Associations Between Motor Cortex Inhibition & Gait Variability

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Background & Objective

The ability to coordinate both legs during walking is important for proper and effective ambulation.

Levels of Gamma-Aminobutyric acid (GABA) within the motor cortex are significantly associated with control and coordination of the upper extremities[1].

The objective of this project was to understand how motor cortex inhibition contributes to the control of gait in healthy young adults using transcranial magnetic stimulation and wireless inertial sensors.

Methods & Design

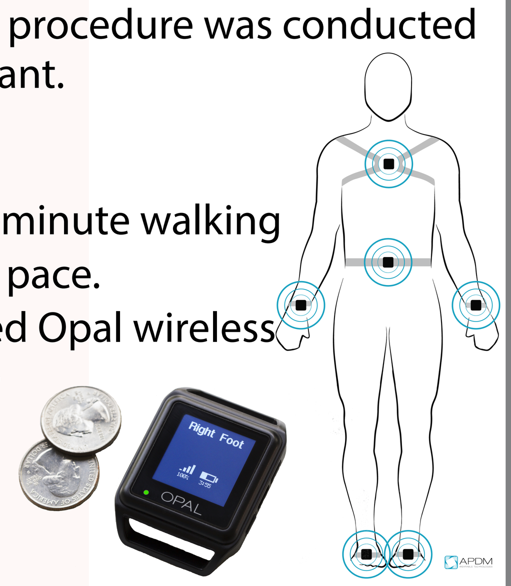
- 14 Young adults: Gender: 9 M | 5 F; Age (y) (24.37±3.58); Weight (kg) (69.04±13.77) participated in 2 separate days of testing each lasting 1.5 hours.

Day 1:

- Single pulse transcranial magnetic stimulation (TMS) to assess motor cortex inhibition via the cortical silent period (cSP). The leg region of the right and left motor cortex was determined by identifying the resting motor threshold of the respective vastus medialis oblique.
- To assess the cSP, participants were asked to maintain an isometric knee extension at 15% of their maximal voluntary contraction for 2-minutes, during which they received visual feedback.
- Concurrently, a TMS stimulation was given at 120% of resting motor threshold every 7-10 seconds for a minimum of twelve cSPs[2]. This procedure was conducted for both legs on every participant.

Day 2:

- Participants completed a 6-minute walking trial at a normal (self-selected) pace.
- Participants wore 6 validated Opal wireless sensors (APDM) placed on the sternum, lumbar (L5), around each wrist and foot[3,4].



Data Analysis

- During data processing, 2 participants did not have quantifiable cSP's from the right leg. In these cases, their other leg was still included in analysis.
- A paired t-test analysis observed no statistical differences between hemispheric cSP ($p=0.28$)
- Based on a normal distribution, Pearson correlations were performed to analyze the association between cSP and gait metrics.
- Coefficient of variation was calculated using the formula: (Standard Deviation/Mean)

Results

Figure 1. Pictorial progression of TMS procedure and analysis for one representative participant. A) TMS procedure conducted in a seated position separately to each cortical hemisphere. B) EMG trace of muscle activity following TMS with wave descriptors. C) Filtered and rectified EMG of all trials (grey) and averaged trial (green).

