Investigating the Intermuscular Coherences of the Ankle Plantarflexors During Treadmill Walking in Individuals Post-Stroke

University of Nicosia MEDICAL SCHOOL

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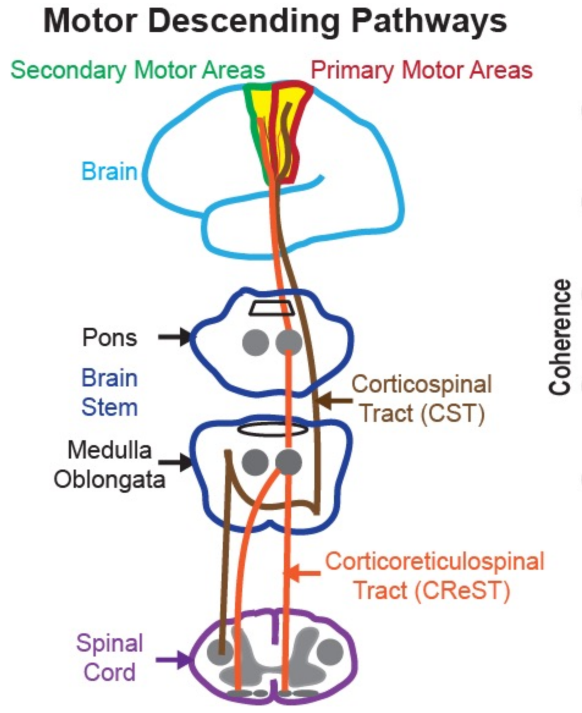
STROKE RECOVERY RESEARCH CENTER

A Center of Biomedical Research Excellence (COBRE) in Stroke Recovery at the Medical University of South Carolina

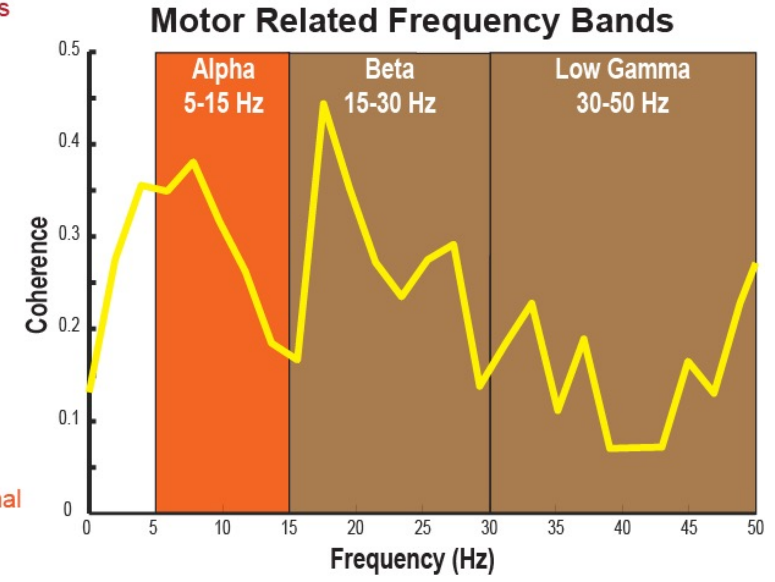
INTRODUCTION

- Walking after stroke is impaired, yet no rehabilitation strategy can lead to full recovery. There is a need for mechanism-driven rehabilitation strategies of promoting walking recovery after stroke.
- Neural oscillations can quantify the common neural drive (i.e., coherence) of the two major motor descending pathways (corticospinal tract – CST; corticoreticulospinal tract - CReST), which both contribute to walking.[1] Alpha band can be used as CReST proxy, whereas beta and low gamma can be used as proxy of CST.[1]

Motor Descending Pathways



Motor Related Frequency Bands



- Previously, the focus was mainly on the beta and low gamma bands of dorsiflexors[2,3,4,5](mainly) in neurotypical [2,3,6](mainly) and post-stroke[4,5](to a lesser extent) walking and on the correlations between those bands and global clinical walking measures.
- Currently, there is limited evidence on the neural oscillations (esp. alpha band) of the plantarflexors[2,5,6] and their correlations with muscle-specific biomechanical measures, which characterize their function during walking.
- Our goal is to explore the neural oscillations among two plantarflexors and their correlations with muscle-specific biomechanical and behavioral measures during walking in individuals post-stroke.

