

Effects of outdoor versus indoor aerobic exercise on prefrontal cortex activity and working memory in older adults with mild cognitive impairment

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Background

- Mild cognitive impairment (MCI) is an intermediate stage of cognitive decline between normal aging and dementia.¹
- Aerobic exercise can improve prefrontal cortex (PFC) activity in and executive function among older adults.^{2,3}
- The health benefits of exercise may be enhanced when performed outdoors in nature, as compared with indoors.⁴

Objective

To compare the effects of aerobic exercise performed outdoors in a forest (OUT) versus indoors (IND) on working memory-related PFC activity among older adults with MCI.

Methods

- Design:** A sub-study of a 2-arm, single-blinded, proof-of-concept randomized controlled trial (NCT05036304).
- Participants:** 45 community-dwelling adults aged 65–80 years with MCI (Montreal Cognitive Assessment (MoCA) <25/30).
- Exercise Program:** Workouts of 10-min warm-up, 40-min aerobic training (45–75% heart rate reserve), 10-min cool-down. 2 workouts/week for 12 weeks.

Green Outdoor Exercise (OUT)
Walking in forest



Indoor Exercise (IND)
Treadmills and stationary bikes



- Outcome Measures:**
 - PFC Activity:** A 16-optode, 22-channel functional near-infrared spectroscopy (fNIRS) system used 844nm light to measure change in oxyhemoglobin concentration (ΔHbO) over the PFC during the N-back task (Figure 2).
 - Working Memory:** Measured by accuracy (% of responses correct) in the letter N-back task (Figure 2). Subjects did 2 blocks each of 1-back and 2-back (16 letters per block).
 - Data Processing:** fNIRS data were processed in Homer 3. HbO values were block-averaged for each N-back condition (1-back and 2-back), then averaged across channels in each region of interest (bilateral, left, and right PFC).



- Complete Case Analyses:** ANCOVA comparing group outcome changes, adjusted for baseline outcome, baseline MoCA, and sex.

