Physical activity and sleep duration (but not efficiency) are each associated with brain function during an inhibitory task: Cross-sectional results from the MONITOR-OA Study

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Background

- Physical activity (PA) and sleep quality are each critical for the maintenance of brain functions which decline with age.

- There is also increasing evidence that PA and sleep quality share a dynamic relationship with each other and cognitive health.

- However, few studies have examined whether PA and sleep are associated with brain function simultaneously, in synergy, or in silos.

Objective

- We investigated the associations of brain activation patterns during an executive performance task with:
  1. Objectively measured PA:
  2. Objectively measured sleep duration
  3. Objectively measured sleep efficiency

Study Design

- We used baseline secondary data from the MONITOR-OA randomized controlled trial.

- At baseline, we measured PA and sleep quality for 7 days using the SenseWear Mini for all 61 trial participants (**Figure 1**).

- A subset of 30 participants underwent a 3T MRI scan using the GO-NOGO executive task (**Figure 2**).

Analysis

- We examined relationships between PA, sleep duration, and efficiency with GO-NOGO reaction time (**Table 2**).

- We contrasted blood-oxygen level dependent (BOLD) signal activity during the NOGO – GO conditions of accurate trials.

- We examined the association of brain activation patterns with PA, sleep duration, and efficiency.
  - Covariates: age, sex, and education
  - Significant clusters were corrected for multiple comparisons ($p < 0.05$)
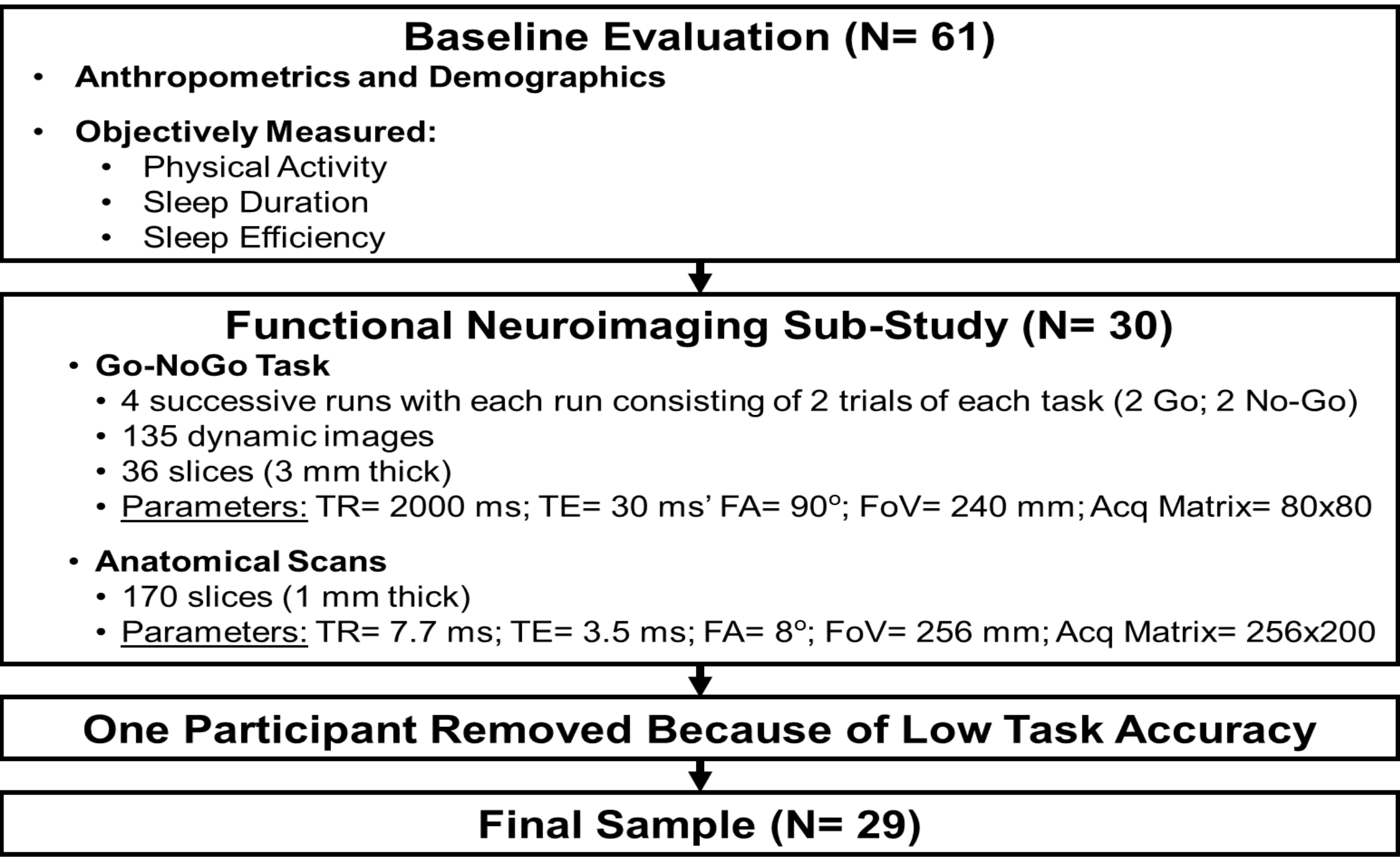 - Significant clusters are highlighted in red in **Figure 3**
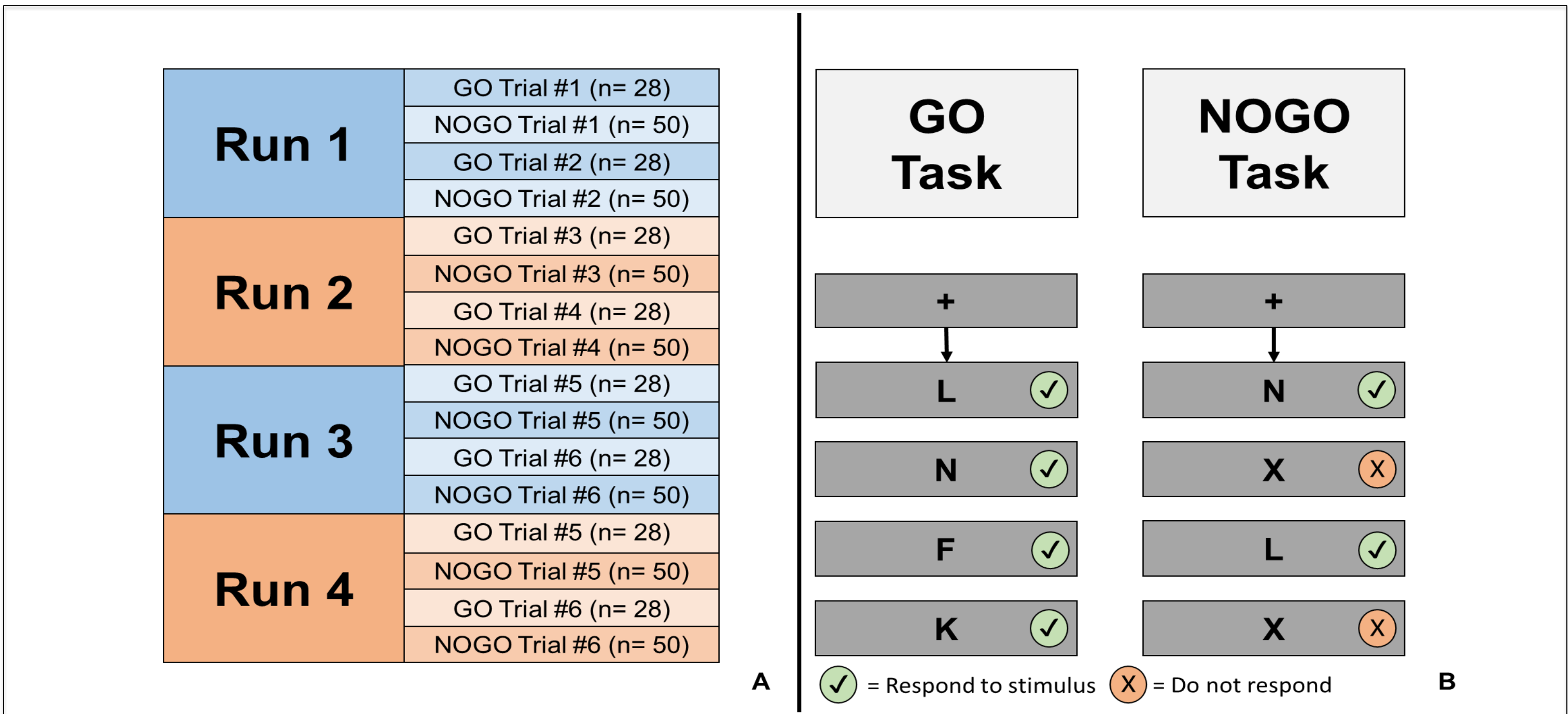

