Module-Based Analysis of Upper-Limb Movement Post-Stroke

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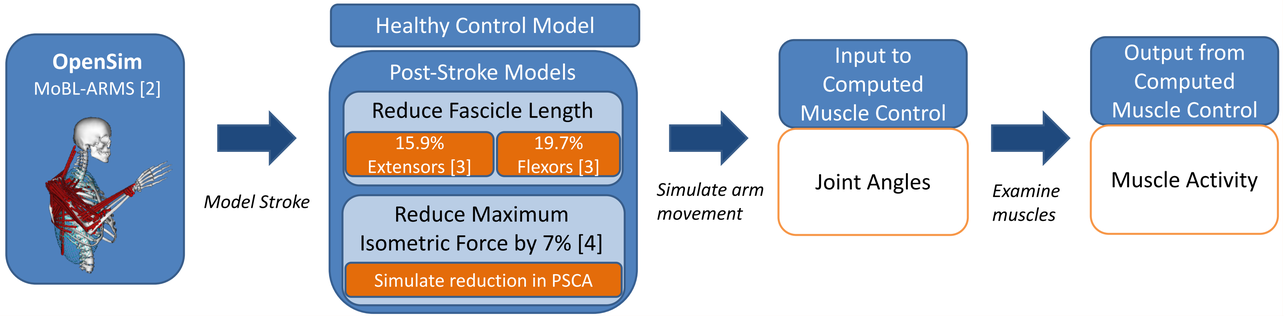
INTRODUCTION

- Muscle modules are groups of muscles that activate together to generate a specific movement.
- The number of modules and their activation timing can describe the level of independent movement that the muscles are capable of producing.
- The number of modules in the lower limb have been shown *in vivo* to reduce after stroke [1].

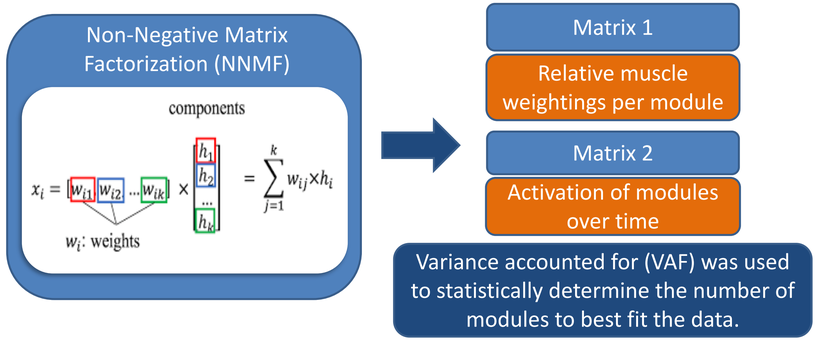
Objective: To examine to what extent the number of muscle modules in the upper limb reduce post-stroke.

METHODS

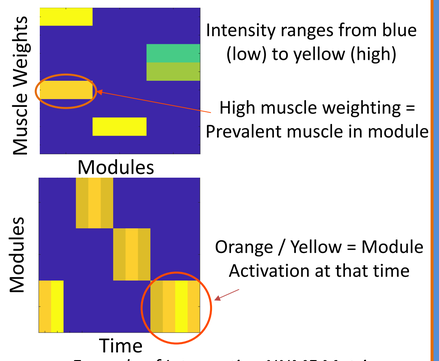
Data Collection: MoBL-ARMS model in OpenSim was used to simulate post-stroke changes to muscles and estimate muscle activity.



Computational Analysis: Non-negative matrix factorization (NNMF) was used to break down muscle activity into two matrices: (1) muscle weighting matrix per module and (ii) a module activation over time matrix.



Variance accounted for (VAF) was used to statistically determine the number of modules to best fit the data.



Example of Interpreting NNMF Matrices

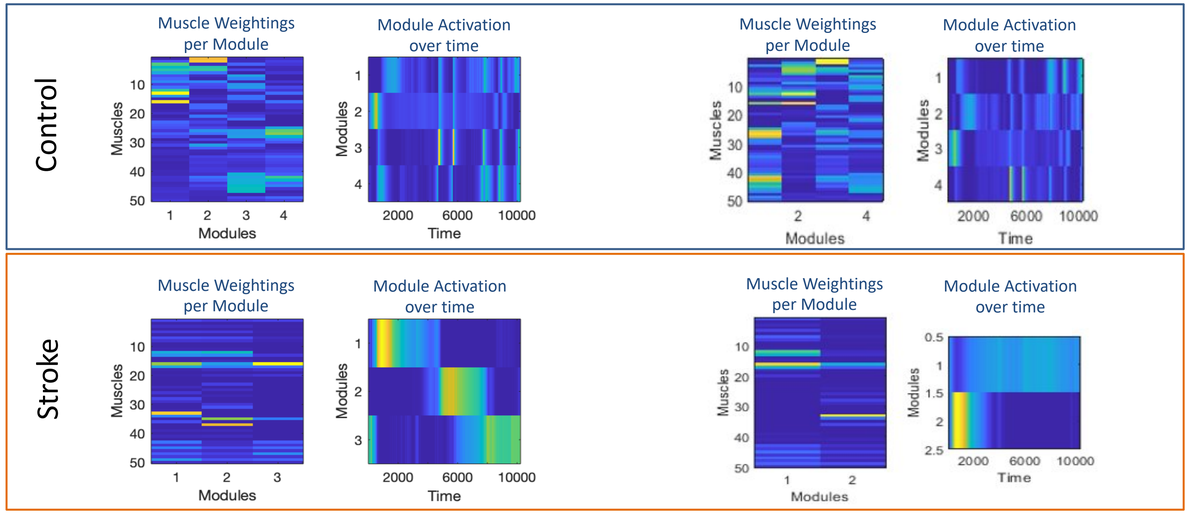
REFERENCES

[1] Clark D.J. et al. (2010) *J Neurophys*, (103): 844-857 **[2]** Saul K.R. et al. (2015) *Comp Methods in Biomechanics and Biomedical Engineering,* (18): 1445-58
[3] Nelson C.M. et al. (2018) *J SAGE,* (32): 799-809. **[4]** Ryan A.S. et al. (2002) *Archives of Physical Medicine,* (83): 1703-1707.

RESULTS & DISCUSSION

Reducing FASCICLE LENGTH reduced the calculated number of modules from 4 to 3.

Reducing MAXIMUM ISOMETRIC FORCE reduced the calculated number of modules from 4 to 2.



Fascicle Length **Maximum Isometric Force**

- **Modular activation timing overlaps more extensively post stroke**
  - Module activation is less distinct over the time it takes to complete the reaching task
  - Overlap indicates that muscles are not firing independently
- **Muscle weightings in modules are altered**
  - Control: prevalent muscle weightings in each module consisted of parts of the body that typically contracted together in reaching movements (e.g., muscle compartments of the extensor digitorum activated simultaneously)
  - Stroke: muscles within the modules were no longer biomechanically related in reaching movement (e.g., triceps long head and flexor digitorum co-activated)

CONCLUSIONS

- The simulations indicate a reduction in the number of modules between the control and stroke states. This finding suggests that the structural changes in muscles following stroke impact how individuals generate movement.
- Future efforts should examine additional factors regarding how upper limb muscle physiology changes post-stroke and should make use of experimental data in order to ensure the simulations represent real-world conditions.