Age and Sex: Effects on Brain Properties Assessed by ^1H_2O T_1 Histograms

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SYNOPSIS

Cerebral ^1H_2O T_1 maps were collected from 29 healthy adult controls (17 M, 12 F) at 4 T. T_1 histograms were constructed and analyzed to determine the global white matter (WM) T_1 range, and normalized volume fractions of WM, gray matter (GM) and CSF tissue water. Significant sex differences in WM T_1 (F > M), and volume fractions of WM (M > F) and GM (F > M) were found. With age, the men showed significantly increased WM T_1 values, decreased GM volumes, and increased CSF. In contrast, women were much more immutable with age.

INTRODUCTION

^1H_2O MRI T_1 mapping offers a precise way to characterize brain tissue *in vivo* and has potential for fast objective evaluation of physical and morphological properties. ^1H_2O T_1 values differ between GM, WM and CSF water. These differences give histograms definable structure, and can be used to generate segmented brain images (1). Here, we investigate the effects of sex and age on brain ^1H_2O from T_1 histograms.

METHODS

29 healthy controls [12 F, mean age (±SD) 34 (± 12) y, range 20 - 55 y ; 17 M, age 38 (± 13) y, range 21-65 y] provided informed consent before participating in this study. MR data were acquired on a 4.0T MRI instrument. Quantitative T_1 maps were collected using a multislice inversion recovery (IR) sequence with a low flip angle ($\alpha < 20°$) sampling pulse. Twenty-six 3 mm thick slices, with in-plane resolution of 1 mm, were collected in ~9 minutes. The T_1 recovery was sampled at 16 linearly spaced inversion times (TI); $0.025\ s \le TI \le 4.7\ s$. The signal intensity, S(TI), of each voxel was fitted to a two-parameter single exponential IR equation using a gradient expansion algorithm. The histographic WM and GM peaks were fitted by Gaussian functions to obtain peak positions, and fixed integration limits were used to obtain WM, GM, and CSF areas. Normalized volume fractions were obtained by dividing the integrated areas by the total histogram integral. Non-parametric statistics were used and the unit of analysis was the subject. Linear regression was used to determine association between age and histogram parameters.

RESULTS

The T_1 maps of **Figure 1a** (25 of 26 slices displayed) were obtained from a 23 y man (left panel) and a 65 y man (right panel). The corresponding histograms are displayed in **Figure 1b.** A summary of average parameters extracted from the histograms is found in the **Table** [mean (± 1 SD)]. The average WM ^1H_2O T_1 peak position is found at a larger value (by ~2.5%) for the women compared to the men [Table T_1 values are not corrected for sampling during IR]. On average, WM volume fractions were smaller, and GM volume fractions greater, in women than men. WM volume fractions did not change significantly with age for either group, but GM significantly decreased with age for the men ($P < 0.001$, $R=0.755$, linear regression). There was a trend for decreased GM with age in the women ($P = 0.058$, $R=0.560$). CSF volume fraction increased with age only for men ($P =0.001$, $R=0.711$). Finally, WM T_1 values increased with age for the men ($P = 0.002$, $R=0.694$), but not for the women (**Figure 2**).

	Position "WM" (msec)	Area % "WM"	Area % "GM"	Area % "CSF"
All (n=29)	837 (± 19)	39.5 (± 3.8)	51.4 (± 3.8)	9.4 (± 4.5)
Women (n=12)	849 (± 20)	37.3 (± 2.6)	53.0 (± 3.7)	9.7 (± 4.2)
Men (n=17)	828 (± 13)	41.0 (± 4.0)	49.8 (± 3.4)	9.1 (± 4.8)
P	0.004	0.011	0.014	NS

DISCUSSION

Our results suggest several notable sexual dimorphisms that likely reflect structural and chemical brain differences. We find that women have less WM and more GM than men, consistent with other reports (2,3). Our findings indicate that global WM water T_1 values are slightly larger (~2.5%) in women than men. A previous study (4) found no sex difference in WM T_1, but another reported a substantially larger (13%) WM water proton T_1 value for women than men (5). Overall, men showed more significant age-related changes than women in histographic metrics of WM T_1, and GM and CSF volume fractions. Men suffered greater age-related losses of brain tissue than women showing a significant negative correlation between GM volume fraction and age, and a positive correlation with CSF volume fraction and age. This decrease in GM, however, may reflect decreases in neuronal cell size, rather than density, with normal aging (6). Increased WM T_1 with age is a new finding, perhaps indicating loss of axonal density or increased inflammation and glial activation (7). Increased creatine and myoinisotol with age supports the notion of gliosis (8,9). **SUPPORT:** [NMSS RG 3168A1, NIH RO1 NS40801, DOE DE-AC02-98CH108]

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Figure 1a 23 y 65 y

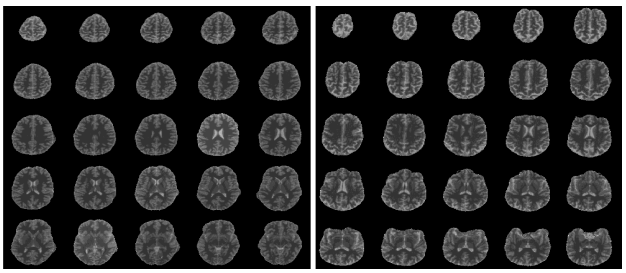

Figure 1b

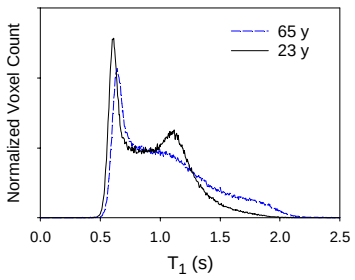

Figure 2