METHODS

Subjects

	Gender	Age (years)	Height (cm)	Body Mass (kg)
14 Chronic* Stroke Survivors	6 Females	62 ± 13	174 ± 12	83 ± 22
	Type of Stroke	Time Post-Stroke (months)	Hemiparetic Side	Fugl-Meyer Leg (max 34)
* > 6 months after stroke onset Mean ± SD	12 Ischemic	35 ± 27	11 Right	26 ± 3

Experimental Procedures

Treadmill Walking

3x 1-min walking trials seperated by 1-minute of rest (last 30 sec/trial used in data analysis)

Self-Selected Walking Speed (SSWS) [group mean ± 1SD (CV)]: 0.51 ± 0.22 m/s (43)

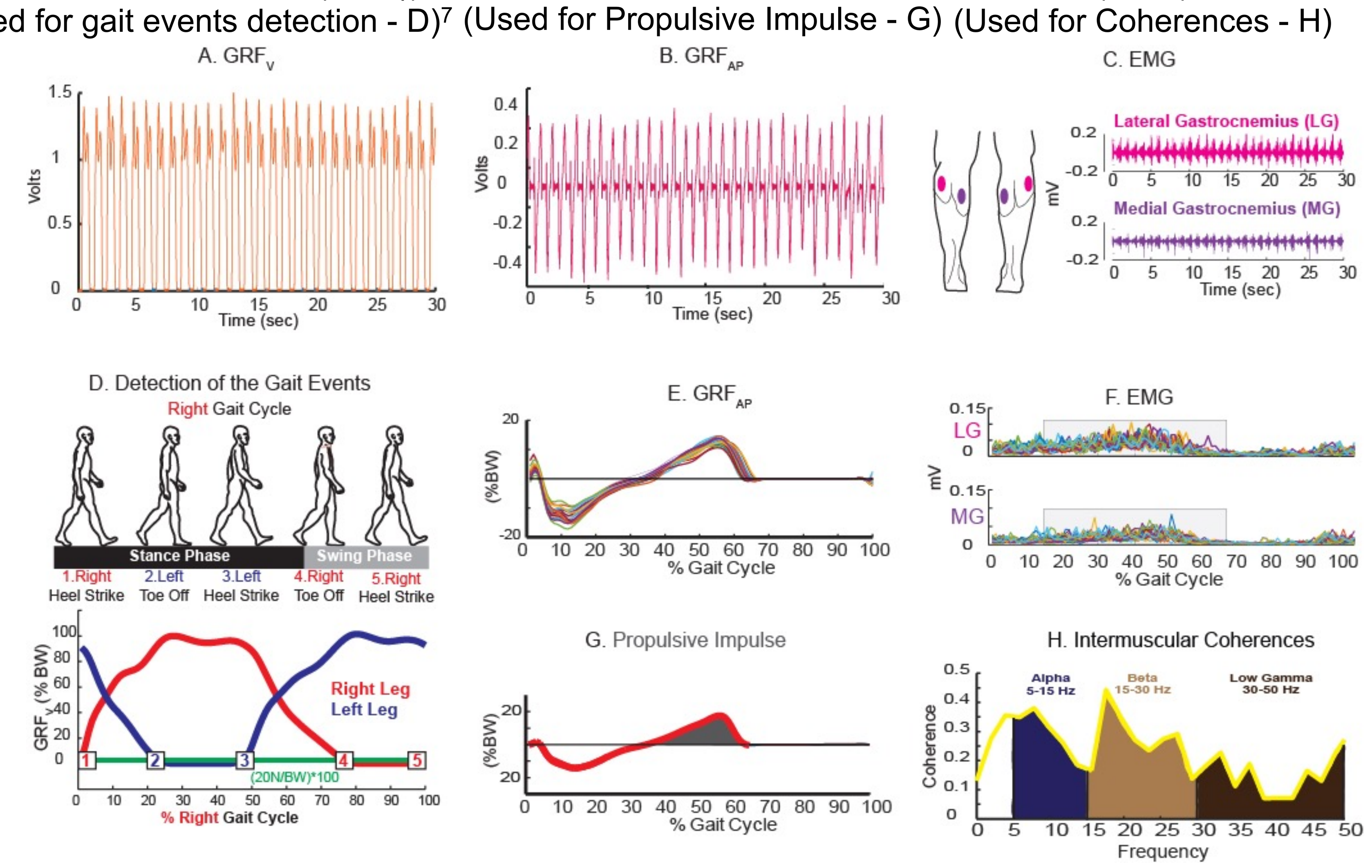
METHODS

Data Acquisition and Analyses:

