Hydration status does not affect brain water content or myelin water fraction in healthy volunteers

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Introduction: Multi-echo T_2 relaxation allows for measurement of myelin water fraction (MWF, quantitatively related to myelin content[1]), water content (WC) and geometric mean T_2 (GMT_2), providing novel information about the human brain. Until recently, the T_2 technique was limited to a single slice, however, a newer 3D technique[2,3] has made multi-slice T_2 imaging possible and led to increased brain coverage. As T_2 is so sensitive to signal from water, a person's hydration status could potentially influence these water derived measures. In order to better characterise T_2 relaxation measures in healthy volunteers over a larger brain volume and determine the possible effect of hydration status on the various MR parameters, we investigated the histogram characteristics of MWF, WC, GMT_2 and mean T_1 from normal white and grey matter.

Methods: 20 healthy volunteers (11M/9F, mean age 31y, range 21-57y) were scanned with a Philips Achieva 3.0T MR scanner 4 times over 3 days. DAY 1 - baseline scan (scan 1) followed by overnight hydration with 3L of water; DAY 2 – hydrated scan (scan 2) followed by overnight dehydration from 9 hours of fasting; DAY 3 – dehydrated scan (scan 3) followed by a 1 hour break and then another dehydrated scan (scan 4) for reproducibility. The MRI protocol consisted of a 3D T_2 relaxation sequence utilizing a 90º excitation pulse followed by 32 slab-selective refocusing pulses flanked by gradient crusher pulses (32 echoes, TR = 1200ms, 10ms echo spacing, voxel size = 0.94x1.88x5mm, 7 slices)[2] and an inversion recovery experiment (5 TIs (150 - 3000ms), TR/TE=6.4/3.1 ms, TFE = 120, shot interval = 5000 ms, FA = 10º, 13 slices)[4]. The double flip angle method was used for B_1 correction[5]. T_2 distributions were extracted using a regularised non-negative least-squares algorithm[6]. MWF was calculated as the relative area under the T_2 distribution from 0-40ms to the total area. GMT_2 was calculated as the mean T_2 on a logarithmic scale from $40ms<T_2<200ms$. WC was determined from the total area under the T_2 distribution corrected for B1 inhomogeneity, T_1 relaxation and normalised to external water standards. T_1 was calculated using a mono-exponential fit. Images from each volunteer were registered to the baseline TI=1500ms scan. White and grey matter was segmented using FSL FAST and eroded by one voxel to minimise partial volume effects.

Results: Histograms of MWF, WC, T_1 and GMT_2 in white and grey matter for each volunteer and averaged men and women are shown in Figure 1. Table 1 shows the resulting average histogram metrics over all volunteers for each of the four MR parameters at baseline. The only significant differences found between males and females were the peak height of MWF and WC. No significant differences were found between histogram metrics from scans done at different hydration levels. Average coefficients of variation for WC, MWF, T_1 and GMT_2 were 1.7%, 7.7%, 0.63% and 0.46%, respectively.

Discussion: White and grey matter histograms of WC, T_1 and GMT_2 and grey matter histograms of MWF were consistent in shape between each volunteer and averaged men and women with only minor variations in peak height and location. However, white matter MWF histograms were considerably more varied where some volunteers had defined peaks and others had MWF decreasing steadily from the zero axis. A recent paper found volumetric changes with hydration status[7]. Fortunately, MR parameters did not depend on hydration state indicating that fasting or drinking large quantities of water is not a concern for quantitative MR studies. Histograms of T_1 and GMT_2 were consistent with previous results[8,9].

Conclusion: Healthy volunteers show slight variations but similar shapes in histograms for different MR parameters. Females had larger WC and MWF peak heights in white matter than males. Importantly, differences in hydration status associated with standard clinical procedures (ie. overnight fasting) do not influence histogram measures of myelin water fraction, water content, T_1 and T_2.

