



# Effects of arterial stiffness between objectively measured physical activity and domain-specific cognition in older adults



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## Abstract

**Purpose:** To examine the effects of arterial stiffness (AS) on the associations between objectively measured physical activity (PA) and domain-specific cognitive functioning in older adults. **Methods:** This cross-sectional analysis included baseline data from 415 older adults enrolled in the Physical Activity and Aging Study (PAAS). Cognitive functioning was measured by working memory using Digit Span Test and selective attention and processing speed using computerized Stroop Test. PA over 7 days was measured with Omron accelerometer-based pedometers and time engaged in light-, moderate-, and vigorous-intensity PA with FitBit Charge 2 wristbands. AS was derived from carotid-femoral pulse wave velocity (cfPWV; AtCor Sphygmocor XCEL). High AS status was defined as cfPWV  $\geq 10$  m/s, which is an established risk factor of cardiovascular diseases. Multivariable linear regression was used to model the associations between PA, AS, and each cognitive-domain score. **Results:** Participants were a mean age of 72 ( $\pm 6$ ) years old and were well educated with 82% having a bachelor's degree or higher. Participants were also cognitively healthy (Mean Score of Mini-Mental State Examination 29.2 [ $\pm 1.29$ ] out of 30). Participants with high AS status (20.96%, n=87) accumulated fewer total steps per day ( $p=0.01$ ), engaged in less light-intensity PA ( $p<0.01$ ) compared to those with low AS. There were no significant group differences for other cognitive test scores. Light-intensity PA was associated with better performance on the digit span forward among those with high AS ( $p=0.01$ ), but not those with low AS status, after adjusting for age, sex, education, diabetes, hypertension, current smoking status, and heavy alcohol intake ( $p=0.01$ ) from linear regression. However, no significant results were found in other PA variables regardless of AS status. **Conclusion:** These results suggest a possible benefit of light-intensity PA on working memory among older adults with high AS status, who are at higher risk of developing cardiovascular diseases.

## Introduction

High arterial stiffness (AS) is an established risk factor of cardiovascular diseases that can have detrimental effects on cognitive health. The benefits of physical activity (PA) in cognitive health are well described, but the effect of AS between objectively measured PA and cognition among older adults is not well described.

## Objective

To examine the effects of AS on the associations between objectively measured PA and domain-specific cognitive functioning in older adults.

## Methods

### Participants:

- 415 older adults enrolled in the Physical Activity and Aging Study (PAAS).
- Inclusion criteria:**  $\geq 65$  years old at recruitment. **Exclusion criteria:** previous stroke, self-reported colorblindness, and depressive symptoms (scoring  $\geq 9$  on the Geriatric Depression Scale).

## Methods

### Measures:

- Cognitive functioning was measured with the Digit Span Test (working memory), in which higher score meant better performance; and Stroop Test (selective attention and processing speed) in which shorter time meant better performance. Time engaged in light-, moderate-, and vigorous-intensity PA was measured with FitBit Charge 2 wristbands.
- AS was derived from carotid-femoral pulse wave velocity (cfPWV; AtCor Sphygmocor XCEL). The higher velocity, the higher AS. **High AS** was defined as cfPWV  $\geq 10$  m/s, which is an established risk factor of cardiovascular diseases.

### Data analysis:

Multivariable linear regression was used to model the associations between PA and each cognitive-domain score for low and high AS groups.

