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Long-term balance training enhances sensorimotor GABA Levels in older adults: A 7 T longitudinal magnetic resonance spectroscopy study

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Introduction

γ-aminobutyric acid (GABA) is the primary inhibitory neurotransmitter in the brain that is known to play a pivotal role in regulating the excitation/inhibition balance that is essential for various behavior domains and in particular motor inhibition. Cortical inhibitory control was shown to be less pronounced in elderly adults relative to young adults. Indeed, older adults with lower GABA levels within the pre-supplementary motor area showed deficits in inhibitory motor control. Short-term motor learning has shown impacts on cortical GABA modulation, however, the influence of long-term balance training on GABA levels is less understood, especially in elderly population. In this study, we seek to evaluate the effect of three-months balance training on sensorimotor GABA level in elderly adults using 7T magnetic resonance spectroscopy (MRS). GABA levels were measured by the MEGA-sSPECIAL, which has high measurement reproducibility for GABA in the motor cortex at 7T. To study the effect on other brain metabolites, the short echo time semi-adiabatic SPECIAL sequence was used for neurochemical profiling.

METHODS

- Sixteen healthy volunteers (66 – 79 years old, 8 males / 8 females) gave informed consent prior to the study and participated MR measurements at 7T (Siemens, Erlangen, Germany) for both sessions. MP2RAGE sequence was used to acquire images for the voxel positioning. B0 field inhomogeneity was optimized using first- and second-order shims with FAST(EST)MAP. Localized 1H single-voxel spectra from the sensorimotor cortex are acquired by the semi-adiabatic SPECIAL and MEGA-sSPECIAL sequences.
- After the first MRS session, participants underwent three months of progressive, multifaceted balance training. They trained around 3 times per week (a total of at least 30 trainings) for 45 minutes in supervised group sessions. After three months, they underwent the second MRS session with the same protocols as the first one.
- MR spectra were averaged after frequency drift and phase correction using FID-A and analyzed by LCModel for quantification. Metabolites with CRLB larger than 30% were considered as non-detected. The resulting metabolite concentrations were corrected for tissue composition and unsuppressed water signal was used for metabolite quantification. A paired t-test was used to test metabolite concentration difference between two MRS sessions.

RESULTS

- Figure 1 shows the voxel location in this study. Representative spectra obtained using the two sequences are shown in Figure 2.
- MEGA-sSPECIAL detected a significant increase in GABA concentration in the post-training session compared to pre-training ($p < 0.01$) (Figure 3 left).
- We found no significant metabolite concentration difference between pre- and post-training sessions using short TE method (Figure 3 right).

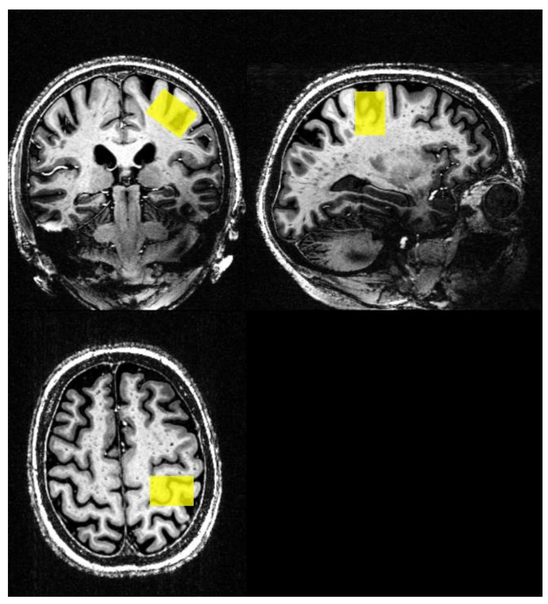


Figure 1. Exemplar voxel placement for motor cortex.