MR Parameter			Histogram Metrics		
			Mean	peak height	peak location
Water Content	WM	1	0.75	6.7%	0.75
		2	0.77	6.9%	0.74
		3	0.77	7.0%	0.74
		4	0.78	6.6%	0.75
	GM	1	0.89	4.9%	0.91
		2	0.88	5.8%	0.91
		3	0.88	5.4%	0.91
		4	0.89	5.2%	0.92
Myelin Water Fraction	WM	1	0.064	8.8%	0.052
		2	0.064	8.9%	0.05
		3	0.066	9.0%	0.052
		4	0.063	8.8%	0.056
	GM	1	0.011	19.2%	0.01
		2	0.012	19.6%	0.01
		3	0.012	19.7%	0.01
		4	0.012	19.3%	0.01
T_1 (s)	WM	1	0.98	12.9%	0.92
		2	0.99	12.5%	0.92
		3	0.99	12.6%	0.92
		4	0.99	12.7%	0.92
	GM	1	1.42	10.8%	1.49
		2	1.42	10.9%	1.49
		3	1.42	11.1%	1.49
		4	1.42	10.8%	1.49
Geometric Mean T_2 (s)	WM	1	0.070	16.1%	0.069
		2	0.070	16.4%	0.069
		3	0.070	16.3%	0.069
		4	0.070	16.6%	0.069
	GM	1	0.075	13.4%	0.074
		2	0.075	13.3%	0.074
		3	0.075	13.4%	0.074
		4	0.075	12.8%	0.075

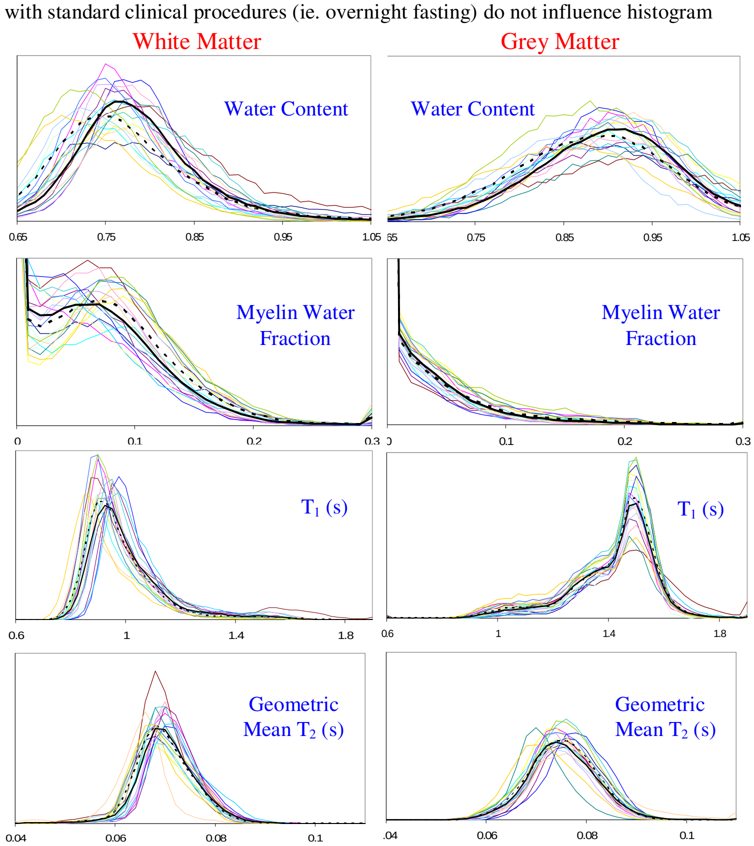

Figure 1: WC, MWF, T_1 and GMT_2 histograms for each control. Also shown are average histograms for females (solid line) and males (dashed line).

References: [1]Laule MS 2006:12:747. [2]Mädler. ISMRM. 2006:2112. [3]Mädler. MRI. 2008;26:874 [4]Mädler. ISMRM. 2006:958. [5]Wang MRM 2005;53:408. [6]Whittall. MRM. 1997;37:34. [7]Duning Neurology 2005;64:548. [8]Parry. J Neurol. 2002;249:1279. [9]Whittall. MRM. 2002;47:403.