HUman Rehabilitation Group
TEXAS A&M UNIVERSITY

Correlation between Slip Severity and Muscle Synergies of Slipping

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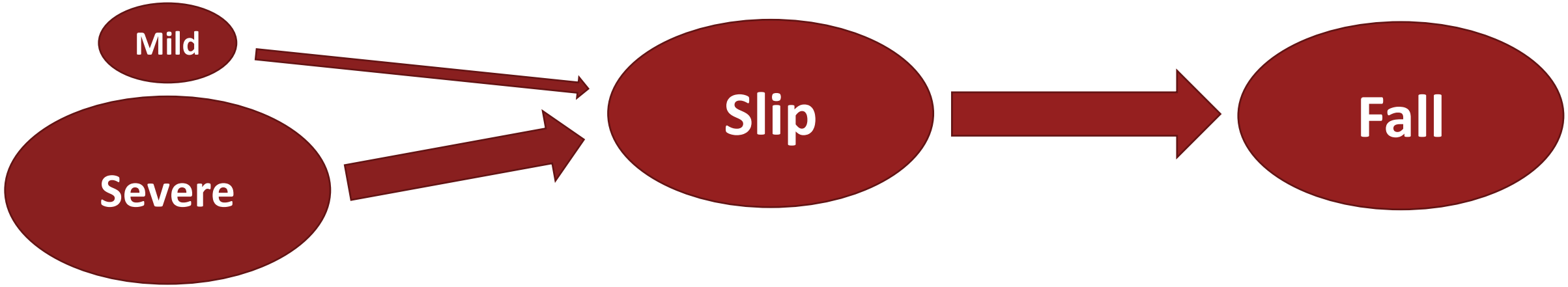
Why do we care?

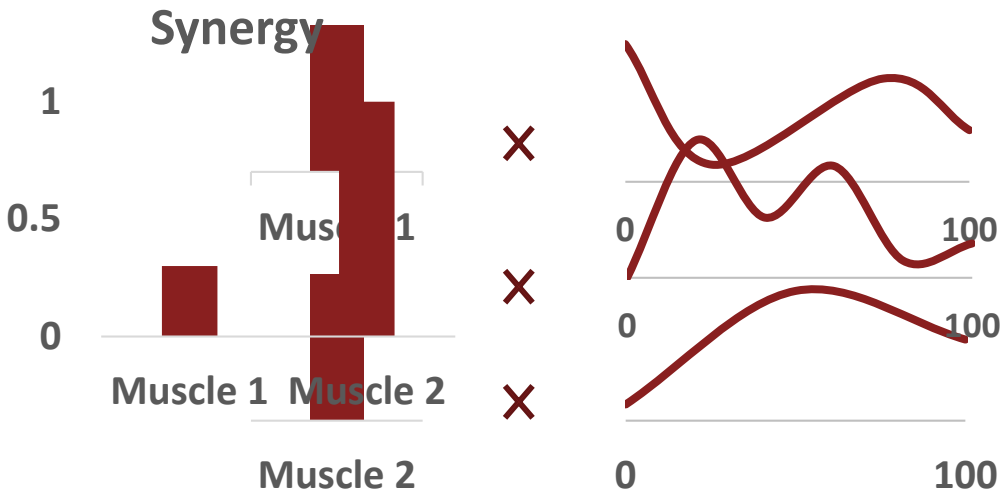
- Over $16 billion damage due to slips, trips, and falls in 2012 [1]
- Fall injuries have a growing trend[2]
- Slipping is the main trigger to falling[3]



[1] Liberty Mutual Research Institute for Safety, 2014.
[2] Bureau of Labor Statistics U S Department of Labor, 2015.
[3] Di Pilla, S. ***Slip, trip, and fall prevention***, 2009.

What is a *"Muscle Synergy"*?

- Human's musculoskeletal system is redundant and over-actuated
- Individual muscle control imposes a huge computational load
- Muscle synergy hypothesis suggests that the Central Nervous System (CNS) might unite muscles in groups[1]