Vertical Ground Reaction Force (GRF_V) (Used for gait events detection - D)[7]

Anterior-Posterior Ground Reaction Force (GRF_{AP}) (Used for Propulsive Impulse - G)

Electromyography (EMG) (Used for Coherences - H)



A-C: 30 sec Raw collected data

E-F: Processed data divided in gait cycles

G-H: Calculated dependent measures

Dependent Measures:

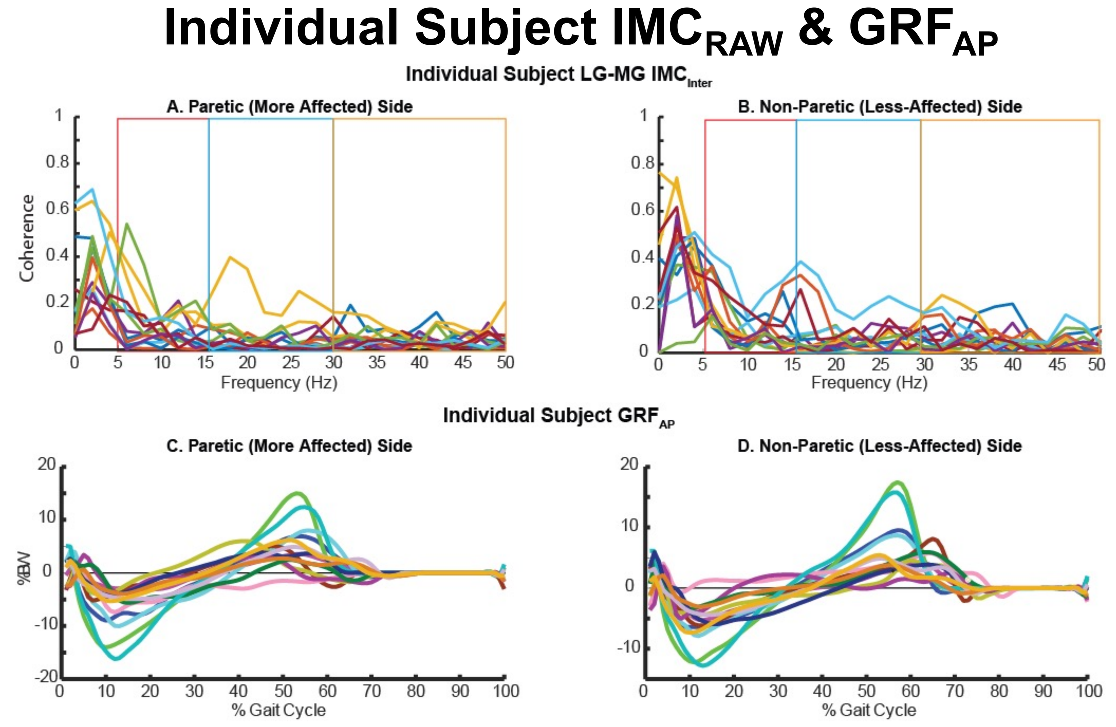
- Intermuscular Coherences (IMC): Raw (IMC_{RAW}), Z-Transformed (IMC_Z), Raw – Random (IMC_{DELTA})
- Propulsive Impulse (PI: muscle-specific biomechanical measure) & Walking Speed (SSWS: behavioral walking measure)

Statistical Analyses:

- Wilcoxon matched-pairs signed rank test [IMC_{Raw} & IMC_Z] - to test the interlimb differences (paretic vs. non-paretic limb).
- Wilcoxon one sample signed rank test [IMC_{DELTA}] - to test the intralimb differences (within each limb).
- Correlations (Spearman Rho: r_s) between IMC_{Raw} & IMC_Z and PI & SSWS (only for bands that IMC_{DELTA} was p < 0.05).

