

Does Fluid Intake Before Scanning Affect Water Content Measured in Brain?

Sandra M. Meyers¹, Irene M. Vavasour², Cornelia Laule^{2,3}, Shannon H. Kolind^{4,5}, Roger Tam^{2,6}, Burkhard Maedler⁷, David K. Li^{2,6}, Alex L. MacKay^{1,2}, and Anthony L. Traboulsee⁸

¹Physics and Astronomy, University of British Columbia, Vancouver, BC, Canada, ²Radiology, University of British Columbia, Vancouver, BC, Canada, ³Pathology and Laboratory Medicine, University of British Columbia, Vancouver, BC, Canada, ⁴FMRI Centre, University of Oxford, Oxford, United Kingdom, ⁵Neuroimaging, University College London, London, United Kingdom, ⁶MS/MRI Research Group, University of British Columbia, Vancouver, BC, Canada, ⁷University of Bonn, Bonn, Germany, ⁸Medicine, University of British Columbia, Vancouver, BC, Canada

INTRODUCTION:

Accurate measurement of water content (WC) is valuable for assessing changes in brain water such as edema associated with a number of neurological diseases including stroke and brain tumors, as well as monitoring the effects of therapy (1; 2). As practically all of the MR signal in brain comes from water, MR measurements of WC could be affected by the hydration state of the subject being scanned. Previous studies have shown that dehydration and rehydration can significantly affect brain volume (3); however, the effect of fluid intake on MR measured brain WC is currently unknown. **The purpose of this study was to determine whether differences in hydration state, which could arise from standard clinical procedures such as overnight fasting, affect WC measured in brain.**

METHODS:

MRI Experiment: 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. Two water phantoms were placed beside the head during scanning and served as external standards. The MRI protocol consisted of a 3D T₂ relaxation sequence utilizing a 90° 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) (4) and an inversion recovery (IR) experiment (5 TIs (150 - 3500ms), TR/TE=6.4/3.1ms, TFE = 120, shot interval = 5000 ms, FA = 10°, 13 slices). The images were corrected for B₁ homogeneity artifacts using the Constant LEvel AppeaRance (CLEAR) algorithm.

Post-Processing and Analysis: T₂ images were registered to the baseline IR 1500ms T₁ using in-house registration software (5). T₂ distributions were calculated for every voxel in the T₂ relaxation data set using a modified Extended Phase Graph algorithm combined with regularized non-negative least squares (6) and flip angle optimization (7). The CSF portion of the T₂ spectrum was corrected for T₁ relaxation using a T₁ of 3s, while the rest of the spectrum was corrected using the T₁ obtained from the inversion recovery, which was fit with a mono-exponential. Relative WC (rWC) was calculated using the method outlined by Whittall and MacKay (8), with an additional temperature correction applied to the water standard signal to account for differences in density between room temperature (24°C) and body temperature (9). Measurements of WC using the left water bottle as a standard were less reproducible and noisier when compared to those using the right, so WC was taken relative to the right water bottle signal. rWC means were computed in 5 grey matter (GM) and 5 white matter (WM) brain regions of interest (ROIs). A one-way ANOVA was conducted to compare means between scans.

RESULTS:

Figure 1 shows one subject's rWC maps, for the slice on which brain regions were drawn. Qualitatively, rWC looked very similar between scans. Mean rWC, along with standard deviation over all subjects, is displayed for each structure in Figure 2. rWC values for both the GM and WM structures were found to be higher than those reported previously: WM average rWC was 0.78 (as opposed to 0.71 (8)), and GM average rWC was 0.88 (as opposed to 0.83 (8)). Figure 2 shows that rWC values were very similar across scans, which was confirmed with ANOVA (all p-values were greater than 0.2, indicating no significant difference between scans). We observed a large variation in rWC across brain structures, as well as a large difference between individuals (shown by the large error bars).

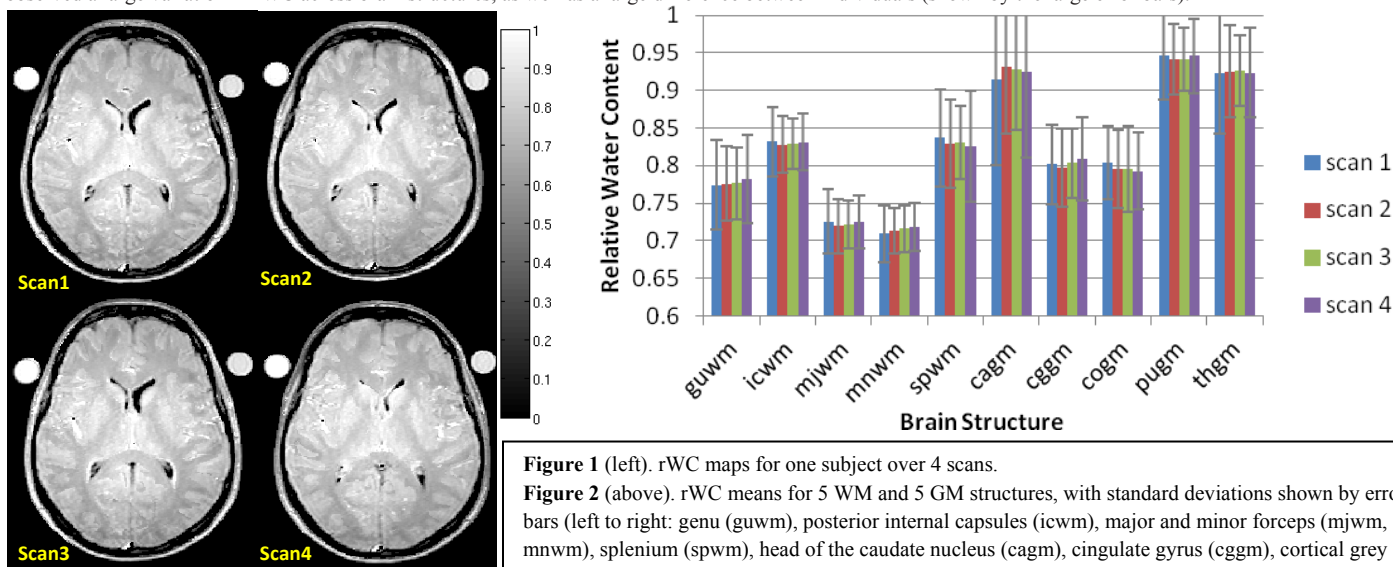


Figure 1 (left). rWC maps for one subject over 4 scans.

Figure 2 (above). rWC means for 5 WM and 5 GM structures, with standard deviations shown by error bars (left to right: genu (guwm), posterior internal capsules (icwm), major and minor forceps (mjwm, mnwm), splenium (spwm), head of the caudate nucleus (cagm), cingulate gyrus (cggm), cortical grey (cogm), putamen (pugm), and thalamus (thgm))

CONCLUSIONS: The results of this study show no significant difference in relative brain WC measurements for subjects with different hydration states; thus, changes in fluid intake before scanning do not appear to have a measurable effect on brain WC. We suspect that the higher rWC values are due to some difficulty with CLEAR reconstruction in the region outside the brain, and for this reason we have used the terms "relative WC" as opposed to WC. Further investigation into a more effective water standard is required to improve the performance of CLEAR B₁ inhomogeneity correction within the region of the water standard.

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