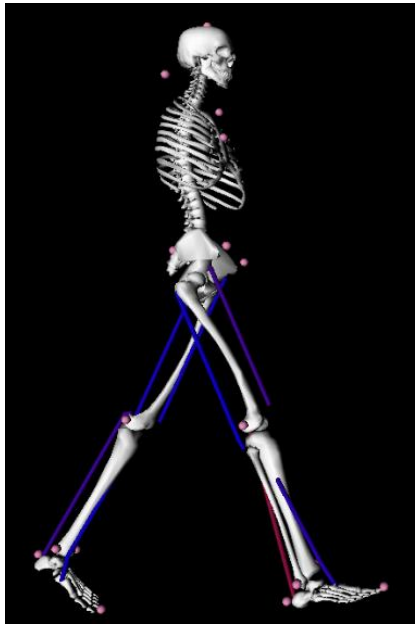


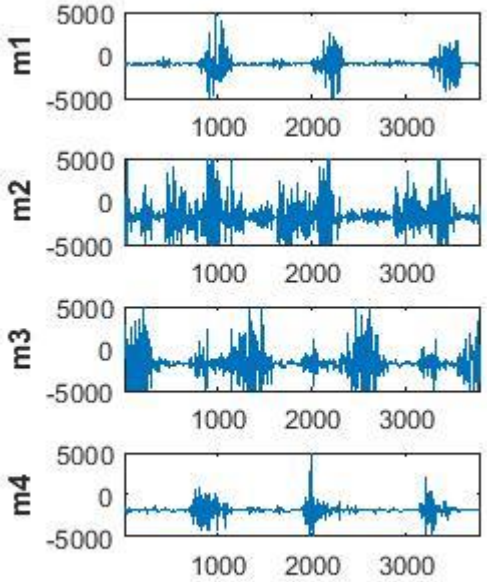
Motor-task

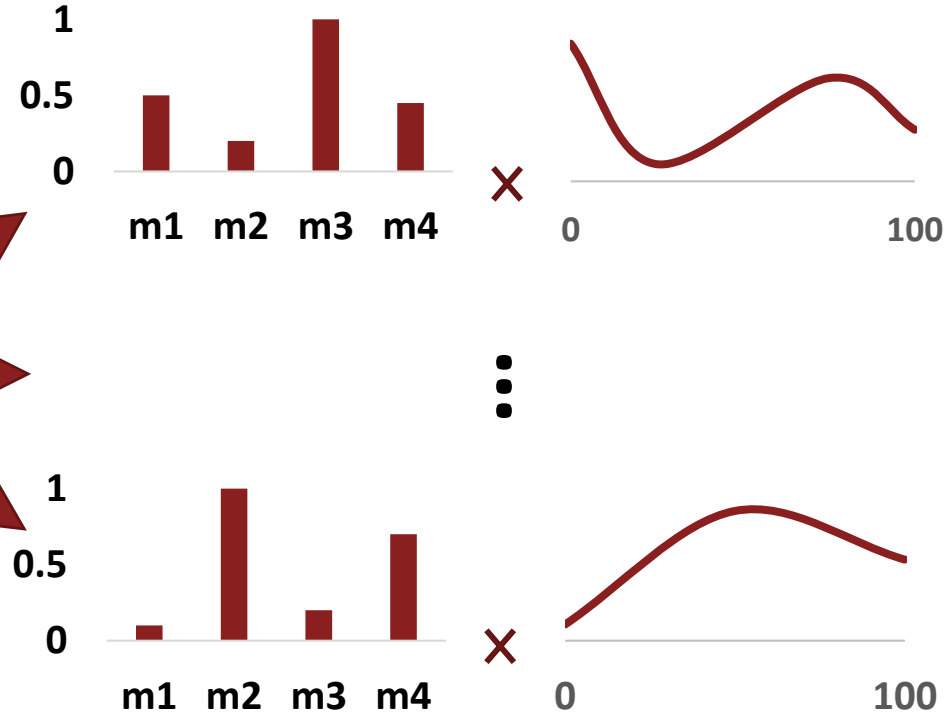
[1] Ting, L. H., & Macpherson, J. M. Journal of Neurophysiology, 2005.

Why Muscle Synergies?

- Synergies might represent sub-tasks of the original motor-task[1]
- Studying synergies leads to a identification of these sub-functions
- Our previous study has extracted muscle synergies for slipping and walking[2]







[1] Neptune, R. R., et al. ***Journal of Biomechanics***, 2009.
[2] Nazifi, M. M., et al. ***ASB***. Columbus, OH, 2015.

