Using sEMG Signal Frequency to Evaluate Post-Stroke Elbow Spasticity

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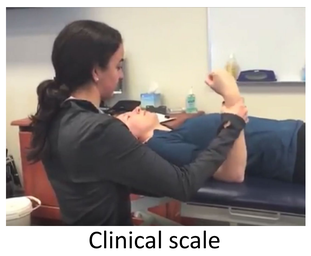
SEMG-BASED SPASTICITY MEASURES

Widely used clinical scale MAS [1] relies on perceptive resistance of clinicians to measure spasticity.

sEMG-based muscle activity measures are promising relevance and feasibility, but spastic reactions might be confounded by other types of muscle activities when monitored with sEMG signal amplitudes.



Clinical scale

sEMG-based measures [2]

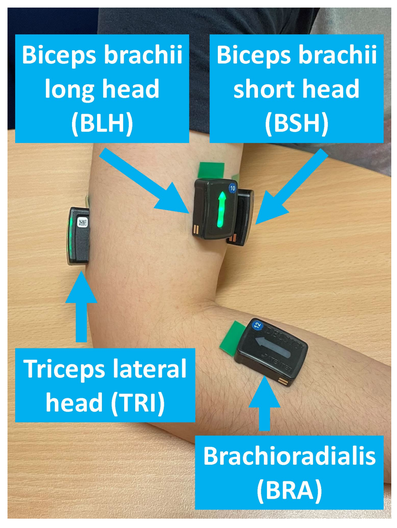
Spasticity patient: Higher MAS → Larger resistance force [3] Lower sEMG mean frequency

Healthy individual: Higher force production [4] Increased sEMG frequency

AIM: To explore the use of sEMG signal frequency to assess spasticity

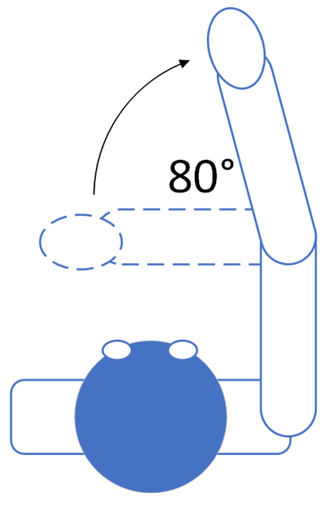
STUDY PROTOCOL

- Four sEMG sensors with a sampling rate of 1.11kHz were placed on the elbow flexors and extensors of the subjects' impaired arm.
- Passive elbow extension movements at 9 velocities (from $10^{\circ}.s^{-1}$ to $90^{\circ}.s^{-1}$) were performed by a robot (aligned with [5] where spastic reactions could be observed).
- Inspired by [3], the mean frequency of the pre-processed sEMG signal during the onset period was analysed for BSH, BLH, and BRA. The elbow reflex torque [5] was also obtained to describe the spastic response intensity.



