Contribution of pair-specific intermuscular coupling to the regulation of agonist-antagonist co-contraction during maximal isometric flexion of the fingers

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As a consequence of high muscle redundancy, a given exerted net force may be generated by an infinite set of individual muscle tensions, making the motor control problem extremely complex. Although widely investigated, the mechanisms governing muscle coordination are yet to be thoroughly understood, especially regarding agonist-antagonist co-contraction. Interestingly, the hand is one of the most complex musculoskeletal systems in which the functional role of extensors and the co-contraction level differ according to hand configuration for a same functional demand. Through intermuscular (EMG-EMG) coherence analysis combined with hand musculoskeletal modelling, our aim was to better understand mechanisms underlying the control of muscle redundancy at the co-contraction level.

Thirteen participants performed maximal isometric fingers flexions in two hand configurations: power grip (Power) and finger-pressing on a surface (Press). Hand kinematics and force/moment measurements were used as inputs in a musculoskeletal model of the hand to determine muscular tensions and co-contraction level. Wavelet-based EMG-EMG coherence analysis was performed between key wrist and fingers flexors and extensors: Extensor Carpi Radialis (ECR), Extensor Digitorium Commonis (EDC), Flexor Carpi Radialis (FCR) and Flexor Digitorum Superficialis (FDS). T-tests were used to identify differences in kinetic variables between Power and Press. Following ANCOVA with maximal net force as a covariable, bootstrap technique was used to test between-configuration differences on EMG-EMG coherence.

Our results showed changes in all muscular tensions developed by the fingers and wrist flexors and extensors between Press and Power ($p < .05$), leading to increased co-contraction in Power (74.88 ± 2.84 % vs. 37.42 ± 12.83 %; $p < .05$). The ANCOVA indicated a lack of correlation between EMG-EMG coherence and maximal net force in Power and Press ($p < .05$). Accordingly, results showed that, irrespective of the exerted force, beta-range (β; 15-35 Hz) EMG-EMG coherence was higher in Press than in Power for both ECR/FCR and ECR/EDC muscle pairs ($p < .05$), with no significant difference for ECR/FDS ($p > .05$). Further, a strong correlation was found between co-contraction and β EMG-EMG coherence ($r = -0.61$; $p = .007$) for ECR/FCR muscle pair.

Changes in β EMG-EMG coherence between hand configurations showed that muscle functional requirements were associated with pair-specific modulation of intermuscular coupling. This finding was consistent with the hypothesis that intermuscular coupling could be a mechanism contributing to the organization of muscle forces coordination according to task constraints and muscle functional role. The correlation specifically observed between co-contraction and β EMG-EMG coherence for ECR/FCR muscle pair sustains the hypothesis that a muscle-pair specific intermuscular coupling could take part in the regulation of agonist-antagonist co-contraction.