Objective

- To compare the slipping muscle synergies between “mild slippers” and “severe slippers” to identify inter-group discrepancies

Hypothesis

- There are significant differences in both synergies and activation coefficients of mild and severe slippers

Methods

- 20 healthy subjects free of gait disorders
- Asked to walk on a pathway with two force plates embedded
- After 2-3 walking trials, a slippery contaminant was applied
- Data was collected in University of Pittsburgh

Methods

Collected data included:

EMG:

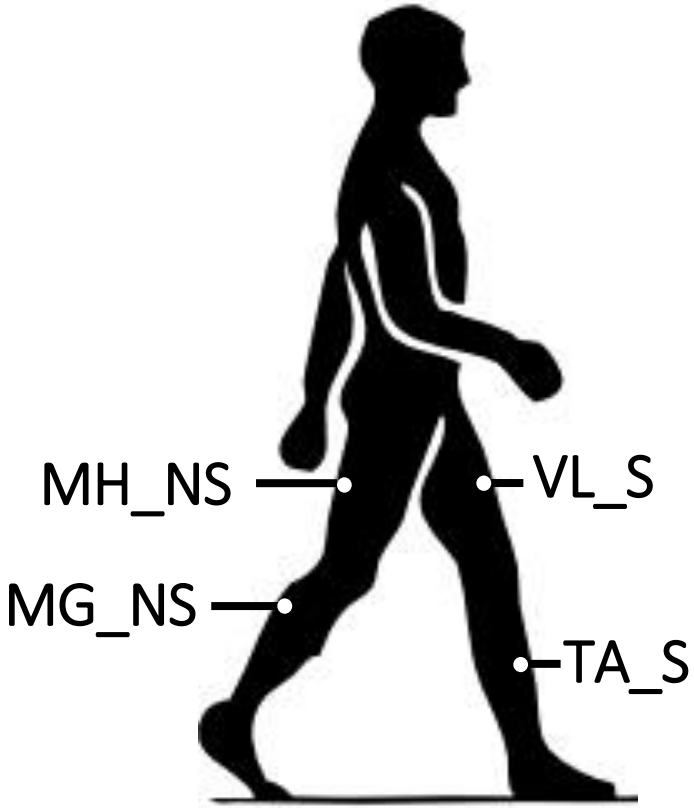
- To extract synergies
- medial hamstring (MH)
- tibialis anterior (TA)
- vastus lateralis (VL)
- medial gastrocnemius (MG)

Motion capture:

- To study Peak Heel Velocity (PHV)

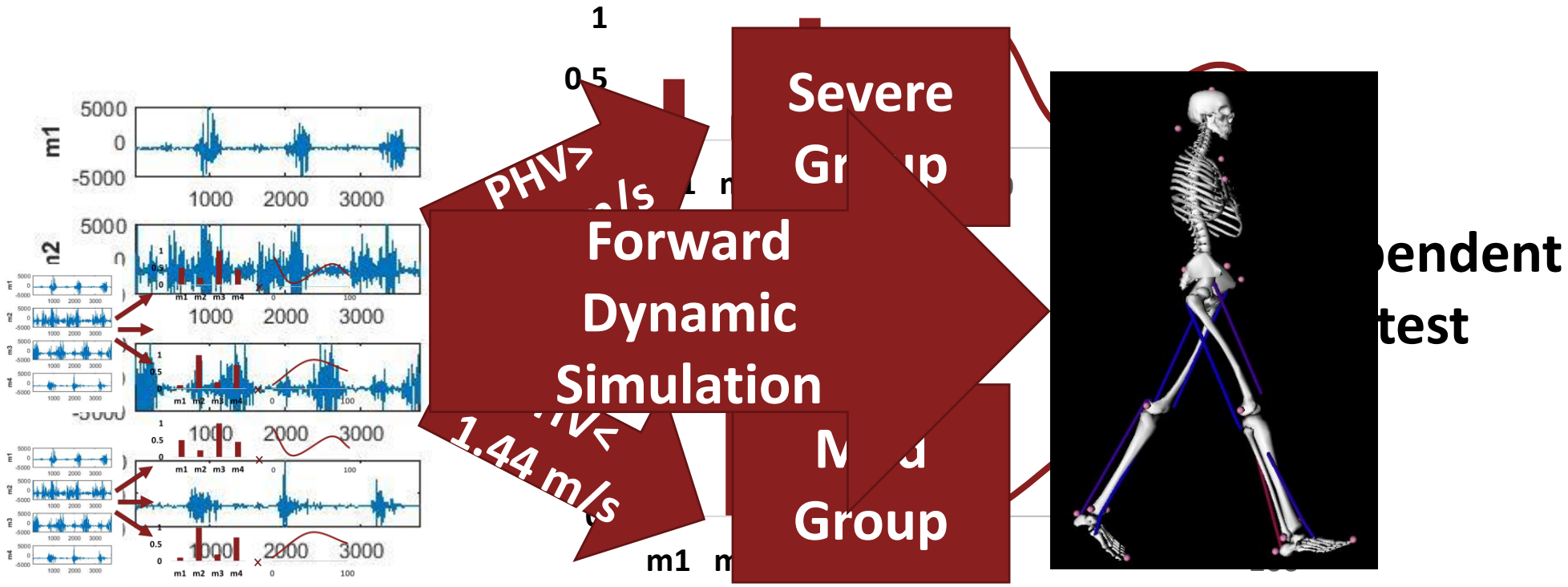
GRF:

- To detect the heel strike moment



Methods

- The first 300 ms after the heel strike was used to extract synergies
- A PHV greater than 1.44 m/s was considered a severe slip[1]



[1] Lockhart, T. E., et al. ***Ergonomics***, 2003.

