Variability in inhibitory function reflects changes in motor performance after physical exercise

Courtney E. Walters Jr[1], Lisa C. Krishnamurthy[1,2], Javier Omar[1], Kevin Mammino[1], Bruce Crosson[1,3], Gabriell Champion[1], Venkatagiri Krishnamurthy[1,3], Kaundinya Gopinath[4], Steve Wolf[1,5], Andrew J. Butler[6], Joe R. Nocera[1,3,5], Keith M. McGregor[1,3]

[1]VA Rehabilitation R&D Center for Visual and Neurocognitive Rehabilitation, Atlanta VAMC; [2]Georgia State University, Department of Physics and Astronomy; Emory University School of Medicine, Departments of [3]Neurology, [4]Radiology, [5]Rehabilitation Medicine

U.S. Department of Veterans Affairs
Atlanta VA Health Care System

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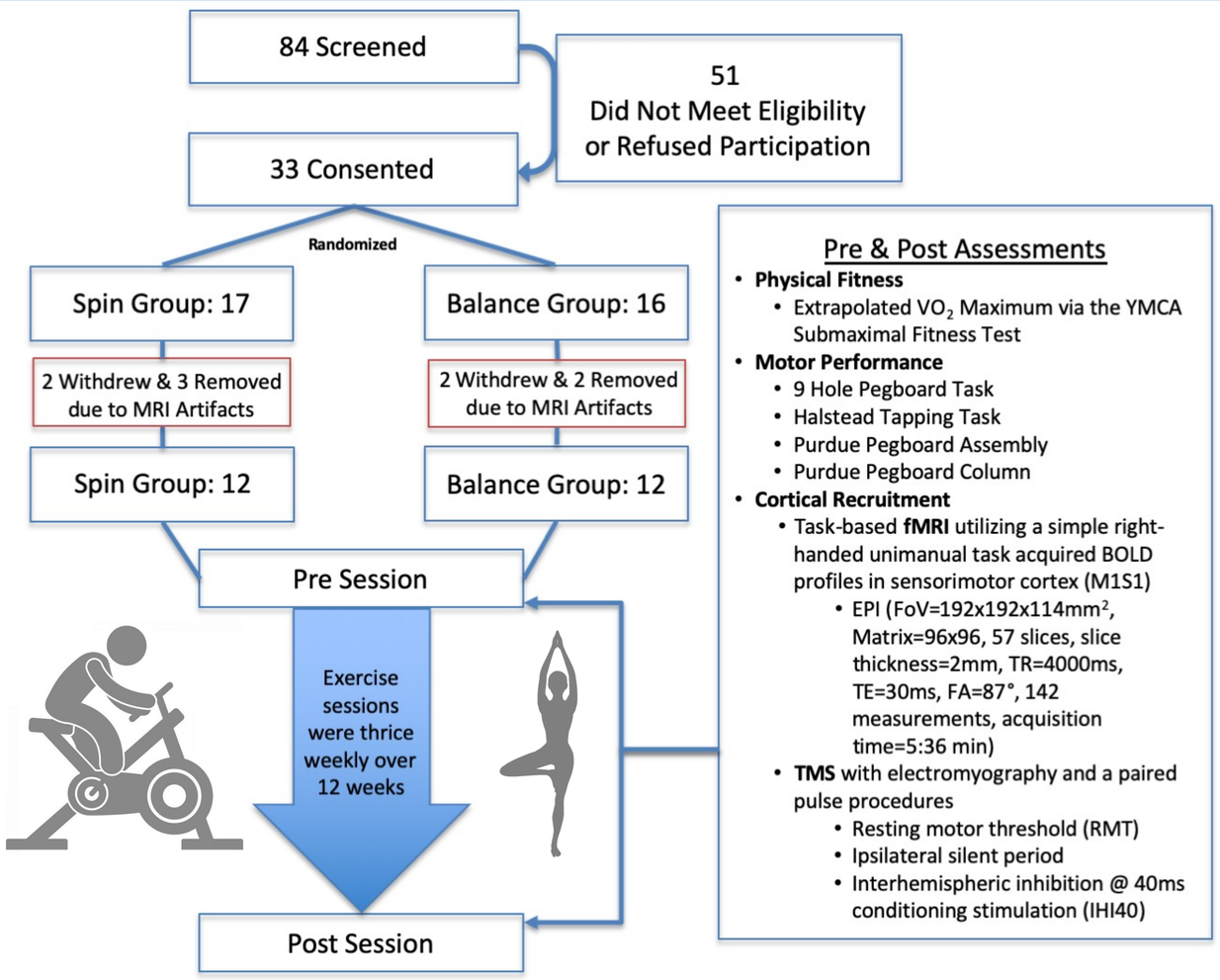
Introduction