RESULTS

Individual Subject IMC_{RAW} & GRF_{AP}

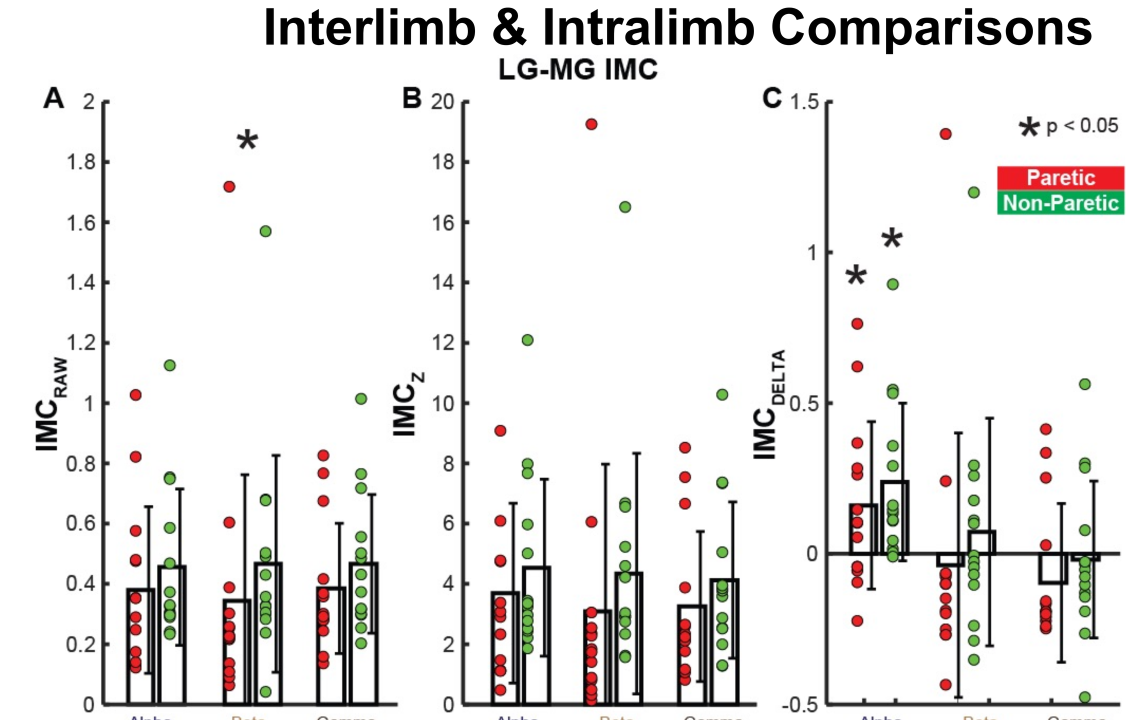


A-B: IMC_{RAW} of the paretic (A) and non-paretic (B) limb across subjects. Note the inter-subject variability and that overall, the paretic coherence is lower than non-paretic coherence.

C-D: GRF_{AP} of the paretic (C) and non-paretic (D) limb across subjects. Note the inter-subject variability and that overall, both limbs are similar.

A-D: Each line depicts mean across all gait cycles/subject.

