Central-peripheral and intermuscular interactions are co-regulated in stroke subject

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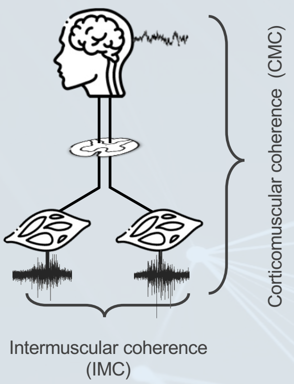
Introduction

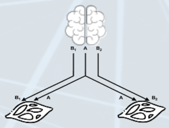
Motor control study



Variables

CMC
=
Central-peripheral communication
(Conway et al., 1995; Salenius et al., 1997)
+
Involvement of central mechanisms in voluntary motor control
(Boonstra et al., 2013; Conway et al., 1995)

IMC
=
Common central drive
(De Luca & Erim 2002)



Involvement in muscle coordination
(Dai et al., 2017)

Chronic stroke

↗ CMC during **anisometric** contractions
(Delcamp et al., 2022a; Fang et al., 2009; Gao et al. 2018)
⇩
More central-peripheral communication

↗ IMC during **anisometric** contractions for :
Agonist-Antagonist muscles pair
(Delcamp et al. 2022b; Becker et al., 2018; Kitatani et al., 2018)
Antagonist-Antagonist
(Delcamp et al., 2022b; Becker et al., 2018)
⇩
More common central drive

Aim

CMC & **IMC**
=
Representing the **central drive** (Boonstra 2013)
+
Involved in **movement control** (Boonstra 2013)
+
Altered by stroke (Delcamp et al., 2022a; 2022b)
+
Associated with **motor function** (Delcamp et al., 2022b; Krauth et al., 2019)
⇩
Is there a **link** between CMC and IMC in **healthy** or **chronic stroke** subjects ?

Methods

- **Participants:**
  - 24 **chronic stroke** subjects: with an active elbow extension limitation of at least 15°
  - 22 **healthy subjects**
- **Task:** 20 elbow extensions (Fig. 1)

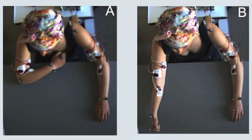
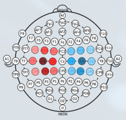


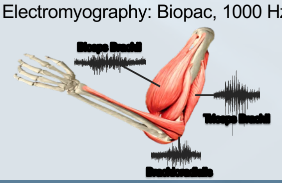
Fig. 1 : Experimental setup: right elbow flexed (A) and extended (B).

- **Recordings:**
  - Electroencephalography:



BioSemi ActiveTwo, 64 electrodes; 1024 Hz

  - Electromyography: Biopac, 1000 Hz



- **Variables:**

IMC
- Agonist-Antagonist muscles : Triceps Brachii – Brachioradialis (TB-BR)
- Antagonist-Antagonist : Biceps Brachii - Brachioradialis (BB-BR)

CMC : Ipsilesional hemisphere and contralateral muscles :
- Triceps Brachii
- Biceps Brachii
- Brachiodialis

→ Average for both muscle pairs

- **Coherence quantification:**
  - Coherence **volume**
  - In the **Beta** frequency band [13-31 Hz]
  - In the **200ms** temporal window **preceding the velocity peak** (Fig. 2)

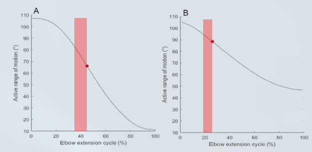
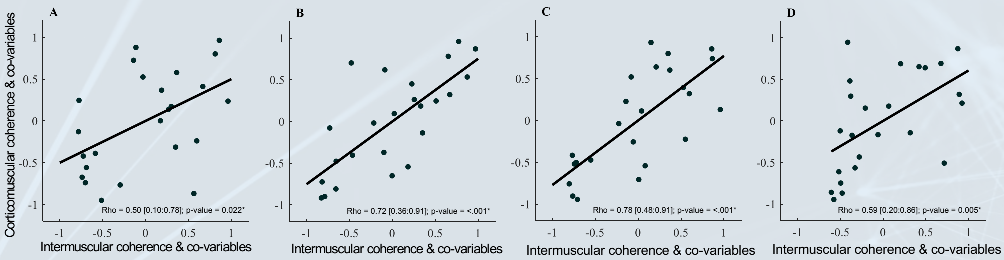


Fig. 2: Variation of active elbow range of motion in control (A) and stroke subjects (B). The red dot represents the peak velocity and the red window represents the 200ms window of intermuscular coherence quantification.

Results



- **Significant correlations** between CMC & IMC for **stroke** subjects (Fig. 3):
  - **Paretic** & **Non-paretic** limbs
  - **Agonist-Antagonist** & **Antagonist-Antagonist** muscles pairs
- **No correlation** between CMC & IMC for **healthy control** subjects

Fig. 3 : **Partial rank spearman correlation** of paretic limb of stroke subjects for the biceps brachii - brachioradialis (**A**) and triceps brachii - brachioradialis muscle pairs (**B**) and of the non-paretic limb for the biceps brachii – brachioradialis (**C**) and triceps brachii-brachioradialis muscle pairs (**D**).

Discussion

Central-peripheral communication and amount of **common central drive** directed to muscles
- Are **not correlated** in **healthy** control subjects (Boonstra et al., 2009; De Vries et al., 2016)
- Are **correlated** in **chronic stroke** subjects

→ The greater the central-peripheral communication, the more it is common to the synergistic muscles.

→ Simplification of motor control (Houston et al., 2021) appears in the co-regulation of central-peripheral and intermuscular communication.

Interpretations:

- **Paretic** limb of stroke subjects
  - Modification of **motor control** strategies
  - Modification of spinal inhibition → filter action on CMC and IMC
- **Non-paretic** limb of stroke subjects
  - Changes in bilateral cortical activity (Gerloff et al., 2006; Park et al., 2016)
  - Modification of bilateral inhibition mechanisms (Chaco et al., 1984)

Becker et al., *Med Biol Eng Comput.*, 2018; Boonstra et al., *Neurosci Lett. 2009;* Boonstra et al., *Front Hum Neurosci.*, 2013; Conway et al., *J Physiol.*, 1995; Chaco et al., *Electromyogr Clin Neurophysiol., 1984;* Dai et al., *Front Neurol.*, 2017; Delcamp et al., *Clin Neurophysiol.*, 2022; Delcamp et al., *Front Neurosci.*, 2022; De Luca & Erim, *J Neurophysiol.*, 2002; De Vries et al., *J Neurophysiol.* 2016. Fang et al., *Clin Neurophysiol.*, 2009; Gao et al., *Front Neurol.*, 2018; Gerloff et al., *Brain.* 2006; Houston et al., *Trans Neural Syst Rehabil Eng. 2021.* Kitatani et al., *Clin Neurophysiol Off J Int Fed Clin Neurophysiol.*, 2016; Krauth et al., *Front Neurol.*, 2019; Park et al., *J NeuroEngineering Rehabil. 2016;* Salenius et al., *J Neurophysiol.*, 1997.