Results

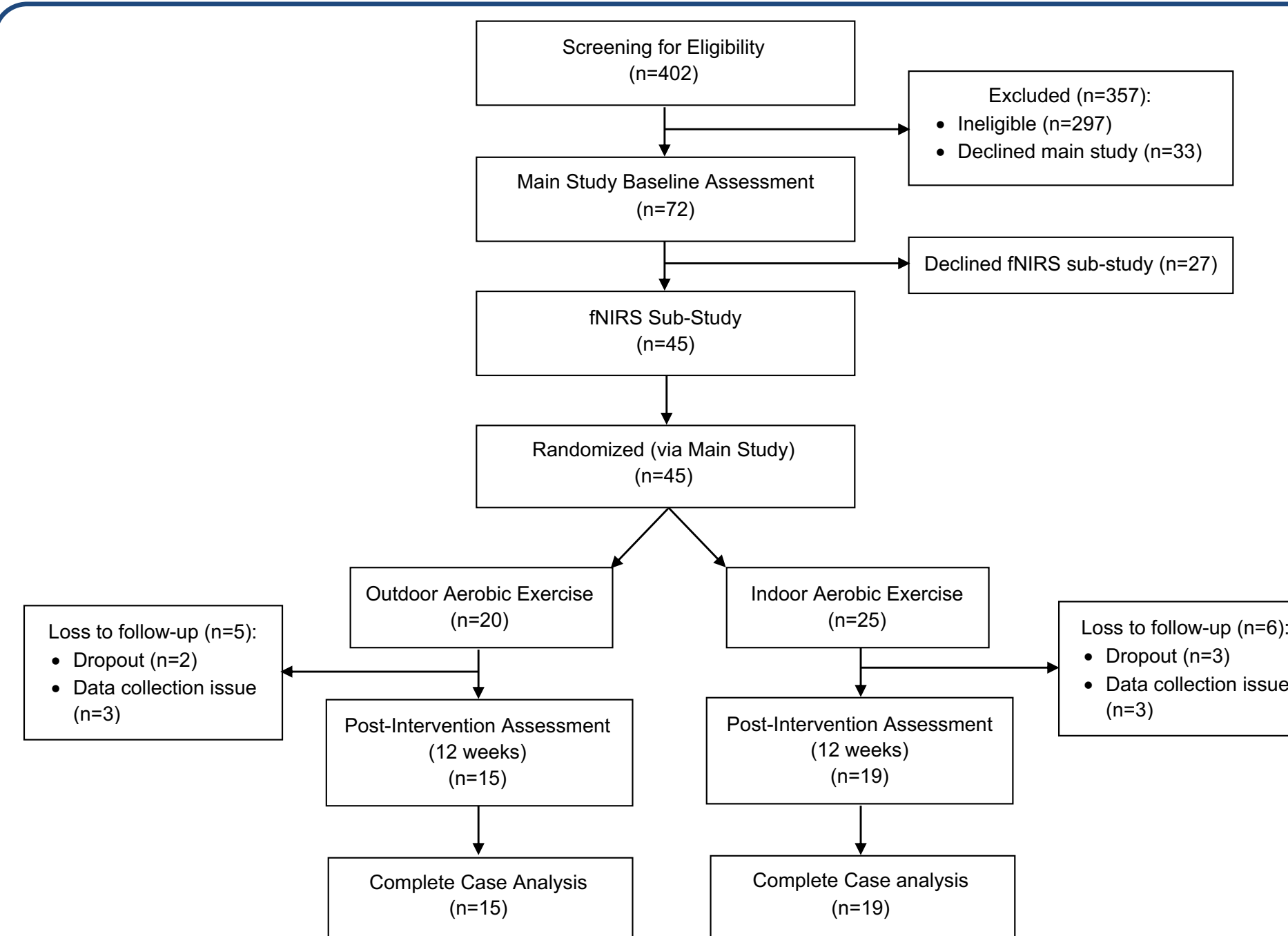


Figure 1. CONSORT participant flow diagram.

Table 1. Baseline participant characteristics. Values are mean (SD) or n (%).

Variable	Indoor Program n=25 Mean (SD) or n (%)	Outdoor Program n=20 Mean (SD) or n (%)
Age (years)	73.40 (4.13)	74.60 (3.23)
Sex: Female, n (%)	11 (44%)	15 (75%)
Male, n (%)	14 (56%)	5 (25%)
Montreal Cognitive Assessment (max. 30 points)	22.16 (2.36)	22.95 (1.54)
Education > High School, n (%)	21 (84%)	19 (95%)
Body Mass Index (kg/m ²)	27.49 (4.66)	28.08 (4.29)
6-Minute Walk Test (m)	473.76 (69.90)	473.30 (90.34)
Physical Activity Scale for the Elderly	119.63 (63.28)	89.58 (35.88)
1-back ΔHbO , bilateral PFC (μM)	7.51 (27.2)	0.83 (19.7)
2-back ΔHbO , bilateral PFC (μM)	4.40 (23.1)	10.6 (20.8)
1-back accuracy (% responses correct)	80.3 (24.9)	81.2 (18.8)
2-back accuracy (% responses correct)	69.0 (17.9)	67.1 (21.2)