sEMG sensor placement

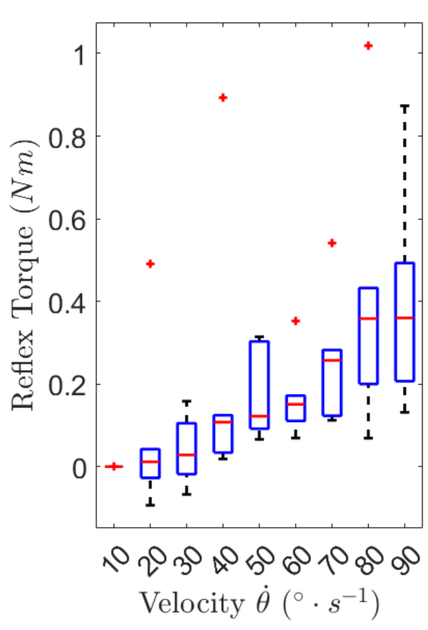
The initial posture

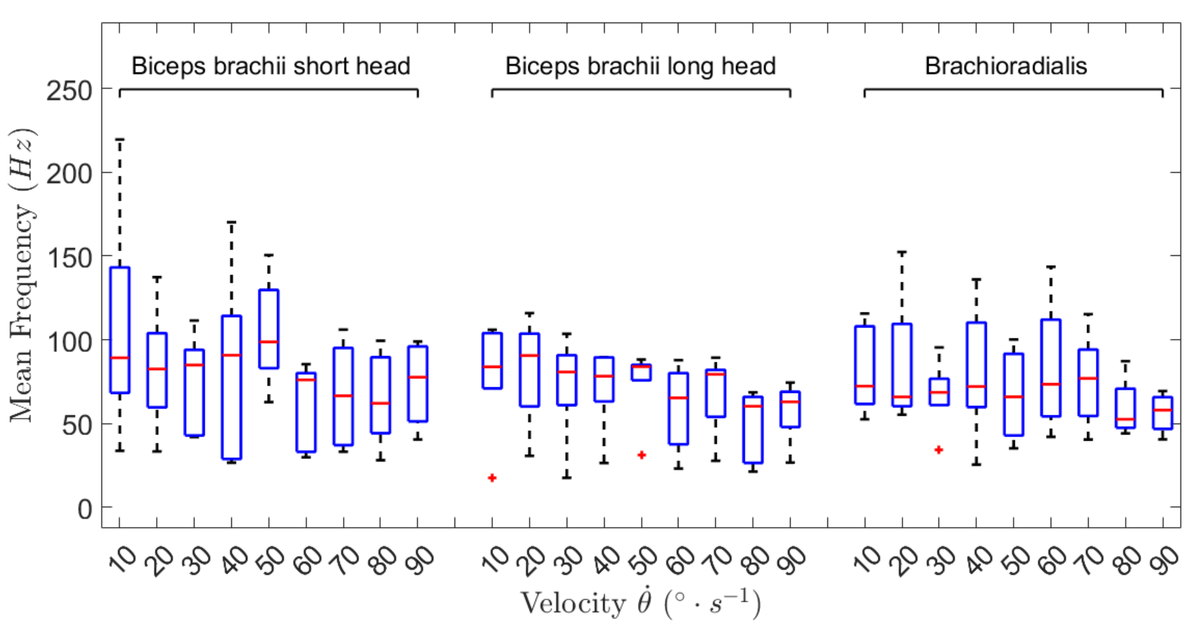


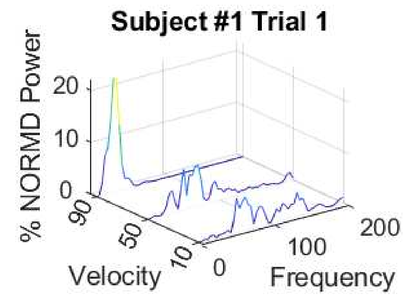
Elbow extension movement

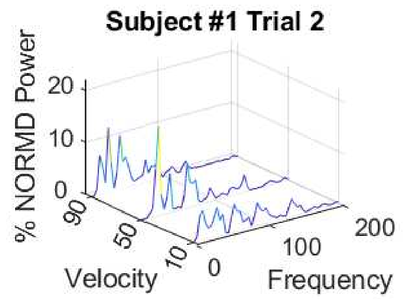
RESULTS

- Three patients with elbow spasticity participated in the experiment*.
- Along with a clear increase of reflex torque at higher velocities, it could only be observed a slight velocity-dependent decreasing trend of the sEMG mean frequency. BLH showed a more monotonic trend among the three muscles.
- The sEMG frequency spectrum of BLH generally demonstrated increased power at a lower frequency (mostly below 50Hz) with an increasing velocity.









DISCUSSION

- A decreasing sEMG frequency corresponds to a more intense spastic response (in agreement with [3]), and the opposite trend between patient sEMG frequency and in healthy individuals may potentially be exploited to detect spasticity.
- The loss of descending inhibitory control following stroke may subsequently alter the balance between the innervations of intrafusal and extrafusal muscle fibres [6] and so potentially affect the sEMG frequency.

CONCLUSION

This work shows an overall slightly decreasing trend of the sEMG mean frequency with increasing movement velocity/spastic reaction. Results suggest that frequency analysis of sEMG measurements might be a useful tool to investigate spastic reactions.

FULL TEXT

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[1] Cusick et al., Australian Occupational Therapy Journal, 2015. [2] Hu et al., IEEE Trans Neural Syst Rehabil Eng, 2018. [3] Wang et al., 39th EMBC, 2017. [4] Luttmann et al., International journal of Industrial ergonomics, 2000. [5] Guo et al., 44th EMBC, 2022. [6] Mukherjee et al., Frontiers in neurology, 2010.

* Ethics approved by the Melbourne Health HREC (62637/MH-2021) and Ruijin Hospital CTEC (2021356)