EMG-EMG coherence reveals increased reticulospinal contributions to upper limb postural adjustments

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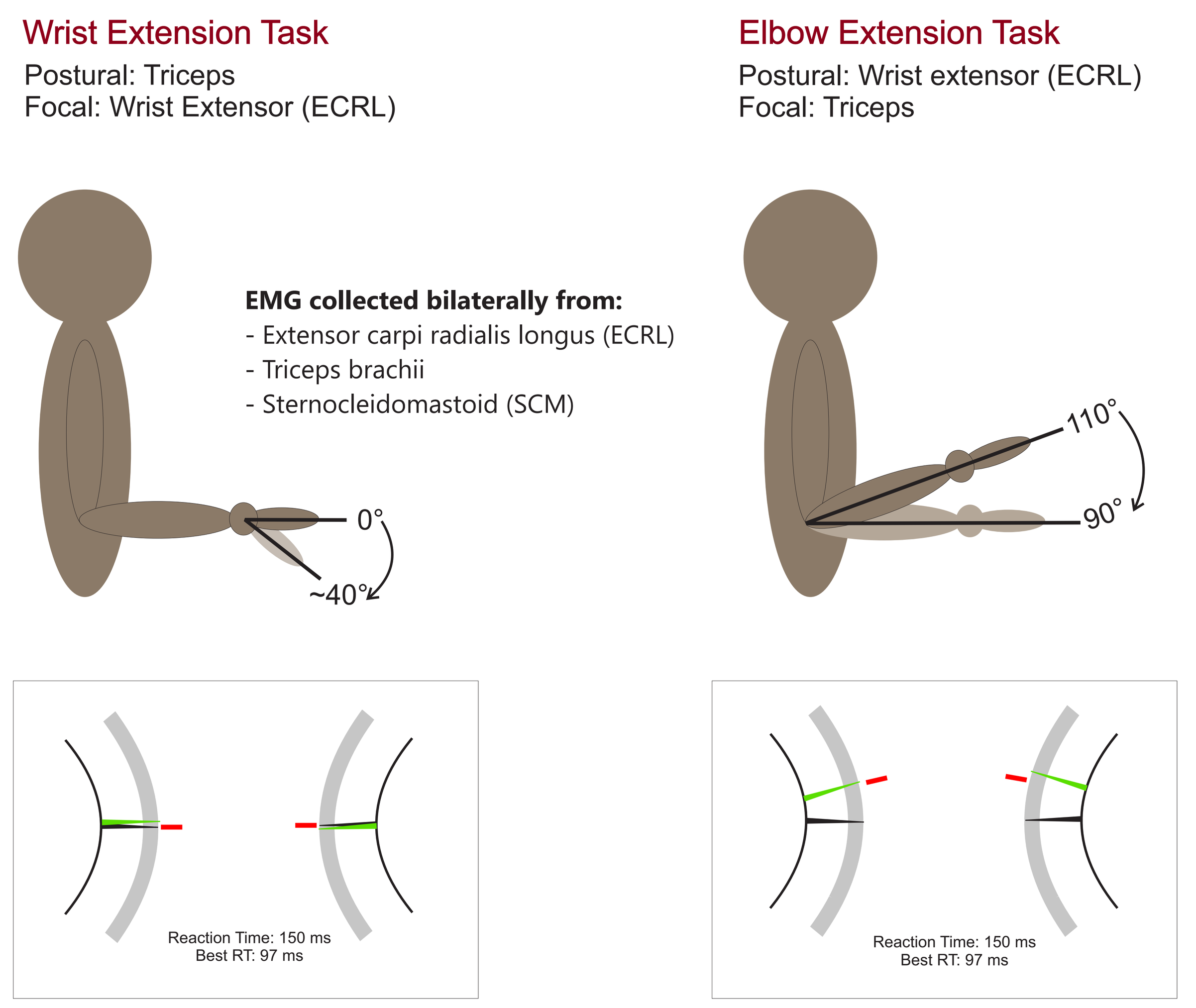
Background

