

Physical Activity, Executive Functioning, and Frontal Lobe EEG in Early Adolescence

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INTRODUCTION

- **Embodied cognition theory** proposes that cognitive processes are shaped by the body's interactions with the environment
- **Attention-Deficit/Hyperactivity Disorder (ADHD)** is a common neurodevelopmental disorder related to impaired executive functioning (EF) which impacts academic performance.
- **Physical activity (PA)** has been shown to improve EF.
 - Open-skill sports, which require dynamic decision-making (e.g., basketball, soccer) are beneficial for EF
 - Closed-skill sports (e.g., running, swimming) which involve more repetitive movements in predictable environments are thought to be less influential in EF development (Ludyga et al., 2022; Becker et al., 2018).
- **EEG** studies of brain activity during EF tasks have demonstrated key brain regions including the prefrontal cortex across the alpha frequency band (8-12Hz; Arabi, 2023; Casey, 1997).
 - Smaller EEG resting-state-to-task changes have been found to correlate with better EF performance (Allison & Broomell, 2024; Zhang et al., 2018, 2019).

OBJECTIVE

This study explores how frequent engagement in open-skill sports impacts EF performance and is associated with changes in baseline-to-task EEG at alpha frequency bands (8-12 Hz) in the dorsolateral prefrontal cortex (dIPFC).

HYPOTHESES

H1: Frequent engagement in open-skill sports (IV) predicts better EF performance as measured in number of errors (DV) related to set-shifting ability on the WCST.

H2: The relationship between engagement in open sports with errors will vary based on alpha frequency, with grater participation related to lower errors for children with high alpha. For children with low alpha, engagement in open sports will be unrelated to errors.



Participants complete EF tasks while EEG is recorded.

METHODS

Participants ($n=28$; ages 11-14; 62% boys) were recruited from a charter middle school affiliated with Western Carolina University. Participants completed the *Physical Activity Questionnaire for Children (PAQ-C)* and the *Wisconsin Card Sorting Task (WCST)* in counterbalanced order. EEG was recorded during a resting state baseline and the WCST. Power in the 8-12Hz frequency band from frontal electrodes F3, F4, F7, and F8 were averaged as a latent factor.

A structural equation model (SEM) based on 28 observations was estimated using the maximum likelihood with missing values (MLMV) method to examine the regression of predictors *engagement in open sports* and *EEG power* on the dependant variable *number of errors*.

RESULTS

Results indicated main effects of frontal EEG during the WCST as a significant positive predictor of errors, ($B = 6.00$, $SE = 1.80$, $p = .001$), baseline EEG power was a significant negative predictor ($B = -3.05$, $SE = 1.03$, $p = .003$). A significant interaction was found for EEG power during the WCST task across levels of open skilled sports which was predictive of number of errors on the WCST, ($B = -0.95$, $SE = 0.25$, $p < .001$), suggesting that more frequent engagement in open-skilled predicted fewer errors in participants having higher EEG power during the WCST .

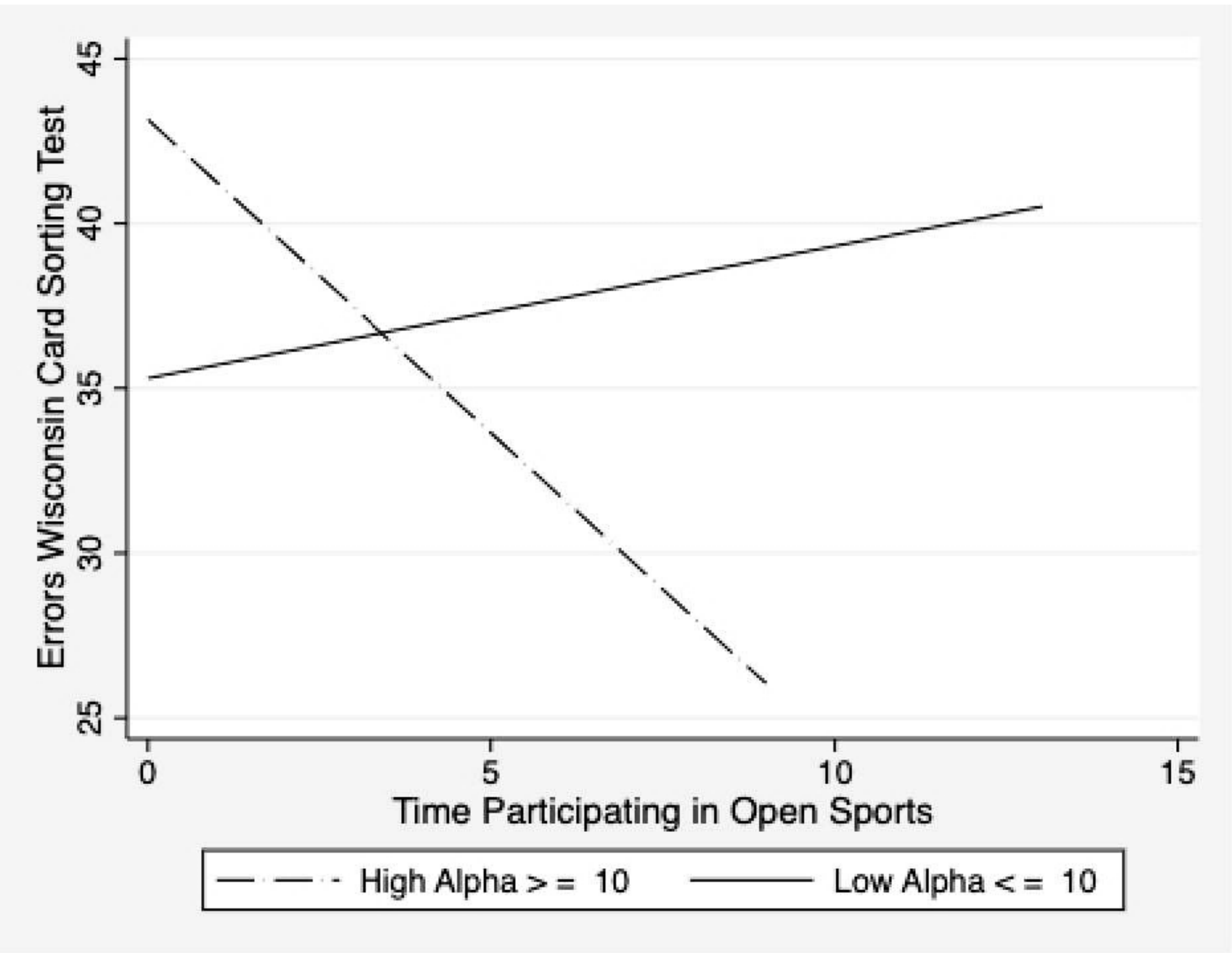
Table 1

Predictor	B	SE	95% CI
alpha during WCST	***6.00	1.80	[2.47, 9.53]
baseline alpha	** -3.05	1.03	[-5.07, -1.04]
engagement in open sports	*2.24	1.03	[0.22, 4.25]
open sports x alpha (WCST)	***-0.95	0.25	[-1.45, -0.45]

* $p < .05$, ** $p < .01$, *** $p < .001$

Figure 1

Weekly Engagement in Open Sports and WCST Errors for Participants having High and Low Alpha Power



CONCLUSIONS AND APPLICATIONS

Finding suggest that participating in open sports could benefit children with poor EF/attention. This provide support for the importance of middle school physical education programs, and encouraging participation in complex sports, such as basketball and soccer, as a strategy to help children struggling with switching attention and flexible reasoning.

References

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