**Covariates:** Sex, age, education, diabetes, hypertension, smoking, and heavy alcohol intake.

## Results

Table 1. Sample Characteristics by Arterial Stiffness Status

Characteristic	Low AS Status <sup>a</sup>	High AS Status <sup>b</sup>	p-value
n	328	87	
Age, y	71.3 (5.5)	74.7 (6.5)	<.001
Female, n (%)	195 (83.3)	39 (16.7)	0.015
Education			
High School or Technical Degree, n (%)	59 (17.9)	17 (19.5)	0.746
Bachelor's degree, n (%)	120 (36.6)	28 (32.2)	
Beyond bachelor's degree, n (%)	149 (45.4)	42 (48.3)	
MMSE score <sup>c</sup>	29.3 (1.2)	28.9 (1.3)	0.052
Hypertensive, n (%)	125 (38.1)	47 (54.0)	0.007
Diabetes Mellitus II, n (%)	16 (4.9)	17 (19.5)	<.001
Smoking Status, n (%)	3 (0.9)	1 (1.2)	0.842
Heavy Drinking <sup>d</sup> , n (%)	2 (0.6)	2 (2.3)	0.152
cfPWV <sup>e</sup> , m/s	7.99 (1.1)	11.38 (1.9)	<.001
Steps per day	5.93 (3.2)	4.96 (3.0)	0.010
Meeting physical activity guidelines <sup>f</sup> , n (%)	89 (27.1)	16 (18.4)	0.095
Stroop test Congruent reaction time, ms	1309.9 (863.8)	1369.70 (480.3)	0.062
Stroop test Incongruent reaction time, ms	2021.4 (5287.0)	1587.29 (545.7)	0.439
Digit span backwards score <sup>g</sup>	5.0 (1.5)	4.7 (1.3)	0.098
Digit span forward score <sup>g</sup>	6.4 (1.2)	6.38 (1.2)	0.744

Unless otherwise indicated, values are presented as mean (SD). <sup>a</sup> AS, Arterial stiffness status defined as low when carotid femoral pulse wave velocity (cfPWV)  $< 10$  m/s; <sup>b</sup> cfPWV  $\geq 10$  m/s; <sup>c</sup> Mini mental state examination; <sup>d</sup>  $> 14$  drinks/week for men,  $> 7$  drinks/week for women; <sup>e</sup> cfPWV, carotid femoral pulse wave velocity; <sup>f</sup>  $> 7500$  steps/day; <sup>g</sup> Maximum number of words recalled.

## Results

Table 2. Multivariable Linear Regression of time engaged in Physical Activity and Arterial Stiffness status with Domain-specific cognitive scores

	DSF <sup>a</sup> Score		DSB <sup>b</sup> Score		Stroop test Congruent reaction time		Stroop test Incongruent reaction time	
	B (SE)	p-value	B (SE)	p-value	B (SE)	p-value	B (SE)	p-value
Light-intensity PA <sup>c</sup> , hours	0.003 (0.01)	0.749	-0.01 (0.01)	0.693	0.002 (0.00)	0.481	0.01 (0.01)	0.196
Moderate-intensity PA <sup>c</sup> , hours	-0.03 (0.03)	0.279	-0.02 (0.03)	0.536	0.003 (0.01)	0.692	-0.003 (0.01)	0.797
Vigorous-intensity PA <sup>c</sup> , hours	-0.04 (0.03)	0.094	-0.01 (0.03)	0.732	-0.004 (0.01)	0.534	-0.01 (0.01)	0.323
Arterial Stiffness status, m/s	0.05 (0.21)	0.818	-0.29 (0.27)	0.270	0.05 (0.06)	0.440	-0.05 (0.10)	0.585
Light-intensity PA <sup>c</sup> *Arterial Stiffness status	<b>0.07 (0.03)</b>	<b>0.013</b>	0.02 (0.03)	0.616	-0.01 (0.01)	0.518	-0.02 (0.01)	0.171
Moderate-intensity PA <sup>c</sup> *Arterial Stiffness status	<b>0.14 (0.06)</b>	<b>0.022</b>	0.07 (0.08)	0.342	0.01 (0.02)	0.773	0.01 (0.03)	0.796
Vigorous-intensity PA <sup>c</sup> *Arterial Stiffness status	-0.03 (0.08)	0.764	-0.01 (0.11)	0.995	0.00 (0.03)	0.934	0.01 (0.04)	0.793

<sup>a</sup> DSF=Digit Span Forward; <sup>b</sup> DSB=Digit Span Backwards; <sup>c</sup> PA=Physical Activity. Arterial stiffness status as a categorical variable defined as low when carotid femoral pulse wave velocity (cfPWV)  $< 10$  m/s and high and high cfPWV  $> 10$  m/s. B = Regression coefficients. Congruent and Incongruent Reaction times obtained from Stroop Test were log transformed. Multivariable linear models adjusted for age, sex, education, self-reported hypertension, self-reported diabetes type II, smoking status, and heavy alcohol intake.

