First-Order Dynamic Models of Liver T_1 in Response to Isotonic Drink Ingestion in Men (LIQUID)

Natassa N Pittas[1], Ferenc E. Mozes[2], and Michael Pavlides[2,3]

[1]Department of Oncology, University of Oxford, Oxford, UK

[2]Oxford Centre for Clinical Magnetic Resonance Research, Radcliffe Department of Medicine, University of Oxford, Oxford, UK

[3]Oxford NIHR Biomedical Research Centre, Oxford University Hospitals NHS Foundation Trust and the University of Oxford, Oxford, UK

Background

Metabolic dysfunction-associated steatotic liver disease (MASLD), is a prevalent condition affecting approximately one in four adults worldwide [1]. While liver biopsy remains the gold standard for diagnosing MASLD, it carries significant risks and variability, therefore there is a need for non-invasive quantitative MRI markers in assessing liver health and evaluating MASLD [2]. To achieve this, it is crucial to understand how external factors influence these quantitative markers and specifically this study investigates the impact of hydration levels on these markers.

Methods

Six male participants consumed 0.5 L, 1.0 L and 1.5 L of an isotonic drink on different days and underwent MRI scans using a 3 T scanner (Fig 1). The study examined how hydration affects various quantitative markers, including liver T_1, T_2, T_2*, ADC (diffusion), PDFF (lipids), MRE-liver stiffness (LSM), and volume; spleen T_1, T_2, T_2*, and volume; and muscle T_1, T_2, and T_2*. The time course of the T_1 measurements was modeled by assuming that the liver, spleen, and muscle act as first-order linear time-invariant systems (eq. 1) [3].

$$T_1(t) = K_l\left(1 - e^{-\frac{t-\delta}{\tau_l}}\right)u(t-\delta) - K_l\left(1 - e^{\frac{t-\delta-\Delta}{\tau_l}}\right)u(t-\delta-\Delta) + T_1(0)$$

Eq. 1: Liver T_1 fitting function. K_l is a gain factor related to the magnitude of T_1 change, δ a delay between ingesting the drink and the initial upslope in T_1, Δ the length of pulse input, τ_l the rate of water uptake and $T_1(0)$ the baseline T_1

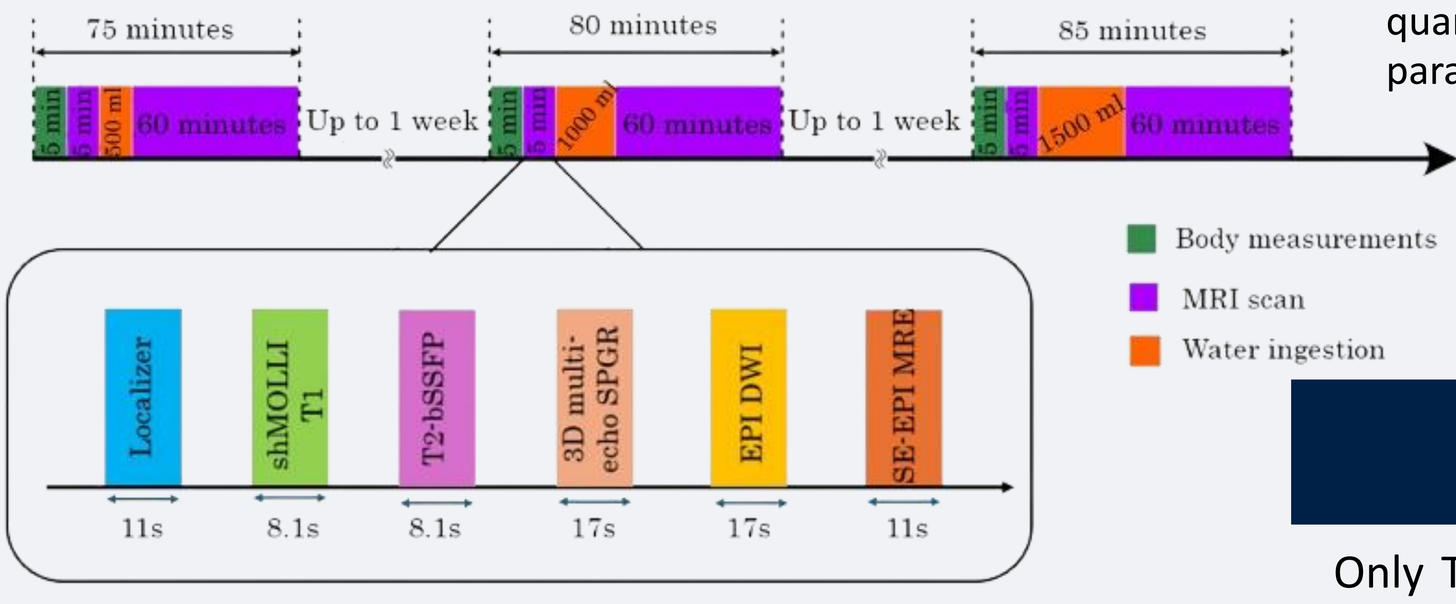

Figure 1: Study flow chart of LIQUID study for one participant

Results

Hydration levels have an impact on quantitative MRI markers employed in the assessment of MASLD. Increased hydration is associated with increased liver T_1(Fig. 2a), T_2, ADC, T_2*, spleen T_1, T_2*, muscle T_1, T_2* values and liver and spleen volume (Fig. 2b), while leading to a reduction in MRE-LSM(Fig. 2c). Interestingly, hydration status did not significantly affect PDFF measurements.