- Levels of physical fitness may explain variability in cortical recruitment and upper extremity motor control due to aging in older adults
- Aging leads to increased bilateral activity and decreased inhibition in the cortex
- It is unknown whether an exercise intervention would change cortical activity and improve motor performance in sedentary older adults
- Type of exercise may confer differential effects on imaging and behavioral outcomes; however, any physical activity intervention may change neural efficiency and promote behavioral function in deconditioned older adults
- This study compared and related change measures of physical fitness, motor performance, and cortical recruitment via functional magnetic resonance imaging (fMRI) and transcranial magnetic stimulation (TMS) between and across groups of previously sedentary older adults in either a 12-week aerobic Spin or non-aerobic Balance exercise intervention

Hypothesis

- Participants would show increased lateralization of cortical activity and measures of inhibition, which would be associated with improvements in motor dexterity and psychomotor speed as a result of the interventions
- Participants in the aerobic exercise intervention would show greater improvements in these measures as compared to a non-aerobic physical activity intervention

Methods



Analysis

- fMRI data preprocessing; Area under curve (AUC) calculated for each voxel
- Volumetric analysis on AUC maps with conservative cluster threshold
- M1S1 BOLD profile analysis (MNI coordinates: +/-39 -22 57)
- Split-plot ANOVA using a REML design: sessions (within) and groups (between)
- Non-parametric Spearman's Rho (ρ) correlation computed for change scores (Post-Pre): physical fitness, motor performance, fMRI, and TMS
- Multiple regression analyses were performed on significant correlations

Results

Demographic Data Between Groups

	Spin Group (n=12)	Balance Group (n=12)
Age	71.1 (6.53)	68.4 (6.07)
Body Mass Index	29.0 (5.25)	28.8 (6.52)
Edinburgh Handedness Inventory	0.98 (0.06)	0.98 (0.06)
Education	16.4 (2.71)	16 (2.95)

Mean (standard deviation)

- Extrapolated VO_2 Maximums increased on average across groups after intervention although variability was present between groups
- RMT showed a significant decrease from Pre to Post across groups, $p<0.01$
- Split-plot ANOVA showed no significant differences in motor performance, fMRI, and TMS between groups at Pre and Post sessions
- Thus, the previously stated analyses were performed across groups

Results

Motor Performance Between and Across Groups

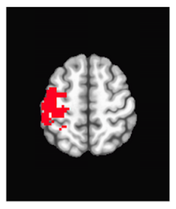
	Spin Group (n=12)		Balance Group (n=12)		All (n=24)	
	Pre	Post	Pre	Post	Pre	Post
9 Hole Pegboard Task (seconds)	25.1 (2.31)	22.8 (2.98)	23.6 (4.09)	24.8 (5.65)	24.4 (3.33)	23.8 (4.52)
Halstead Tapping Task (average presses)	43.0 (7.68)	44.2 (5.89)	44.2 (7.65)	42.8 (6.52)	43.6 (7.52)	43.5 (6.11)
Purdue Pegboard Assembly (points/assemblies)	6.75 (0.79)	7.25 (0.98)	6.72 (0.82)	6.75 (1.19)	6.73 (0.79)	7.00 (1.10)
Purdue Pegboard Column (points/pegs)	10.6 (1.16)	11.8 (1.96)	12 (1.76)	11.8 (2.30)	11.3 (1.63)	11.8 (2.09)

Mean (standard deviation)

- On average, all participants improved their scores for the 9 Hole Pegboard Task, Purdue Pegboard Assembly, and Column

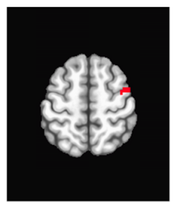
Volumetric Analysis on AUC Maps Across Groups

PRE Volumetric Analysis

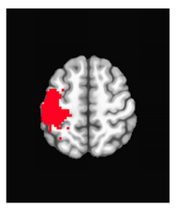


Activation Table

ROI	Size (voxel)	Peak X	Peak Y	Peak Z
Right M1	118	-46.6	+0.4	+49.3
Left M1	790	+38.9	+19.2	+58.2

