Effect of physical exercise on cerebral antioxidant status in older adults

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TARGET AUDIENCE: Clinicians and scientists who are interested in brain aging and lifestyle intervention strategies.

INTRODUCTION: A better understanding of the interaction between cerebral antioxidant capacity and aging is of critical importance for developing neuroprotective strategies against oxidative stress, one of the primary causes of aging and neurodegeneration. Low levels of physical activity and inadequate diet are commonly observed in individuals with poor physical and/or cognitive function [1,2]. The beneficial effects of physical exercise for promoting healthy brain aging and protecting against cognitive decline and dementia have been noted. Possible explanation for this finding is that exercise contributes to increasing cerebral antioxidant capacity, and reducing inflammatory processes and free radical generations, although the specific mechanisms are yet to be determined. Our hypothesis is that exercise enhances cerebral antioxidant levels, which is required to fight oxidative stress in the aging brain. Glutathione (GSH) is the major antioxidant linked with a mechanism of oxidative stress. The objective of this study was to measure the effect of aerobic exercise on the levels of GSH in the aging brain using advanced ^{1}H multiple-quantum chemical shift imaging (MQ CSI) of GSH to provide an objective, quantitative measurement of the cerebral antioxidant status.

Fig. 1. Partial view of simultaneously measured GSH (MQ CSI), and creatine (Cr) and choline (Cho) (SQ CSI) mapping in the human brain using the GSH CSI technique.

METHODS: Seventeen healthy older adults (73 ± 5.5 years, mean ± SD) participated in a 26-week exercise intervention study (14: exercise group, 3: control group with no change in their physical activity). Participants in the exercise group were directly supervised during all exercise sessions for 26 weeks with doses of 50-150% (75-225 mins/week walking on treadmill) public health recommendations. MR scans were performed on a Siemens Skyra 3 T MR system at baseline (prior to exercise) and after 26-weeks' exercise intervention. For the MQ CSI of GSH, a double-band frequency selective 180^{o} pulse was used during the MQ preparation period to achieve spectral selectivity for the strongly coupled cysteine protons of GSH at 4.56 ppm and 2.95 ppm [3]. The CSI parameters were 8 × 8 phase encoding steps, FOV of 20 cm × 20 cm, and slice thickness of 3 cm, and nominal voxel size 2.5 × 2.5 × 3 cm^{3} without zero-filling. The axial CSI slice was positioned across the frontal to parietal brain [3, 4]. The results were divided into "mainly frontal", "mainly parietal", or "fronto-parietal" regions. GSH concentration was determined from the regions of interest using the simultaneously measured Cr signal as an internal concentration reference [5].

RESULTS AND DISCUSSION: Figure 1 shows a partial view of GSH CSI from the brain of an older adult. GSH signals of the cysteine β-CH2 protons at ~3 ppm were clearly detectable in all the CSI voxels. After exercise, GSH levels were increased 25.3% (p=0.02) in the frontal and 18.9% (p=0.03) in the fronto-parietal regions. GSH levels did not differ in any brain region of the control group with no changes in physical activity. In this study, we found GSH levels were higher in older adults who had completed 26 weeks' aerobic exercise. These GSH increases were more prominent in the frontal region than the parietal region, which is consistent with previous studies that found increased frontal brain volume in individuals with higher aerobic fitness [6]. The capacity of assessing GSH levels in older adults could provide a useful objective clinical tool evaluating the effects of lifestyle modifications on the brain antioxidant system.

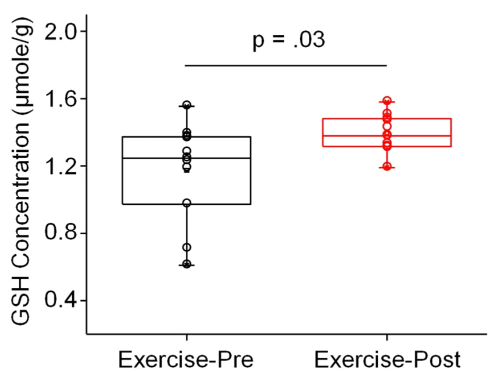

Fig. 2 Effect of aerobic exercises on cerebral GSH levels in older adults (n=11).

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