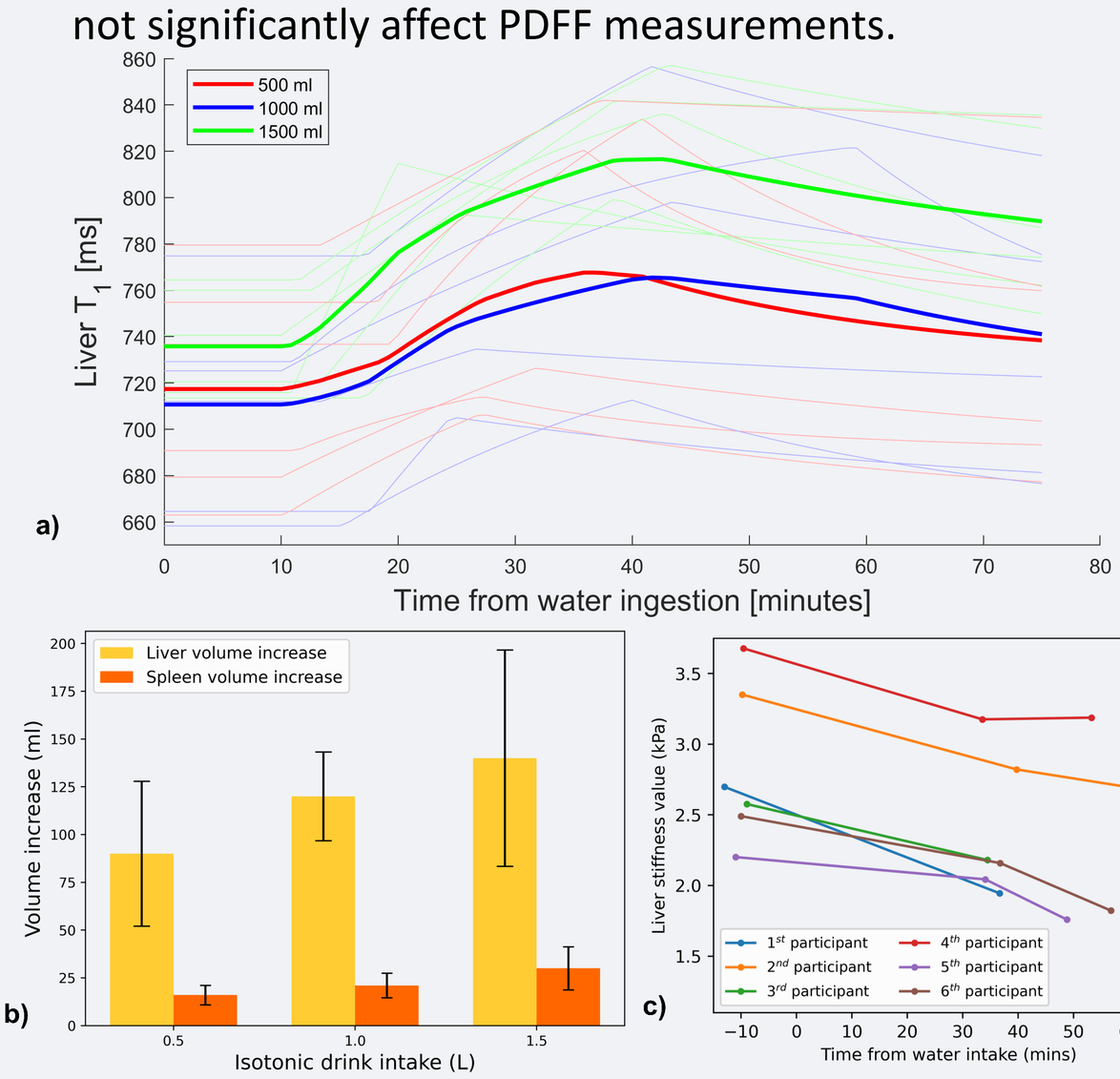

Figure 2: a) Time-dependent changes in liver T_1 relaxation time following isotonic drink ingestion, obtained by fitting T_1 values to a first-order model (eq.1), b) Increase in liver and spleen volume by isotonic drink intake. The error bars represent standard errors, c) LSM arising from EPI MRE sequence for 1.0 L of isotonic drink intake

Table 1: Mean maximum relative change (%) in quantitative MRI parameters

Liver quantitative marker	0.5 L	1.0 L	1.5 L
T_1 [ms]	8	8	12
T_2 [ms]	11	7	11
T_2* [ms]	9	12	12
ADC [mm^2/s]	9	16	20
PDFF [%]	7	8	5
Volume [ml]	5	8	9
MRE-LSM [kPa]	-13	-16	-17

Conclusions

Only T_1 showed changes beyond the expected variability, indicating real change. MRE remained within the normal variability threshold defined by the QIBA profile, PDFF showed no change, and T_2* had minimal variation. The significance of ADC and volume changes remains to be investigated in future studies.

Acknowledgements

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References

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