Results and Discussion

- Four synergies were extracted for each subject
- Information of each severity group is as follows:

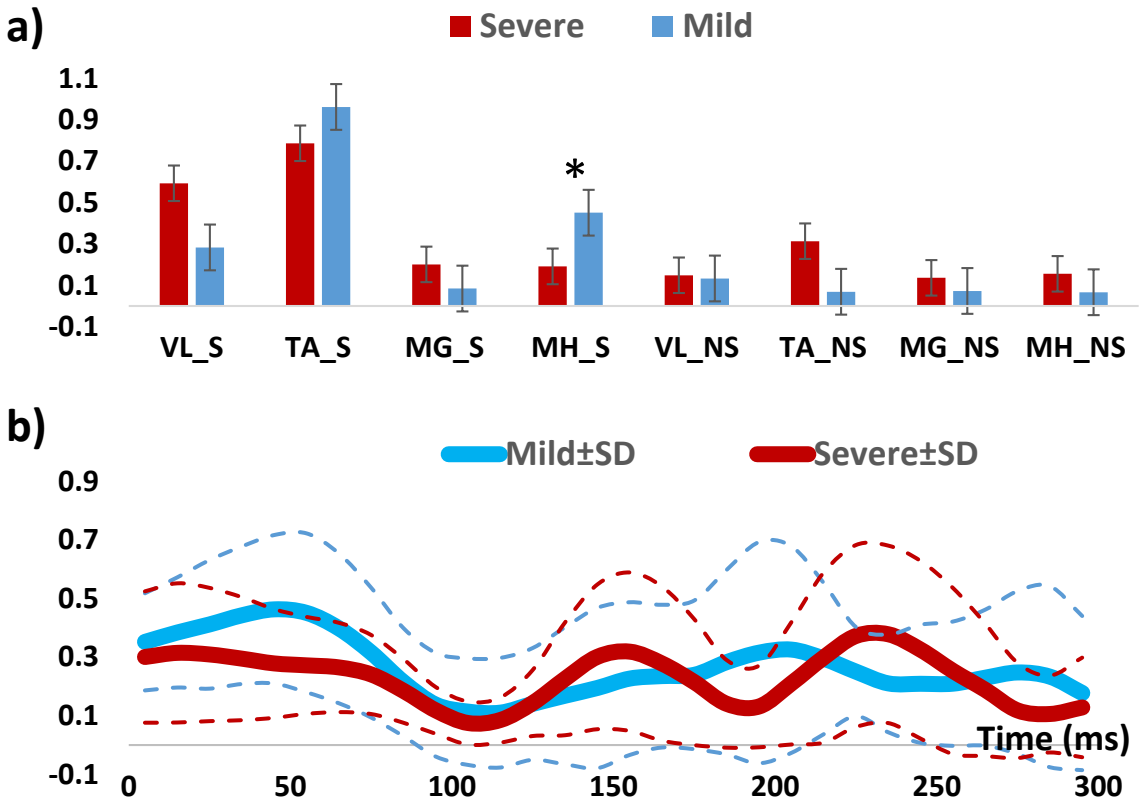
	number	PHV (m/s)	Age	Sex (M/F)
Mild	N=12	0.63±0.25	24.17±2.79	5/7
Severe	N=8	1.87±0.27	22.75±1.48	6/2