- Corticospinal and reticulospinal pathways contribute differentially to the initiation of various types of movements: Balance and posture utilize relatively more reticulospinal input, while voluntary focal movements involve primarily cortical drive[1].
- The location of the muscles innervated by these pathways also varies, with reticulospinal fibers primarily distributed to the motor neurons of axial and proximal muscles, and corticocpinal structures mainly innervating distal extremity muscles[1].
- Motor unit synchronization tends to oscillate at different frequencies for these pathways and therefore each contributes more power to different frequency bands. EMG-EMG power spectrum coherence in the 10-20 Hz range is associated with reticulospinal drive while coherence in the 20-30 Hz range is associated with corticospinal drive[2,3].
- The contributions of cortical and subcortical structures to the preparation and initiation of movements with differing anatomical and functional requirements may be elucidated by this type of analysis[4].

Will postural and focal movements from the same muscle exhibit coherence that is indicative of differential corticospinal and reticulospinal contributions?

Will a startling stimulus alter the contributions of these two pathways to the initiation of movement?

Methods



Feedback showed elbow angle (green) with respect to the horizontal target (black). Starting position for each task was shown with a red marker. RT was provided after each trial.

- 12 participants performed both a simultaneous bimanual wrist extension and a bimanual elbow extension task, completed in separate blocks.
- Each block consisted of 20 practice trials and 80 experimental trials for the given task.
- Following an acoustic warning signal, an 82 dB go-signal was played, to which participants reacted as quickly and as accurately as possible.
- On 20% of trials, a 120 dB white noise startling acoustic stimulus (SAS) was presented pseudorandomly.
- Reaction time (RT) and accuracy feedback was provided after every trial on a computer monitor ~1m away from the seated participant.
- Muscle onsets and movement accuracy were analyzed, and EMG-EMG coherence was calculated[3], followed by analysis of difference in coherence for pairs of interest[5].

Discussion & Conclusions

- The presentation of a SAS resulted in significantly shorter RT, as expected (Figures 1 & 2).
- In the *elbow extension task* only, the postural muscle (**wrist extensor**) was activated significantly *later* compared to the focal muscle (**triceps**) in both stimulus conditions (Figure 2), and may therefore have acted to stabilize the limb at movement end rather than as an anticipatory adjustment.
- A larger difference in coherence in the reticulospinal range (13-20 Hz) is seen when the triceps are acting posturally compared to when they are acting focally (Figure 3, left panels). This difference appears to be larger in startle versus control trials, suggesting increased reticulospinal input to the postural activation of the triceps, with an added contribution from subcortical structures when a startle was elicited.
- When coherence in the control and startle trials are compared, *both muscles* exhibit higher coherence in the startle condition in the corticospinal range (20-30 Hz) when acting posturally, while only the triceps exhibit higher coherence in the startle condition in the reticulospinal range. This may suggests that the startle increases reticulospinal activation to a higher degree in the more proximal muscle.

