figure 3** shows areas of reduced FA, increased AD, RD and MD in MS patients. Correlations between diffusivity indexes and clinical measures are shown in **Figure 4** (positive correlations encoded in red-yellow, negative in blue-light blue).

Figure 3.

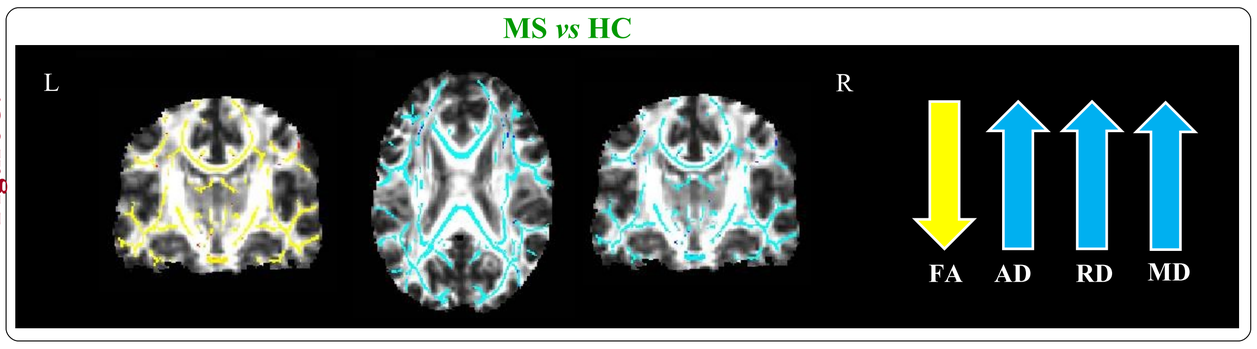
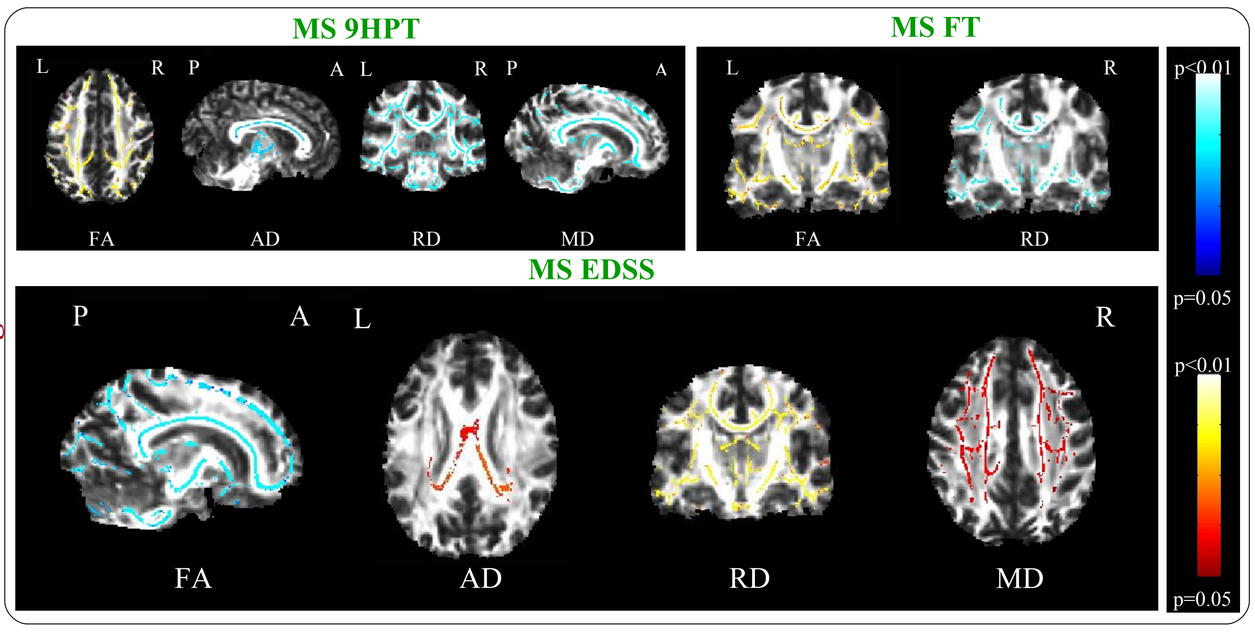


Figure 4.



CONCLUSIONS

- Specific patterns of GM atrophy and widespread alteration of WM integrity contribute to explain motor impairment in MS patients.
- The integration of clinical and MRI measures is likely to provide novel pieces of information for a better understanding of MS clinical manifestations, which is likely to contribute to more specific medical and rehabilitative treatments.

References

1. Roosendaal et al., Neuroimage 2008; **2.** Kern et al., Neuroimage 2010; **3.** Prinster et al., Mult Scler 2010; **4.** Ceccarelli et al., Neuroimage 2008; **5.** Sbardella et al., PLoS One 2013; **6.** Ashburner et al., Neuroimage 2000; **7.** Nichols et al., Hum Brain Map 2002.