

## Prefrontal cortical activation in simple and choice stepping in healthy older adults and older adults with mild-to-moderate dementia

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**Introduction:** Older adults with dementia are two to three times more likely to fall compared to their healthy counterparts. Choice stepping (i.e., the ability to take a series of rapid and accurate steps during walking) is one of the strong determinants of fall risk in older adults. The prefrontal cortex, the center of executive control, is responsible for mediating choice stepping performance. However, the neural dynamics of prefrontal cortical involvement during different stepping tasks in older adults with mild-to-moderate dementia have never been investigated.

This study aimed to examine prefrontal cortical activation during simple and choice stepping in healthy older adults and those with mild-to-moderate dementia.

**Methodology:** This study was a cross-sectional study. Fifteen healthy older adults (HC) and 16 older adults with mild-to-moderate dementia (MD) who could walk 10 meters independently were recruited. The participants were instructed to perform a series of simple stepping tasks (i.e., taking steps to the same target repeatedly) and choice stepping tasks (i.e., taking steps to different targets) in a random order. Functional near-infrared spectroscopy was used to assess the hemodynamic changes in the participants' prefrontal cortical regions during the stepping tasks. Two-way repeated analysis of covariance with task (simple stepping, choice stepping) as a within-group factor, group (HC, MD) as a between-group factor, and age and body mass index as covariates was used to compare the hemodynamic changes between the two groups.

**Results:** HC showed significantly greater activations in right dorsolateral prefrontal cortex ( $p = 0.004$ ), right frontopolar cortex ( $p = 0.011$ ), and right orbitofrontal cortex ( $p = 0.004$ ) during choice stepping than simple stepping (Table 1). MD showed greater right dorsolateral prefrontal cortex activation during both simple ( $p = 0.009$ ) and choice stepping ( $p = 0.010$ ) than HC (Figure 1). No significant "task x group" interaction was found in any prefrontal cortical region.

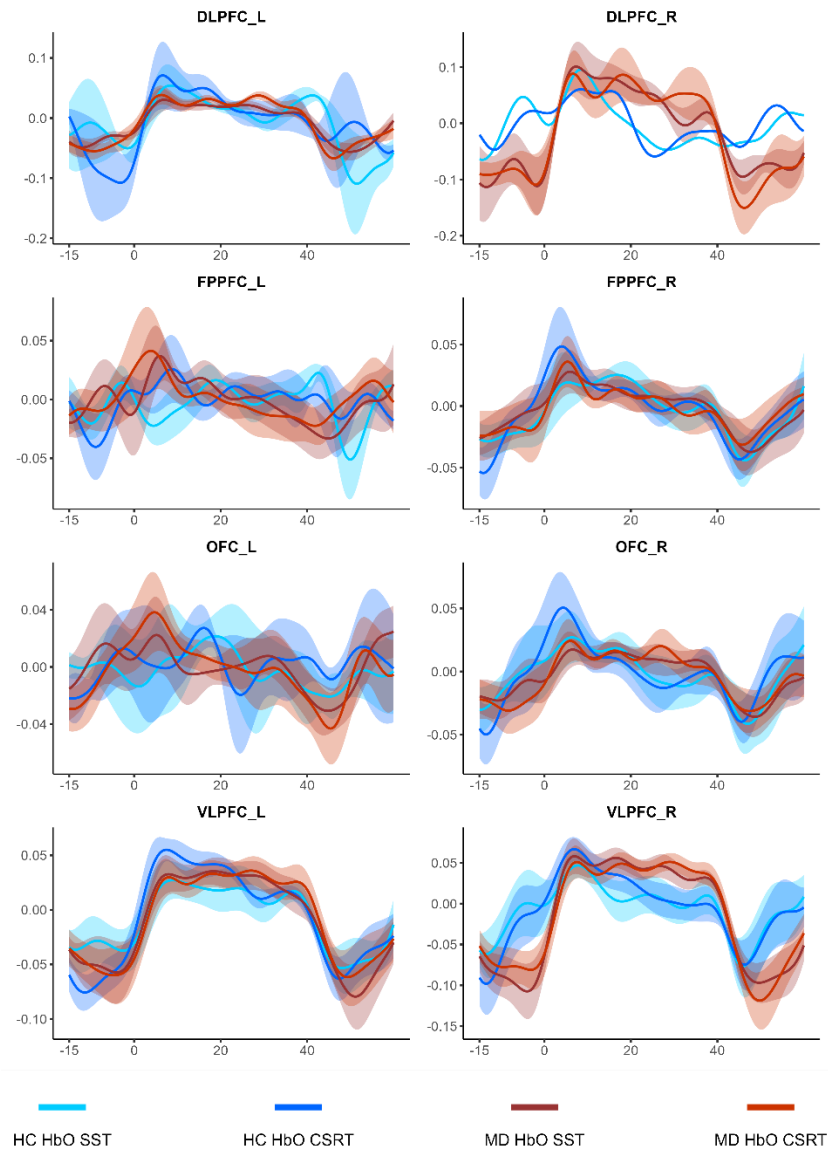
**Conclusions:** Older adults with mild-to-moderate dementia need to activate prefrontal cortex in both simple and choice stepping. In contrast, healthy older adults need to activate prefrontal cortical regions only in choice stepping. This indicates that the neural efficiency of older adults with mild-to-moderate dementia in stepping tasks is reduced, which in turn increases the risk of falls in this population. Our findings provide valuable insights into the neurophysiological risk factors for falls in older adults with mild-to-moderate dementia, as well as evidence for improving fall risk assessment tailored to this population.