Results

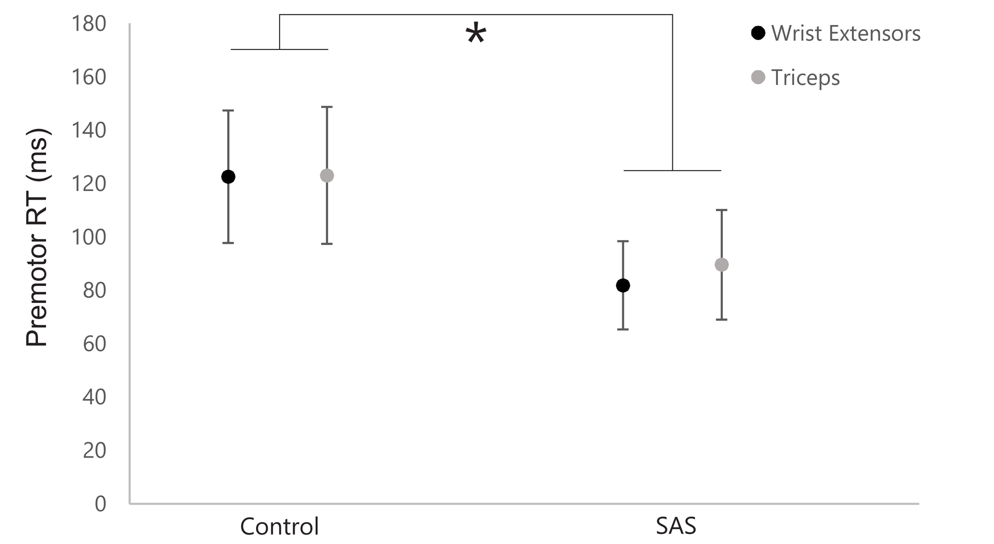


Figure 1. Mean (SD) EMG onset in the ***Wrist Extension task*** for the **focal** (wrist extensors) and **postural** (triceps) muscles. Data are separated based on the type of auditory stimulus presented (control vs. SAS). * denotes p < 0.01.

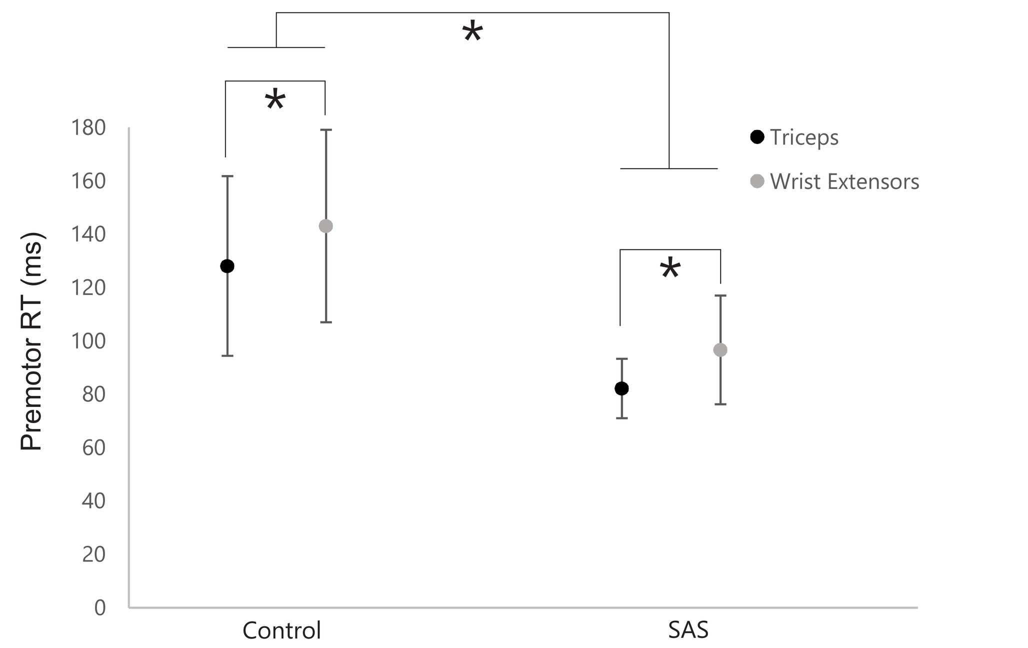


Figure 2. Mean (SD) EMG onset in the ***Elbow Extension task*** for the **focal** (triceps) and **postural** (wrist extensor) muscles. Data are separated based on the type of auditory stimulus presented (control vs. SAS). * denotes p < 0.01.

