

Variability in Executive Control Performance is Predicted by Physical Activity

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Introduction

- Physically active individuals, relative to their sedentary peers, demonstrate improved cognitive functioning on a multitude of cognitive tasks.
- Physical activity (PA) induces neurogenesis, neurotransmission, synaptogenesis, and angiogenesis (Vivar et al., 2012; Berchicci et al., 2013), effectively altering the structural neuroanatomy of the brain.
- However, the positive effects of PA become stronger and more pronounced in the developing and aging brain, while those same effects are diminished or less robust in young adult populations (Voss et al., 2011; Hötting and Röder, 2013).
- Intraindividual variability (IIV) is sensitive to structural and functional changes to neuroanatomy (MacDonald et al., 2006, 2009).
- Are the benefits of PA for young adults not observable for basic RT but instead for the IIV on that task?

Methods

- Participants**
- Experiment One: $N = 248$ (mean age = 20.49, SD = 2.70, 132 male).
 - Experiment Two: $N = 199$ (mean age = 20.04, SD = 1.76, 46 male).
 - Experiment Three: $N = 195$ (mean age = 20.32, SD = 2.72, 47 male).
- Measures**
- The reaction time coefficient of variation (RTCV) is calculated by dividing the standard deviation of a participant's RT by their mean RT for each measure.
 - Attention Network Test: neutral cue, congruent, incongruent, no cue, central cue, spatial cue, double cue.
 - Eriksen Flanker Task: compatible-congruent or compatible-incongruent.
 - Eriksen Flanker Task: compatible-congruent, compatible-incongruent, incompatible-congruent, or incompatible-incongruent trials.
 - International Physical Activity Questionnaire: a self-administered PA survey that measures free-living PA over the antecedent 7 days. The scoring protocol provides for the calculation of total vigorous, moderate, and low intensity metabolic equivalent of task (MET) values (The IPAQ Group, 2005).
- Scoring Protocols**
- Model 1 employed the International Physical Activity Questionnaire's continuous scoring protocol, with total vigorous, moderate, and low intensity METs as the predictor.
 - Model 2 utilized the total weekly METs independent of intensity level.
 - Model 3 used a scoring protocol that categorizes participants as either sedentary or active according to recommendations by the American College of Sports Medicine (ACSM) (Riebe et al., 2018).

Results

- General Analysis**
- Original analysis found that PA over the previous 7 days did not impact basic RT on executive control tasks (Ho et al., 2018).
 - No evidence of a speed-accuracy tradeoff.
- Experiment One**
- RTCV and moderate PA were positively related, such that more self-reported moderate PA was associated with greater IIV.
 - RTCV and vigorous PA were negatively related.
 - IIV decreased with increasing participant age when controlling for the levels of PA in young adults.
- Experiment Two**
- Physical activity was not predictive of congruent or incongruent RTCV according to any of the scoring protocols employed.
- Experiment Three**
- Neither PA METs by intensity nor total METs were predictive of RTCV of any of the four conditions.
 - ACSM category was predictive of incompatible-congruent RTCV, $\beta = -0.35$, $t(191) = 2.31$, $p = 0.022$.

Discussion

- These results support three conclusions about the role of PA on IIV in cognitive functioning:
- First, the intensity of PA is predictive of IIV in attentional and executive control performance.
 - Second, when controlling for the levels of PA in young adults, IIV decreased with increasing participant age.
 - Lastly, task type and cognitive load are important determinants of the relationship between PA and cognitive performance, with IIV offering a novel measure of cognitive functioning.
- These findings are consistent with prior literature which suggests that the role of PA in young adults is reliant on specific interventions and measures in order to detect effects more readily found in adolescent and aging populations.
- We provide evidence that variability in cognitive performance is responsive to PA in young adults and may prove to be a useful measure of cognitive functioning that to this point has been under-reported in the PA-cognition literature.



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Physical activity is predictive of intraindividual variability on attentional and executive control tasks, but only at particular intensities and on certain tasks, indicating that task type and cognitive load are important determinants of the physical activity-cognition relationship.



Physical Activity Levels		
	Mean	SD
Experiment One		
Low Intensity METs	1282.78	1365.87
Moderate Intensity METs	1072.53	1411.67
Vigorous Intensity METs	1373.87	1782.20
Total METs	3728.70	3045.97
Experiment Two		
Low Intensity METs	2037.83	1776.44
Moderate Intensity METs	1104.16	1456.33
Vigorous Intensity METs	1359.24	2058.08
Total METs	4501.22	3437.42
Experiment Three		
Low Intensity METs	2076.12	2000.06
Moderate Intensity METs	1243.81	1551.68
Vigorous Intensity METs	1623.80	2733.12
Total METs	4943.73	4399.06

Unstandardized Reaction Time in Milliseconds					
	Mean RT	SD RT	Mean RTCOV	SD RTCOV	
Experiment One					
Neutral	559.12	81.06	0.205	0.094	
Congruent	592.31	90.27	0.218	0.087	
Incongruent	694.83	103.58	0.205	0.071	
No Cue	662.46	96.05	0.228	0.079	
Center	612.26	89.37	0.227	0.083	
Spatial	575.94	92.21	0.223	0.085	
Double	611.02	87.42	0.224	0.075	
Experiment Two					
Compatible-Congruent	470.43	56.64	0.143	0.069	
Compatible-Incongruent	525.76	62.82	0.140	0.055	
Experiment Three					
Compatible-Congruent	470.20	65.23	0.171	0.095	
Compatible-Incongruent	520.29	67.88	0.169	0.079	
Incompatible-Congruent	505.01	70.38	0.173	0.075	
Incompatible-Incongruent	530.05	82.93	0.185	0.071	

Physical Activity Intensity as Predictors of RTCOV on the Attention Network Test							
	Neutral Cue	Congruent	Incongruent	No Cue	Central Cue	Spatial Cue	Double Cue
Predictor	β	β	β	β	β	β	β
Age	-.14 *	-.12 *	-.11 .	-.10	-.12 .	-.14 *	-.13 *
Sex	.03	-.01	-.02	-.08	.05	.07	.02
Low Intensity METs	.00	.09	.06	.04	.05	.03	.08
Moderate Intensity METs	.18 **	.17 *	.10	.17 *	.09	.12 .	.15 *
Vigorous Intensity METs	-.13 *	-.09	.07	-.12 .	-.07	-.13 .	-.05
R^2	.06 *	.05 *	.03	.05 *	.03	.04 .	.04 .

Note. A significant β -weight indicates the semi-partial correlation is also significant. . indicates $p < .10$. * indicates $p < .05$. ** indicates $p < .01$.

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