**Table 1.** Comparison of changes in HbO2 across prefrontal cortical regions during simple and choice stepping tasks between groups.

Region of Interest	Task	Healthy control (n=15)	Mild dementia (n=16)	Task <i>P</i> value	Group <i>P</i> value	Group * Task <i>P</i> value
		Mean ± SD	Mean ± SD			
<b>DLPFC (Left)</b>	SS	0.007 ± 0.149	0.046 ± 0.161	0.462	0.54	0.710
	CS	0.025 ± 0.182	0.052 ± 0.181			
<b>DLPFC (Right)</b>	SS	-0.03 ± 0.32	0.129 ± 0.29	<b>0.004</b>	<b>0.012</b>	0.437
	CS	0.008 ± 0.337	0.149 ± 0.304			
<b>FPPFC (Left)</b>	SS	0.035 ± 0.15	-0.008 ± 0.167	0.083	0.543	0.72
	CS	0.054 ± 0.172	0.006 ± 0.167			
<b>FPPFC (Right)</b>	SS	0.015 ± 0.151	0.016 ± 0.12	<b>0.011</b>	0.543	0.337
	CS	0.043 ± 0.168	0.028 ± 0.116			
<b>VLPFC (Left)</b>	SS	-0.16 ± 0.484	0.081 ± 0.723	0.078	0.55	0.102
	CS	0.053 ± 0.411	-0.038 ± 0.543			
<b>VLPFC (Right)</b>	SS	-0.007 ± 0.38	0.034 ± 0.175	0.871	0.55	0.455
	CS	-0.01 ± 0.402	0.056 ± 0.178			
<b>OFC (Left)</b>	SS	-0.076 ± 0.314	0.031 ± 0.275	0.455	0.54	0.71
	CS	-0.06 ± 0.323	0.036 ± 0.277			
<b>OFC (Right)</b>	SS	0.122 ± 0.106	0.106 ± 0.081	<b>0.004</b>	0.72	0.431
	CS	0.148 ± 0.105	0.115 ± 0.095			

DLPFC, Dorsolateral Prefrontal Cortex; FPPFC, Frontopolar Prefrontal Cortex; VLPFC, Ventrolateral Prefrontal Cortex; OFC, Orbitofrontal Cortex; CS, Choice Stepping Task; SS, Simple Stepping Task.

*P* values were adjusted using the FDR correction (based on eight regions of interest).



**Figure 1.** Group-level temporal dynamics of HbO activation during SS and CS tasks across eight prefrontal cortex regions in the two groups.

DLPFC\_L, Left Dorsolateral Prefrontal Cortex; FPPFC\_L, Left Frontopolar Prefrontal Cortex; VLPFC\_L, Left Ventrolateral Prefrontal Cortex; OFC\_L, Left Orbitofrontal Cortex; DLPFC\_R, Right Dorsolateral Prefrontal Cortex; FPPFC\_R, Right Frontopolar Prefrontal Cortex; VLPFC\_R, Right Ventrolateral Prefrontal Cortex; OFC\_R, Right Orbitofrontal Cortex; HC, health control; MD, mild dementia; SS, simple stepping task; CS, choice stepping task; Each panel represents one region of interest (ROI), with time aligned to trial onset (rest, -15 - 0 s; task 0 - 40 s). The shaded area around each line represents the standard error of the mean (SEM) across participants.