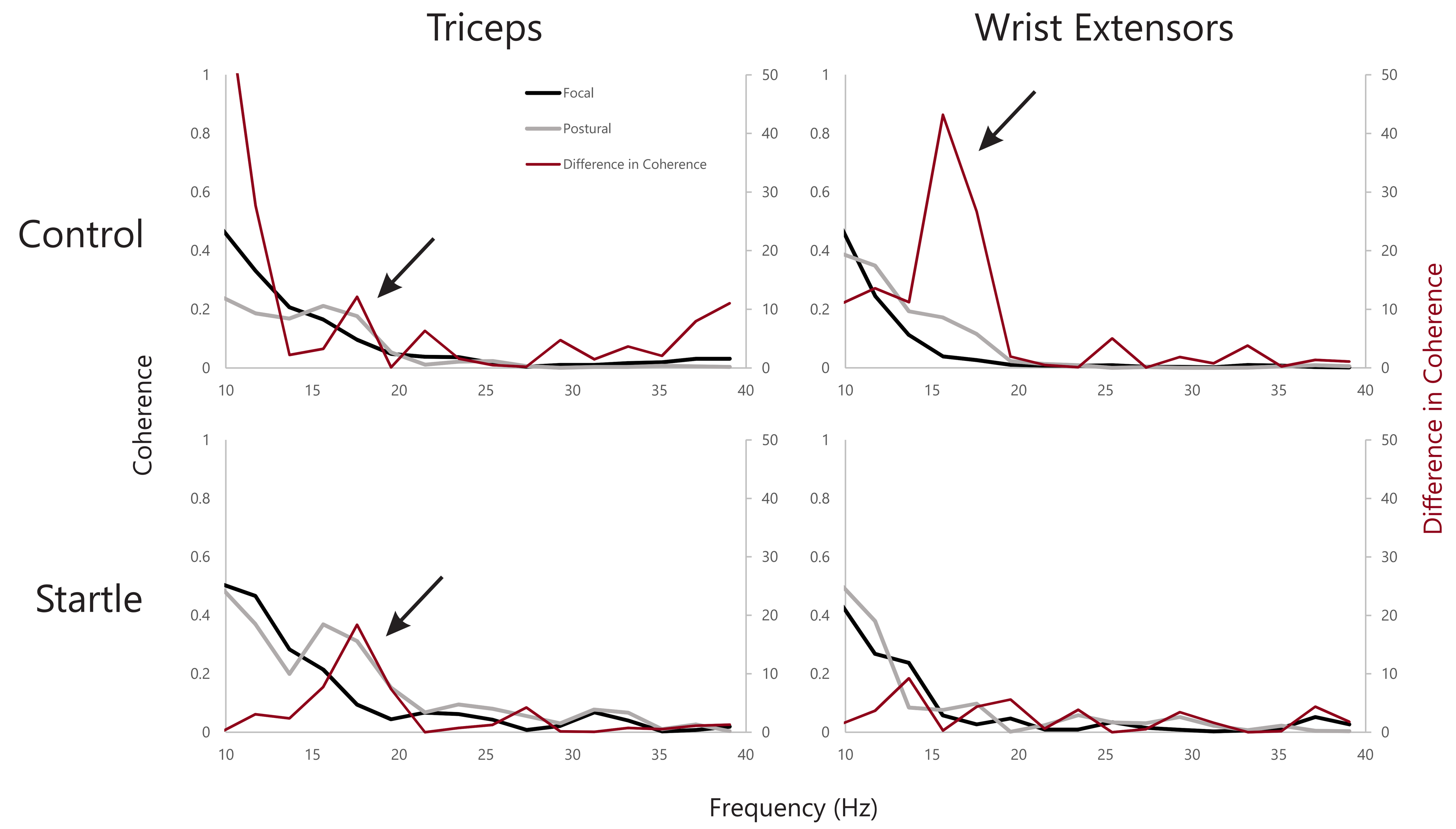


Figure 3. Coherence in the triceps (left) and wrist extensors (right) when the muscles are acting **focally** compared to when they are acting **postourally**. Comparisons were made in control (top) and startle (bottom) trials conditions. The difference in the coherence is shown in **red**, and peaks are indicated with arrows.