Interlimb & Intralimb Comparisons



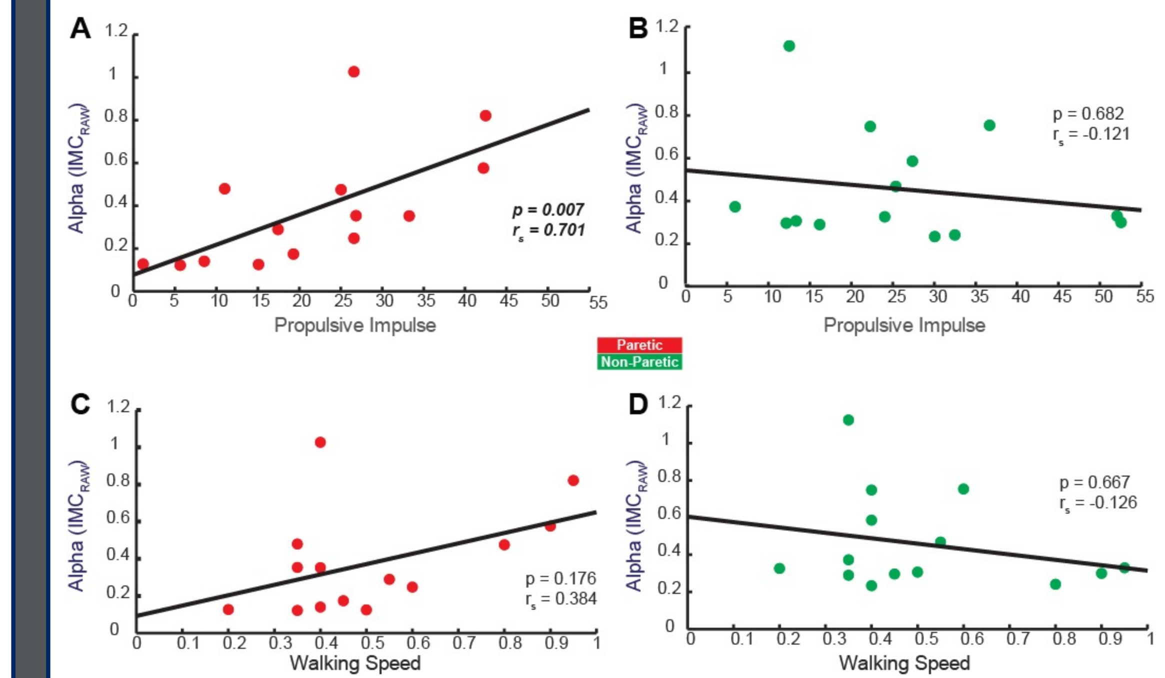
Interlimb (A-B): Compared to the non-paretic limb, only the paretic Beta IMC_{RAW} (A) was significantly (p = 0.0258) different **(paretic < non-paretic)**.

Intralimb (C): Across all three bands, only Alpha band was significant (**paretic: p = 0.0490**; **non-paretic: p = 0.0036**). ***Hence, only Alpha IMC_{RAW} & IMC_Z were used in correlations.***

Colored dots indicate subject data.

RESULTS

Correlations



A-B: Alpha IMC_{RAW} was positively correlated with Propulsive Impulse; but only on the paretic side (A).

C-D: Alpha IMC_{RAW} was not correlated with the walking speed on either side.

As IMC_{RAW}, Alpha IMC_Z (not shown here) was correlated with Propulsive Impulse only on the paretic side (*p = 0.006, r_s = 0.706*); the rest of correlations were non-significant (all ps > 0.05).

DISCUSSION

- Here, we explored whether there was a frequency-specificity of the descending drive (CReST/Alpha vs. CST/Beta&Low Gamma) to ankle plantarflexors (i.e., lateral and medial gastrocnemius) during treadmill walking in individuals with stroke.
- Across the three bands, only the Beta IMC_{RAW} showed a degradation of the common neural drive to the paretic LG-MG. Others have showed a similar degradation in Beta band during post-stroke walking[4,5], yet Alpha band was not reported in those studies. This finding suggests that this degradation might be due to a damage to the CST, which contributes to the activity synchronization of the ankle plantarflexors during walking.[6]
- Compared to previous work, we aimed also to explore the relationships between these bands and muscle-specific biomechanical measure and walking speed. Significant correlations were observed only for the former but not for the latter. This suggests that using a muscle-specific biomechanical measure can unmask relationships that may not be found if global behavioral measures are used.
- Alpha IMC (both raw and z-transformed) was increased as propulsive impulse increased; this was observed only on the paretic limb. This finding suggest a potential contributions of CReST to the paretic propulsion.
- Given that propulsive impulse is impaired after stroke, increasing the Alpha band of plantarflexors may reverse this impairment and result in walking recovery. A frequency-specific (e.g., Alpha) target neuromodulatory technique (e.g., transcranial Alternate Current Stimulation; tACS) could be a promising rehabilitation strategy to promote walking recovery by targeting the increase of propulsive impulse.

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