Figure 1. STROBE Diagram

Figure 2. Illustration of the fMRI task (GO-NOGO)

A) Illustration of run and trial order for the GO and NOGO condition. Participants completed a total of 112 GO conditions, and 200 NOGO conditions.

B) Description of the GO-NOGO task. GO trials required finger tapping responses to 4 letters (L, N, F, or K). During NOGO trials, participants responded to the same letters, but were asked also to not respond to the letter X.

Participant Characteristic	All Participants (N= 61)	MRI Participants (N= 29)	Non-MRI Participants (N= 32)	p
Age (years)	62 (9)	61 (9)	63 (8)	0.46
%Female	82%	79%		0.74
BMI (kg/m²)	29.20 (5.10)	29.61 (4.80)	28.83 (5.41)	0.56
Montreal Cognitive Assessment	26.76 (2.76)	27.30 (1.84)	26.31 (3.26)	0.17
Education				
High School Degree or Less	18%	21%	15%	
Some University	31%	21%	41%	0.25
University Degree or Higher	51%	58%	44%	
Physical Activity (min/day)	85 (74)	72 (48)	97 (91)	0.19
Sleep Duration (min/day)	428 (62)	441 (59)	416 (62)	0.11
Sleep Efficiency (%)	84 (7)	84 (8)	83 (6)	0.71
GO Trial Reaction Time (ms)	-	296 (66)	-	-
GO Trial Accuracy (%)	-	94 (9)	-	-
NOGO Trial Reaction Time (ms)	-	343 (37)	-	-
NOGO Trial Accuracy (%)	-	95 (8)	-	-

Table 1. Participant Characteristics

	Age	BMI	Physical Activity	Sleep Duration	Sleep Efficiency	GO Trial RT	NOGO Trial RT	GO Trial Accuracy	NOGO Trial Accuracy
Age	-	-	-	-	-	-	-	-	-
BMI	-0.169	-	-	-	-	-	-	-	-
Physical Activity	**-0.471**	-0.289	-	-	-	-	-	-	-
Sleep Duration	-0.386	-0.039	0.155	-	-	-	-	-	-
Sleep Efficiency	-0.033	-0.150	0.282	0.309	-	-	-	-	-
GO Trial RT	0.192	0.115	0.163	-0.005	0.016	-	-	-	-
NOGO Trial RT	0.066	0.157	0.122	0.048	0.115	**0.737**	-	-	-
GO Trial Accuracy	-0.118	0.038	0.230	0.258	-0.199	0.007	0.142	-	-
NOGO Trial Accuracy	-0.317	0.152	0.163	0.179	-0.199	-0.333	-0.034	**0.793**	-

Table 2. Bivariate correlations
Significant correlations ($p < 0.05$) are in **bold**

