A Pilot Investigation of the Dose-Response Relationship Between Executive Function and Cerebral Blood Flow

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Abstract

A 10-min single-bout of aerobic exercise improves executive function. Previous work by our group has shown that an increase in regional cerebral blood flow (CBF) to frontoparietal executive networks contributes to this benefit. It is, however, unclear, whether a dose-response relationship exists between executive function improvement and increased CBF. To address this issue, participants (N=9) completed four experimental sessions including: a VO_{2peak} test to determine cardiorespiratory fitness and lactate threshold (LT), and 10-min bouts of light (i.e., 40% of LT), moderate (i.e., 80% of LT) and heavy (15% of the difference between LT and VO_{2peak}) intensity aerobic exercise (via cycle ergometer). To provide a measure of CBF, during each exercise manipulation blood flow velocity and hemoglobin deoxygenation were measured via transcranial doppler ultrasound (TCD) and near-infrared spectroscopy (NIRS). Notably, pre- and post-condition executive function was determined via the antisaccade task. Antisaccades are an executive-mediated response requiring a saccade mirror-symmetrical to a target stimulus and are mediated via the same frontoparietal networks that show task-dependent changes following single-bout and chronic aerobic exercise. Results show CBF increased linearly with increasing intensity (p=.001), whereas antisaccades elicited a post-exercise improvement during moderate and heavy (ps<.06) – but not light (p=.99) – exercise intensities. Moreover, two one-sided tests indicated that the magnitude of the post-exercise improvement in antisaccade RTs across moderate and heavy intensities was within an equivalence boundary (p=.02). Accordingly, results evince that a minimum exercise intensity and associated increase in CBF is required to elicit a post-exercise benefit to executive function.

Results

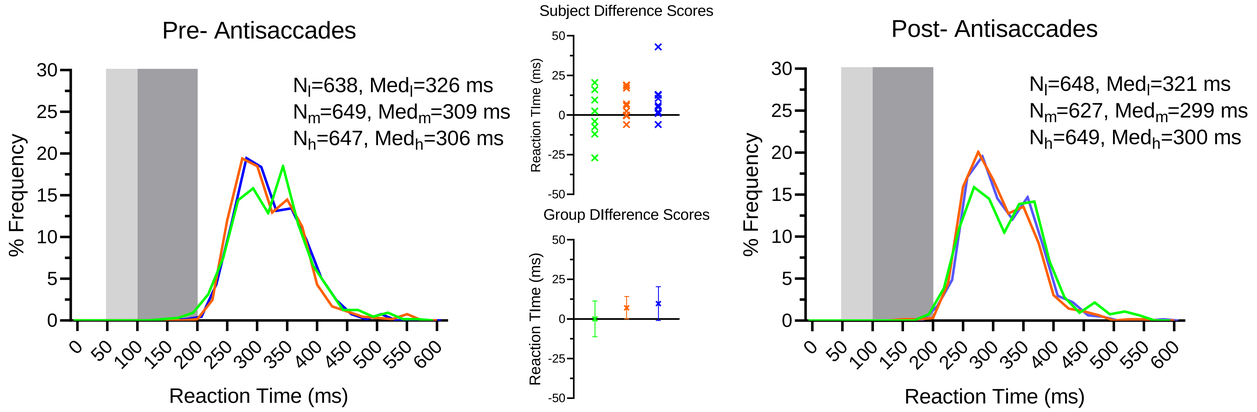

Fig. 1 Antisaccade reaction time (ms) frequency distribution histograms for the light (green), moderate (orange) and heavy (blue) exercise conditions. Light and dark grey boxes depict anticipatory (50-100 ms) and short latency (100-200 ms) saccades. The center panels depict subject-specific (top) and group difference scores.

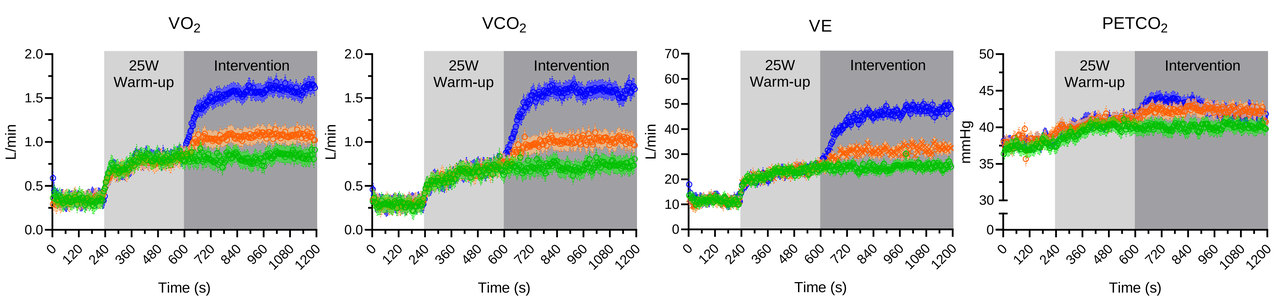

Fig. 2 Group breath-by-breath ventilatory data for oxygen consumption, carbon dioxide production, ventilation and end-tidal carbon dioxide (left to right) via mass spectrometry for the light (green), moderate (orange) and heavy (blue) exercise conditions accompanied by between subject 95% confidence intervals.