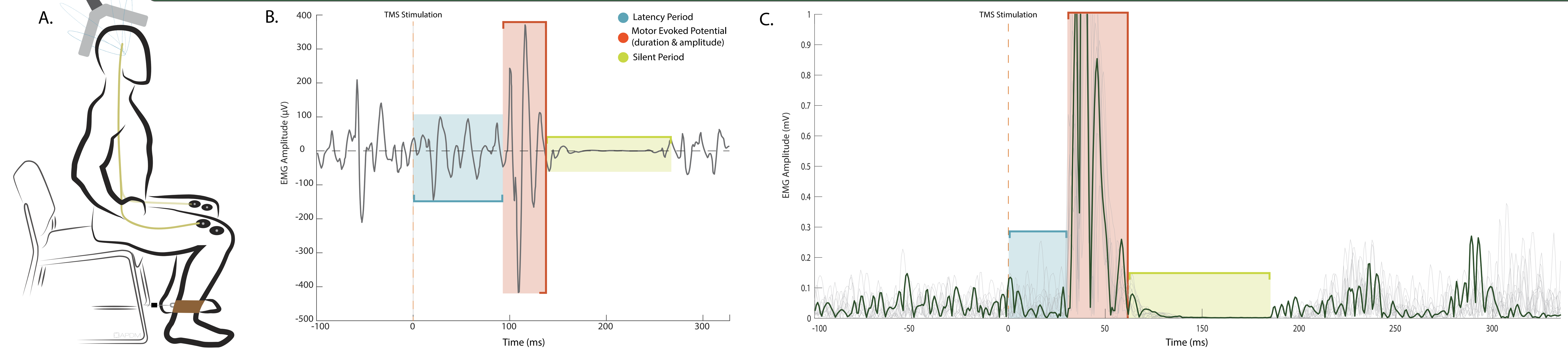
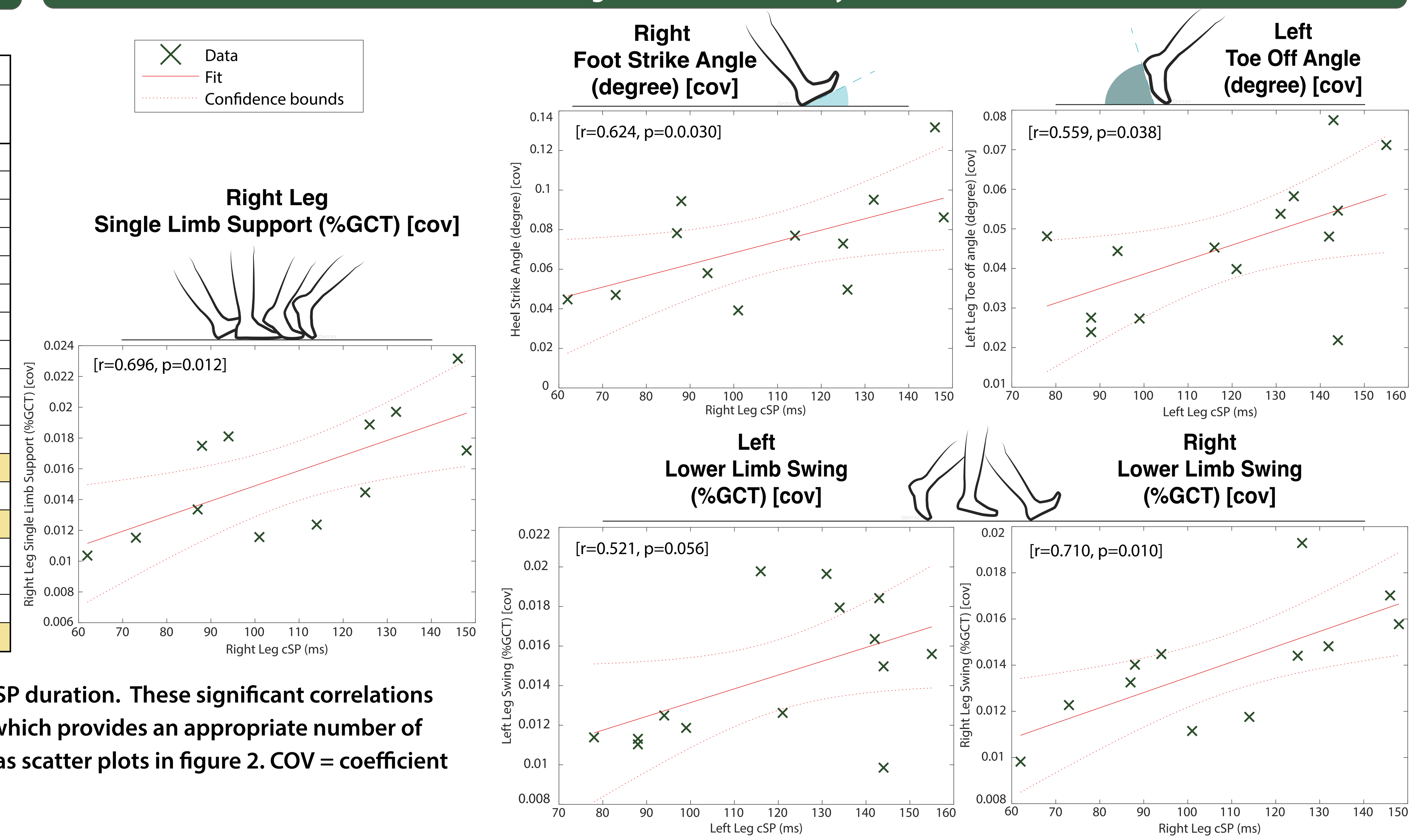