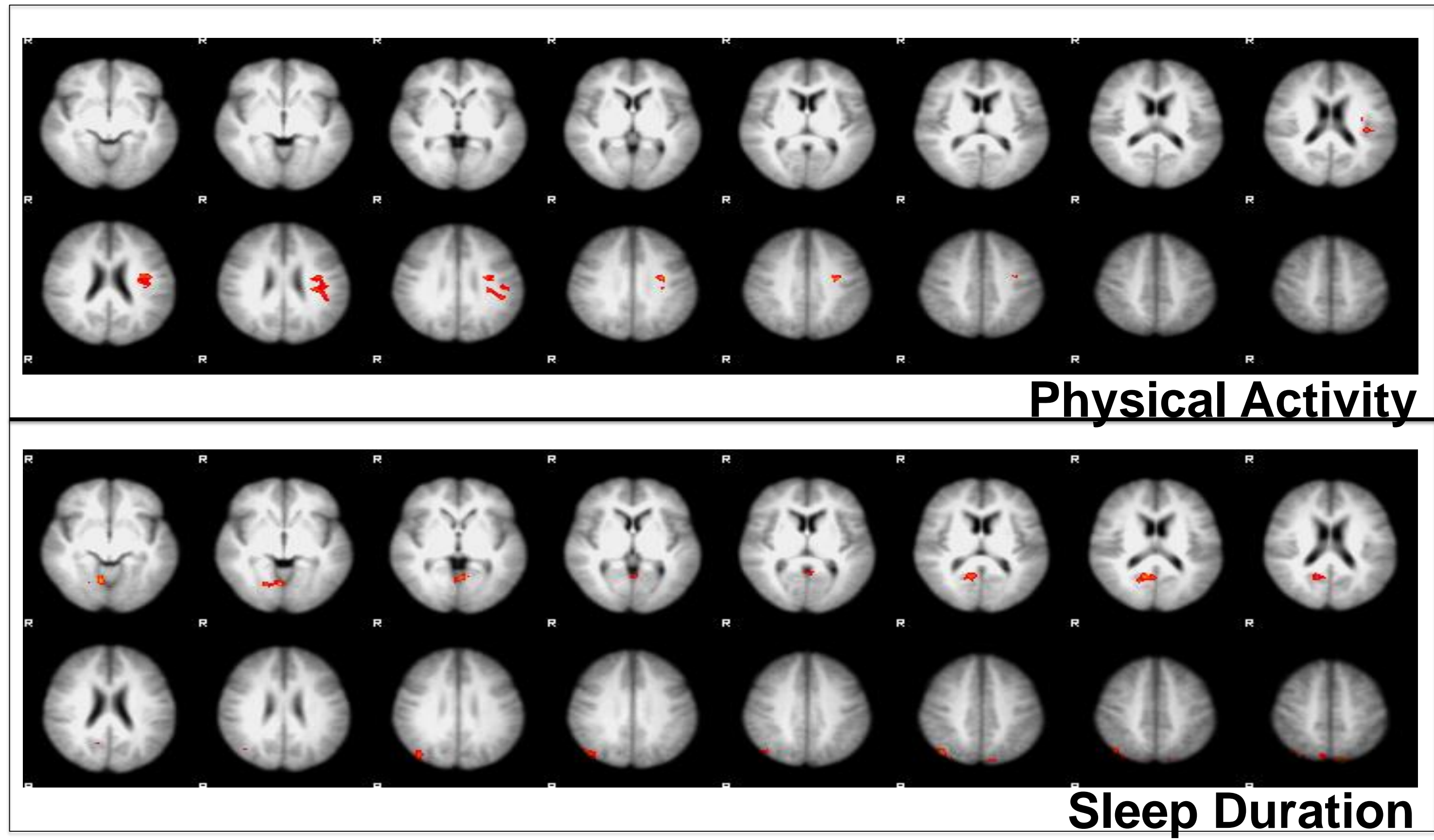**Physical Activity**

Sleep Duration

Figure 3. Association of BOLD signals for NOGO – GO contrast with physical activity and sleep duration (no association for sleep efficiency)
↑PA was associated with ↑BOLD signal activity in the insular cortex.

↑sleep duration was associated with ↑BOLD signal activity in the precuneus, lingual gyrus, and lateral occipital cortex

Conclusion

- **PA and sleep duration are each associated with ↑brain activation** in regions which are 1) associated with executive performance; and 2) susceptible to age-associated decline.

- **Sleep efficiency is not associated with brain activity** patterns associated with executive functions

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