

Neural Correlates of Dual-Task Standing Balance in Older Adults with Mild Cognitive Impairment: An EEG Study

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INTRODUCTION

- Mild cognitive impairment (MCI) is characterized by declines in executive function, attention, and memory that impair the coordination of cognitive and motor processes, making dual-task standing particularly challenging.
- Individuals with MCI exhibit greater postural sway than cognitively healthy older adults and are **~10 times more likely to progress to dementia than cognitively healthy older adults.**¹
- Cortical alpha oscillations (8-13 Hz) reflect inhibitory neural processes that regulate attention and information flow, and **alpha power decreases as postural demands increase.**^{4,6}
- The cortical alpha dynamics underlying dual-task standing in older adults with MCI remain poorly understood.
- This study examines alpha power during dual-task standing to identify EEG biomarkers of impaired postural control.

HYPOTHESIS

- Older adults with MCI would exhibit a greater decrease in alpha power during dual-tasking compared to cognitively healthy older adults.
- Subjects with a greater decrease in EEG alpha power would also exhibit greater dual-task cost, as measured by increased postural sway and impaired balance.

METHODS

- Participants:** MCI: n=10 (Montreal Cognitive Assessment [MoCA] 21-24). Cognitively intact: n=15 (MoCA 25-30).
- Instrumentation:** Motion sensors (APDM, Portland, OR) were placed on both insteps and the lumbar spine (Figure 1).
- EEG was recorded using the **Starstim Enobio 32-channel** wet cap aligned to the international 10-20 system (Figure 2).
- Procedures:** Two 60-second trials were completed under two conditions:

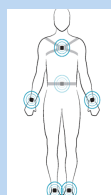


Figure 1. Inertial sensor placement (Mobility Lab Opal; APDM, Inc).⁴

- Quiet standing:** Standing quietly with eyes open.
- Dual-task standing:** Standing with eyes open while performing serial subtractions.
- EEG Processing and Analysis:** Raw EEG data were recorded at 500 Hz, converted using MATLAB, and preprocessed in CARTOOL. Signals were band-pass filtered (1-80 Hz), notch filtered (60 Hz), re-referenced, and noisy channels were interpolated.



Figure 2. Starstim 32-Channel EEG Cap by Neuroelectrics.⁵

- Independent Component Analysis (ICA)** removed eye-blink and motion artifacts. Data were segmented into **2-second epochs** and concatenated for **Fast Fourier Transform (FFT)**. Absolute theta, alpha, and beta power were calculated from predefined regions of interest (left/right anterior, central, posterior).

RESULTS

Table 1. Participant Characteristics

Variables	Older Adults with MCI (n=10)	Cognitively-intact older adults (n=15)
Age (mean and SD)	76 ± 7	73 ± 4.2
Sex (n, female)	7	9
Height (m)	1.6 ± 0.1	1.7 ± 0.2
Body mass (kg)	77 ± 18	76 ± 20
MoCA	22.63 ± 1.2	27.21 ± 2.2

- Repeated Measures ANOVA demonstrated that **older adults with MCI exhibited decreased alpha power in the central left and right regions** from quiet standing to dual-tasking ($p = 0.002$) compared to healthy controls ($p = 0.01$) without an interaction effect ($p = 0.19$) (Figure 3), with similar results in the central left region (Figure 4).
- No significant difference was observed for theta and beta-band powers** between MCI older adults and healthy controls.

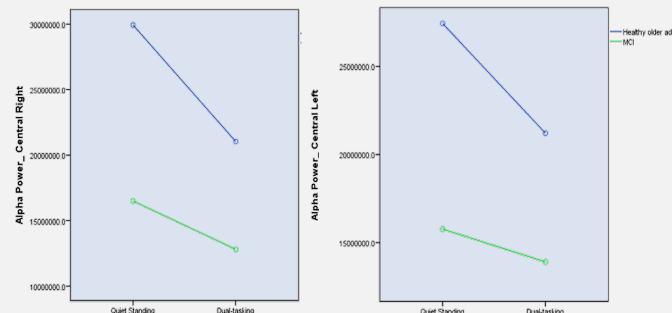


Figure 3. Alpha power in the central right region in healthy older adults (blue) and MCI (green) in quiet and dual-task conditions.

Figure 4. Alpha power in the central left region in healthy older adults (blue) and MCI (green) in quiet and dual-task conditions.

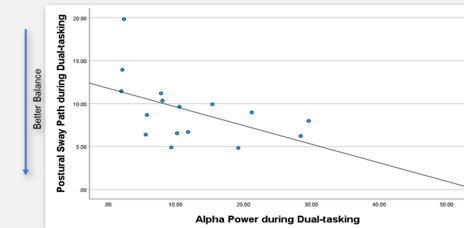


Figure 5. Correlation analysis between postural sway and alpha power during dual-tasking.

- Lower alpha power during dual-task standing was associated with greater dual-task cost, reflected by increased postural sway ($r = -0.47$, $p = 0.01$).

DISCUSSION

- Older adults with MCI exhibited a greater decrease in alpha power from quiet standing to dual-task standing than cognitively intact older adults.
- Within the MCI group, lower alpha power during dual-task standing was associated with greater postural sway, suggesting a role for alpha activity in supporting postural control.
- Reduced alpha band power has been linked to decreased cortical inhibition, which may contribute to poorer balance during dual-task standing.^{7,8}
- Strategies that enhance cortical function during dual-task standing may improve balance and reduce fall risk in older adults with MCI.
- These findings support alpha power as a potential neurophysiological biomarker of early motor-cognitive decline and a target for interventions, such as non-invasive brain stimulation.

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