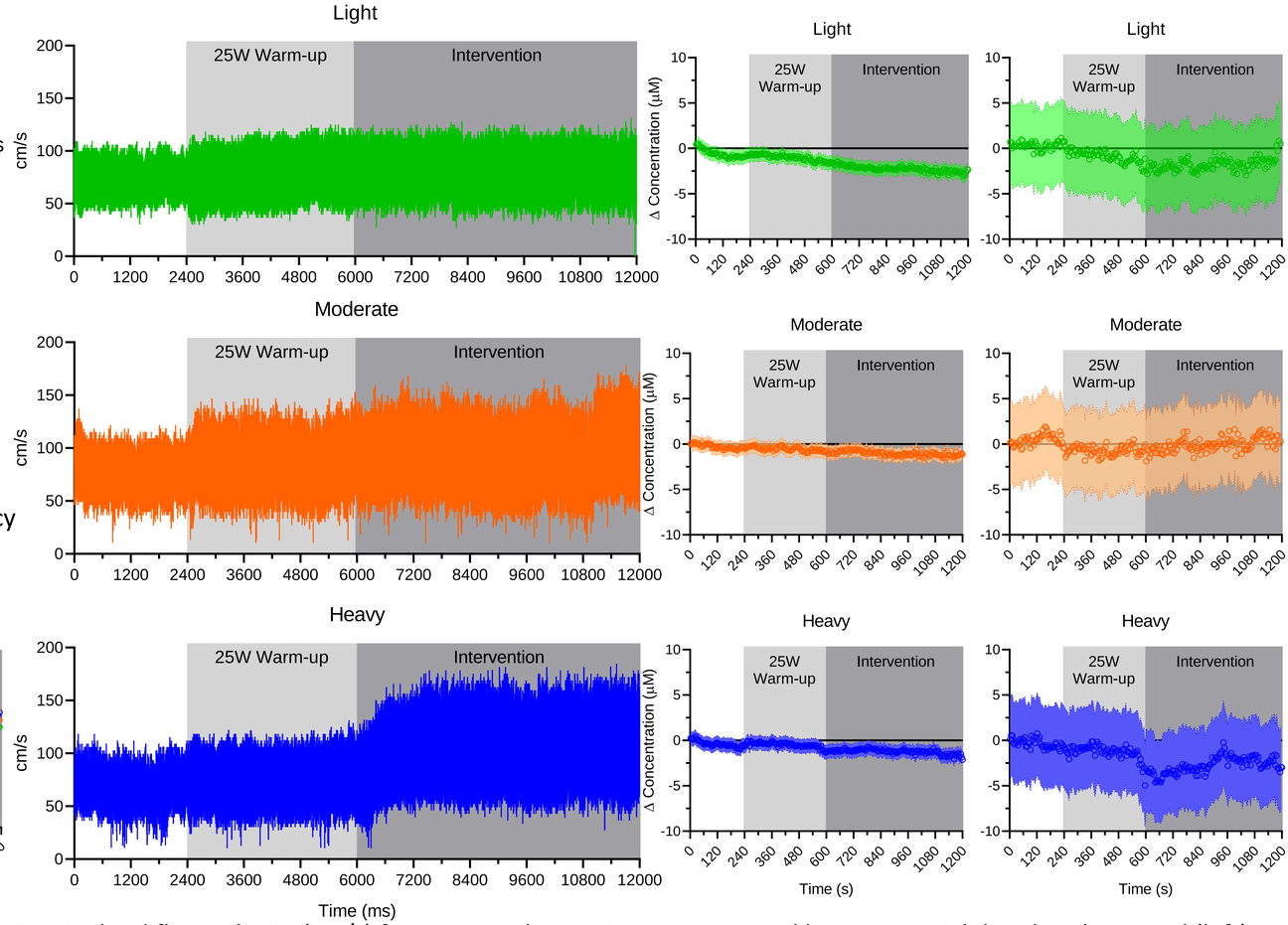

Fig. 3 Blood flow velocity (cm/s) for an exemplar participant measured by transcranial doppler ultrasound (left) and normalized deoxygenated (center) and total hemoglobin concentrations (μM) for the light (green), moderate (orange) and heavy (blue) exercise conditions accompanied by between subject 95% confidence intervals.