Methods

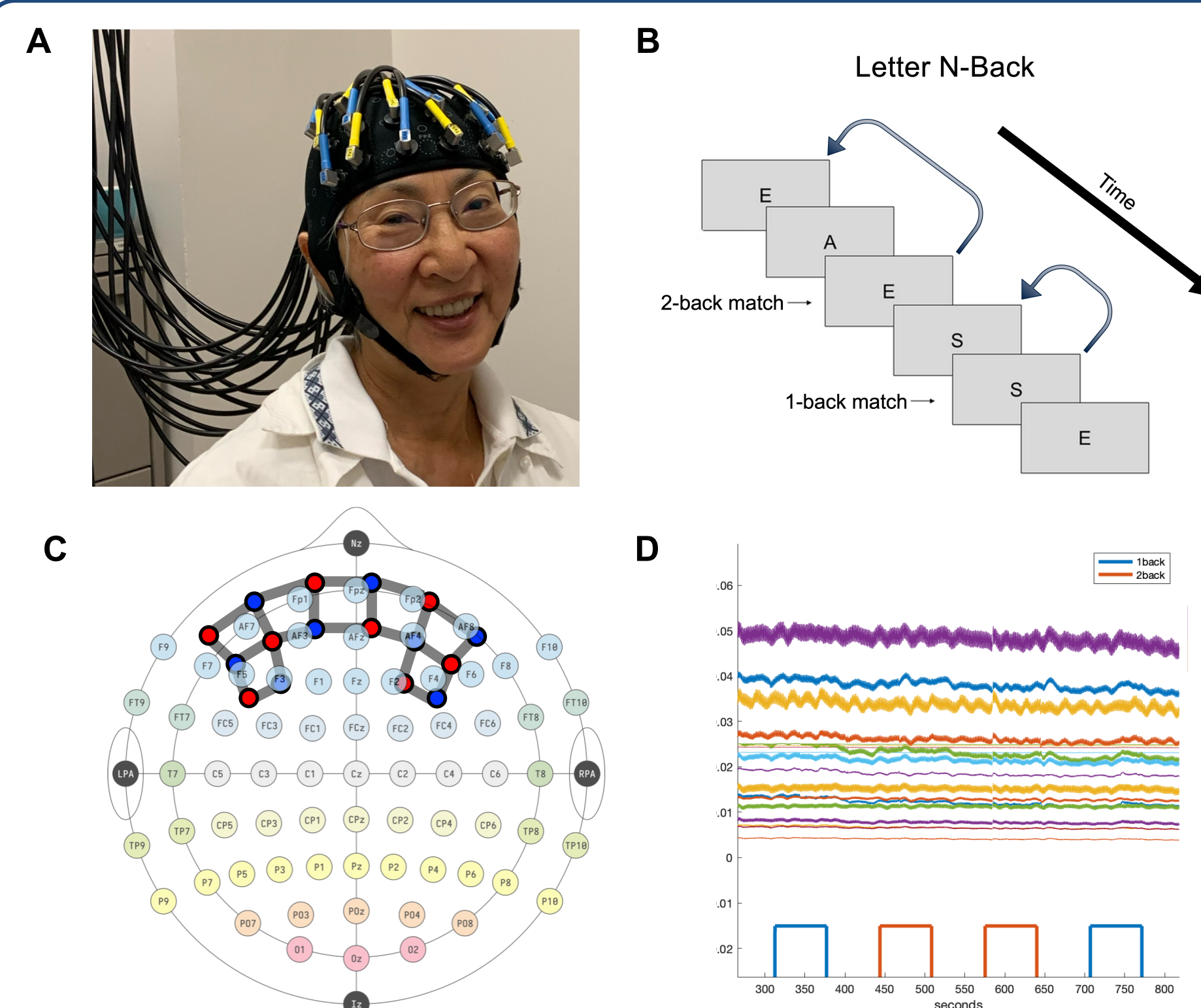


Figure 2. A) fNIRS set-up. B) N-back task. C) Optode layout (red = source, blue = detector) in 10-10 system. D) Sample raw fNIRS data.

Results

There were no significant between-group differences in changes in PFC activity or working memory (Figure 3).

