Effects of grip type on EMG-EMG coherence between hand flexor and extensor muscles during maximal isometric contractions

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Introduction

The hand is a complex musculoskeletal system with important redundancy both at the articular level with 20+ degrees of freedom (DoFs), and the muscular level with more than 40+ muscles, each acting on several DoFs. To solve this so-called “redundancy problem” and mobilize the hand musculoskeletal system:

- The finger force coordination and the functional role of the hand extensors is task-dependent (Snijders et al., 1987; Goislard de Monsabert et al., 2012).
- The functional roles of hand groups can be associated to different distributions of the central drive (Poston et al., 2010).

Interestingly:

- Intermuscular coherence between pairs of electromyographic (EMG) signals reflects the coupling between synergistic muscles (Kattla & Lowery, 2010).
- The level of EMG-EMG coherence has been related to spinal and supraspinal mechanisms underlying motor control (Farmer et al., 2007).

This study investigates type of grip-related changes in muscle force coordination and EMG-EMG coherence between flexor and extensor hand muscle groups during maximal voluntary contractions to provide new insights into the central nervous mechanisms underlying the control of musculoskeletal hand redundancy.

Methods

- 11 right-handed participants.
- Grip force measurement: ATI nano-25.
- Kinematics: Vicon, MX T40.
- Surface EMG: Biopac MP150™, → Wrist flexors and extensors:
  ECR (Extensor Carpi Radialis)
  FCR (Flexor Carpi Radialis)
- Time-frequency coherence analysis in alpha and beta frequency bands (Bigot et al., 2011; Charissou et al., 2016; Kattla & Lowery, 2010).
- Muscle force estimation: biomechanical hand model (Vigouroux et al., 2007; Goislard de Monsabert et al., 2012).
- Statistics: Bootstrap analysis.
- Five 6-s maximum voluntary isometric contractions (MVC) separated by 2-min rest.
- Two task configurations: “Finger pressing” (Press) and “Power grip” (Power).

Results

- MVC for Power grip compared with Finger pressing, p < 0.05.
- Force for ECR in Power grip vs Finger pressing, p < 0.05.
- Force for FCR in Finger pressing vs Power grip, p < 0.05.
- Higher EMG-EMG coherence in a beta frequency band during Finger pressing compared with Power grip, p < 0.05.
- Significant EMG-EMG coherence in an alpha frequency band only for Finger pressing, p < 0.05.

Discussion

- **Muscle coordination**: different sets of muscle forces used during Power grip vs. Finger pressing which results in different level of contraction between wrist flexors and extensors.
- **EMG-EMG coherence**: - alpha: significant quantity of intermuscular coherence only observed during a finger pressing task.
  - beta: lower intermuscular coherence during a power grip compared to a finger pressing task.

  Intermuscular coupling takes part in the regulation of intermuscular coordination during hand tasks especially for adjusting contraction.

  EMG-EMG coherence during MVC hand grip contraction highlights that he relative contribution of spinal and supraspinal mechanisms is modulated according to the task contraints and the functional role of the muscles.