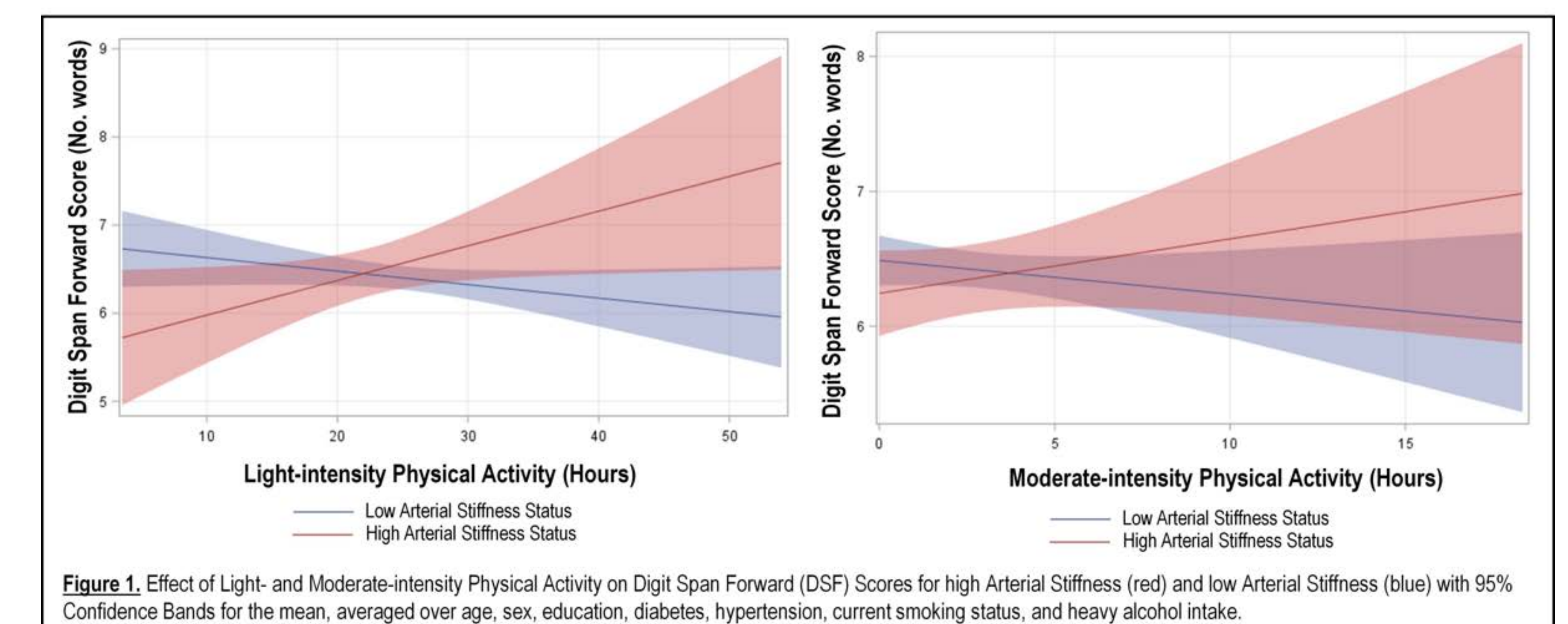


Figure 1. Effect of Light- and Moderate-intensity Physical Activity on Digit Span Forward (DSF) Scores for high Arterial Stiffness (red) and low Arterial Stiffness (blue) with 95% Confidence Bands for the mean, averaged over age, sex, education, diabetes, hypertension, current smoking status, and heavy alcohol intake.

## Conclusion

These results suggest a possible benefit of light- and moderate-intensity PA on working memory among older adults with high AS status, who are at higher risk of developing cardiovascular diseases.

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