Table 2. Cortical silent period duration is associated with variability of several gait metrics.

Table 2.	Left Leg cSP (n=14) Pearson Correlation	Left Leg cSP (n=14) Significance (2-tailed)	Right Leg cSP (n=12) Pearson Correlation	Right Leg cSP (n=12) Significance (2-tailed)
Cadence (steps/min) [mean]	-0.439	0.116	-0.168	0.600
Cadence (steps/min) [cov]	**0.521**	**0.056**	0.346	0.271
Double Support (%GCT) [mean]	-0.200	0.494	0.125	0.699
Double Support (%GCT) [cov]	0.508	0.063	0.477	0.117
Gait Speed (m/s) [mean]	0.094	0.749	**-0.563**	**0.057**
Gait Speed (m/s) [cov]	0.377	0.183	0.321	0.324
Gait Cycle Duration (s) [mean]	0.439	0.117	0.170	0.597
Gait Cycle Duration (s) [cov]	**0.529**	**0.052**	0.533	0.075
Toe Off Angle (degrees) [mean]	-0.080	0.787	0.140	0.664
Toe Off Angle (degrees) [cov]	**0.559**	**0.038**	0.052	0.873
Foot Strike Angle (degrees) [mean]	0.075	0.799	-0.446	0.147
Foot Strike Angle (degrees) [cov]	0.320	0.264	**0.624**	**0.030**
Lower Limb Swing (%GCT) [mean]	0.262	0.366	-0.164	0.609
Lower Limb Swing (%GCT) [cov]	**0.521**	**0.056**	**0.710**	**0.010**
Lower Limb Stance (%GCT) [mean]	-0.262	0.366	0.166	0.607
Lower Limb Stance (%GCT) [cov]	**0.528**	**0.052**	**0.633**	**0.027**
Single Limb Support (%GCT) [mean]	0.122	0.679	-0.072	0.823
Single Limb Support (%GCT) [cov]	0.465	0.094	**0.696**	**0.012**

Figure 2. Gait variability is correlated with contralateral hemispheric cortical silent period; the longer the cSP, the greater the variability.



Multiple metrics of gait variability significantly correlated with contralateral cSP duration. These significant correlations were demonstrated with gait performance acquired during a 6-minute walk, which provides an appropriate number of steps to accurately assess gait variability[5]. Yellow highlights are represented as scatter plots in figure 2. COV = coefficient of variation, %GCT = percent gait cycle time, cSP= cortical silent period.

Conclusion

The current results indicate that motor cortex cSP is significantly related to more complex metrics of walking, specifically gait variability. The observed correlations between motor cortex inhibition and lower extremity coordination during normal walking suggests that the cSP may be an important neurophysiologic marker of gait dysfunction and could serve as an outcome measure in future studies analyzing clinical populations with impaired mobility.

References:

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