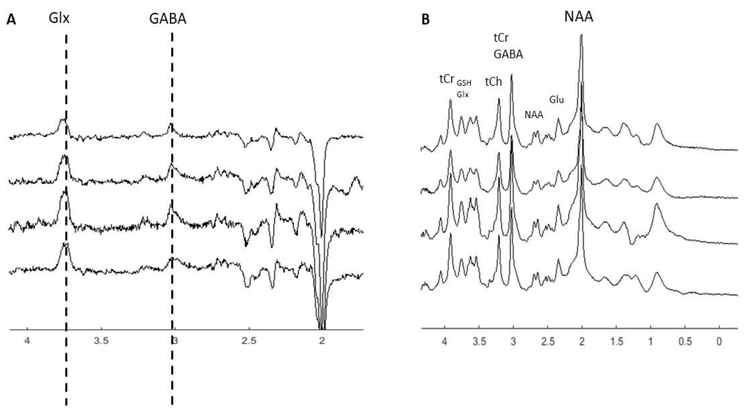
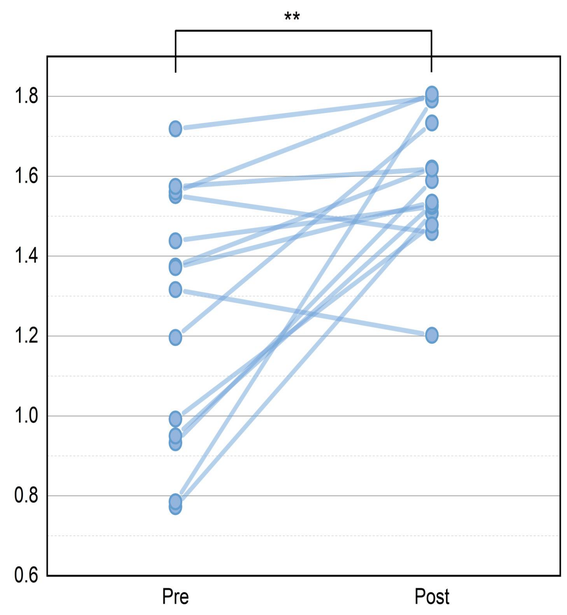


Figure 2. Representative spectra of four subjects for MEGA-sSPECIAL(A) and sSPECIAL(B).



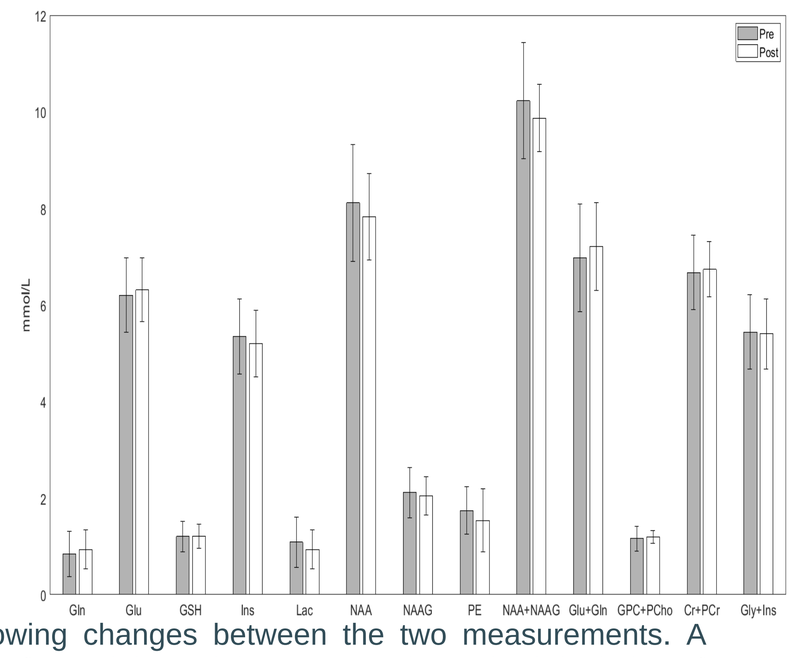


Figure 3. Left: Pair-wise comparison showing changes between the two measurements. A significant increase is found in GABA level after training. Right: Mean and standard deviation of metabolites measured using sSPECIAL. There is no significant difference between pre- and post- training sessions.

CONCLUSION

- Our findings of increased sensorimotor GABA levels as a result of long-term balance training suggest that decline in cortical GABA level in older adults could be mitigated in the training process.
- The finding sheds new light on the plasticity of GABAergic system in elderly population.

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