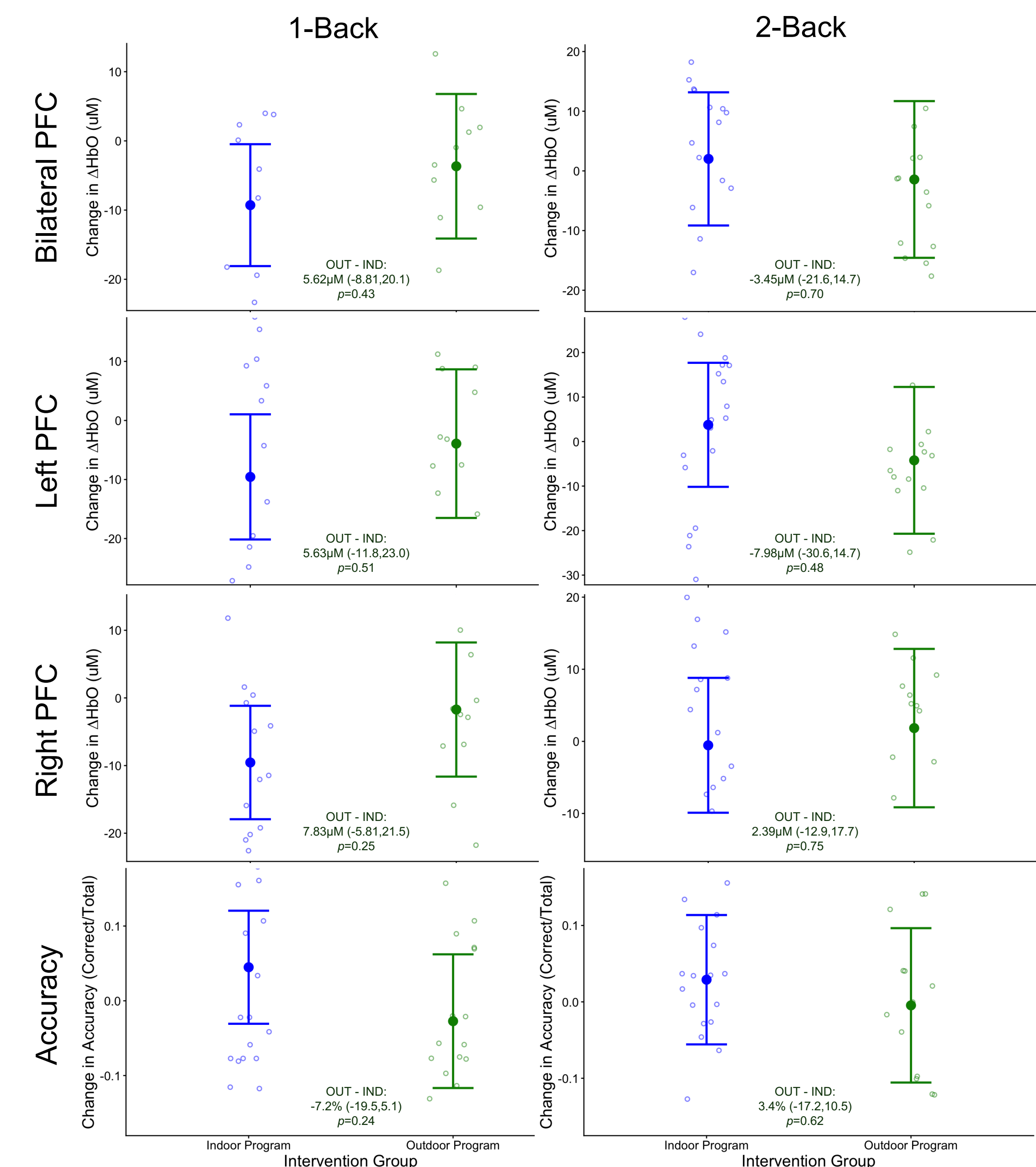


Figure 3. Estimated group mean 12-week changes in task-based PFC oxyhemoglobin changes (ΔHbO) and N-back accuracy. Captions show between-group differences in changes (with 95% confidence intervals and p -values). ANCOVA models adjusted for baseline outcome, baseline MoCA, and sex.

Limitations

- The trial was not powered for these secondary outcomes.
- OUT and IND programs differed in exercise subtype (walking versus cycling) and in exercise mode (overground versus stationary).

Conclusion

Aerobic exercise done outdoors in nature, compared with indoors, did not affect working memory-related prefrontal cortex activity in older adults with MCI.

References

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