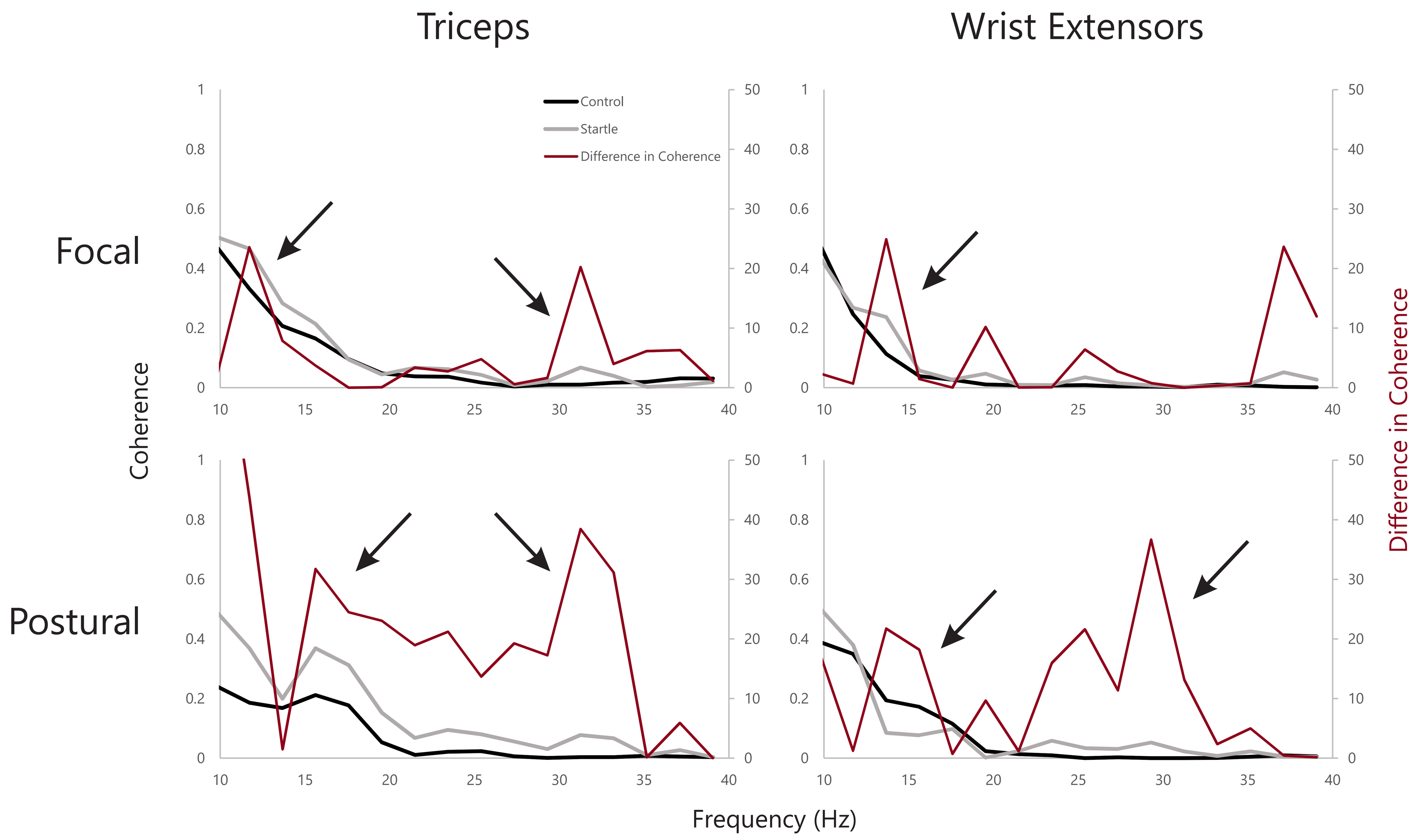


Figure 4. Coherence in the triceps (left) and wrist extensors (right) during **control** trials compared to **startle** trials. Comparisons were made for both the postural role (top) and focal role (bottom) of the muscles. The difference in the coherence is shown in **red**, and peaks are indicated with arrows.

References

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