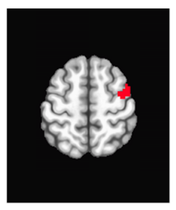


POST Volumetric Analysis



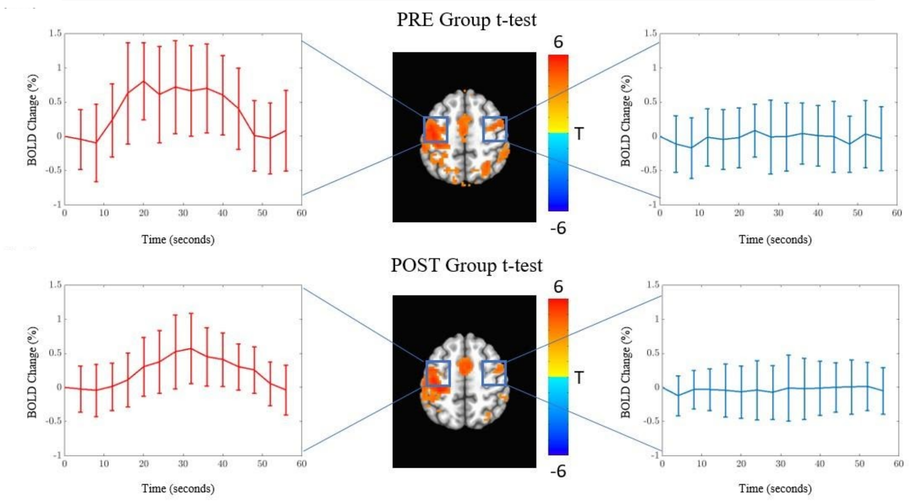
Activation Table

ROI	Size (voxel)	Peak X	Peak Y	Peak Z
Right M1 ↓	85	-43.0	+3.3	+56.8
Left M1 ↑	1,591	+43.6	+25.6	+49.4



- After the exercise intervention, participants across groups showed more left-lateralized changes for significant cortical activity by voxel size

M1S1 BOLD Profile Analysis Across Groups

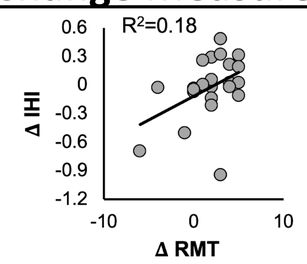


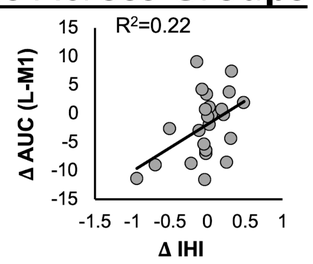
- The extent of positive % change in the BOLD profiles for the left and right M1S1 decreased from Pre to Post across groups

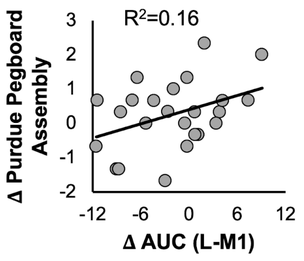
Correlation and Regression Of Change Measures Across Groups

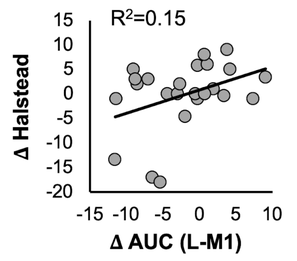
Measure 1	Measure 2	ρ	p-value
Purdue Pegboard Column	Extrapolated VO_2 Maximum	0.47	0.02*
fMRI LM1 AUC	Resting Motor Threshold	0.45	0.02*
Ipsilateral Silent Period	fMRI RM1 AUC	-0.45	0.02*
fMRI LM1 AUC	Interhemispheric Inhibition	-0.42	0.04*
9 Hole Pegboard Task	fMRI RM1 AUC	0.39	0.04*
Halstead Tapping Task	fMRI RM1 AUC	-0.37	0.05*

Note. * - denotes that there was a significant ($p<0.05$) correlation between variables









Conclusions

- By increasing physical fitness through exercise, previously sedentary older adults showed more left-lateralized changes in cortical recruitment, which accounted for the variance associated with improved motor performance
- Increased cortical inhibition via the GABAergic system may drive these changes
- Any physical activity intervention may be effective in altering neurophysiology and motor behavior in severely deconditioned adults

Acknowledgements

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