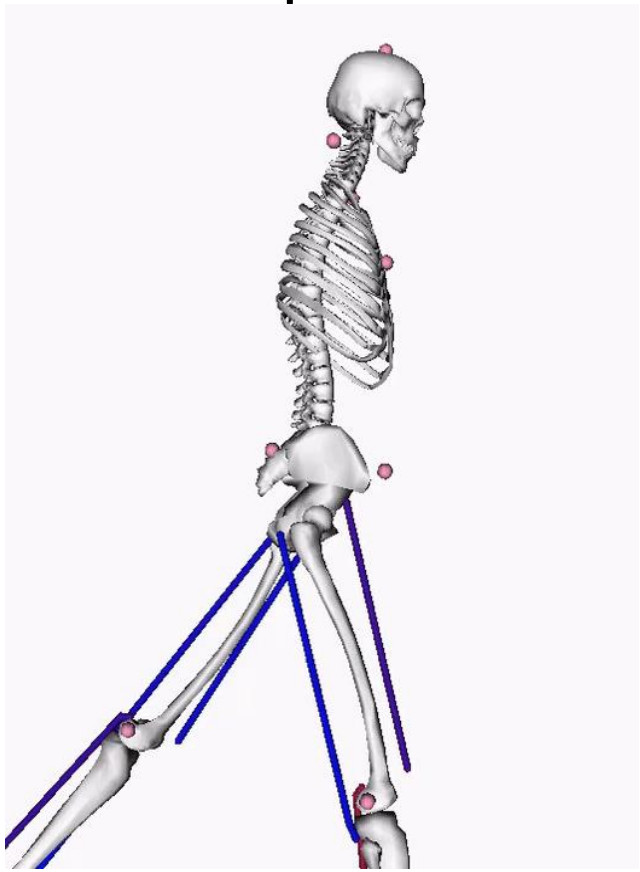
First synergy:

Role: Hip extension/dorsiflexion on the slipping limb

Decelerating the slipping limb, bringing it back near body[1]

More MH_S activity was associated with mild slips





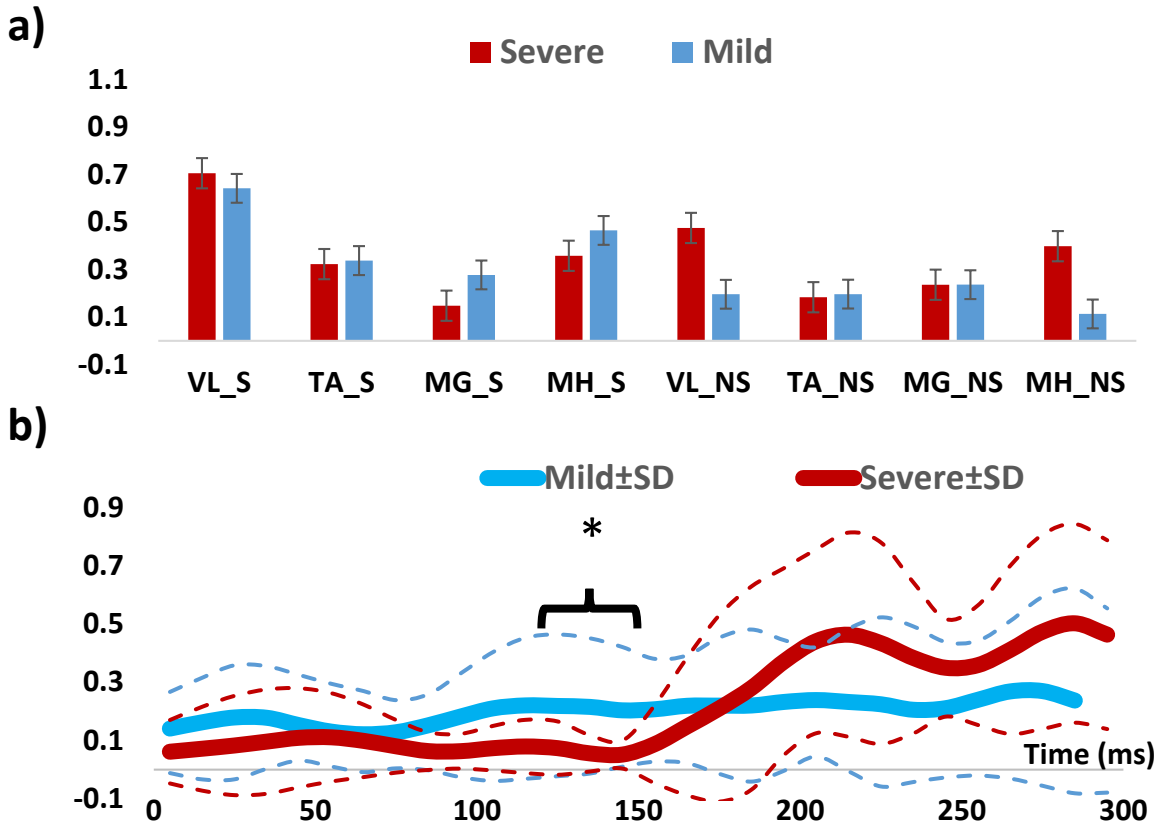
[1] Cham, R., et al. ***Journal of Biomechanics***, 2001.

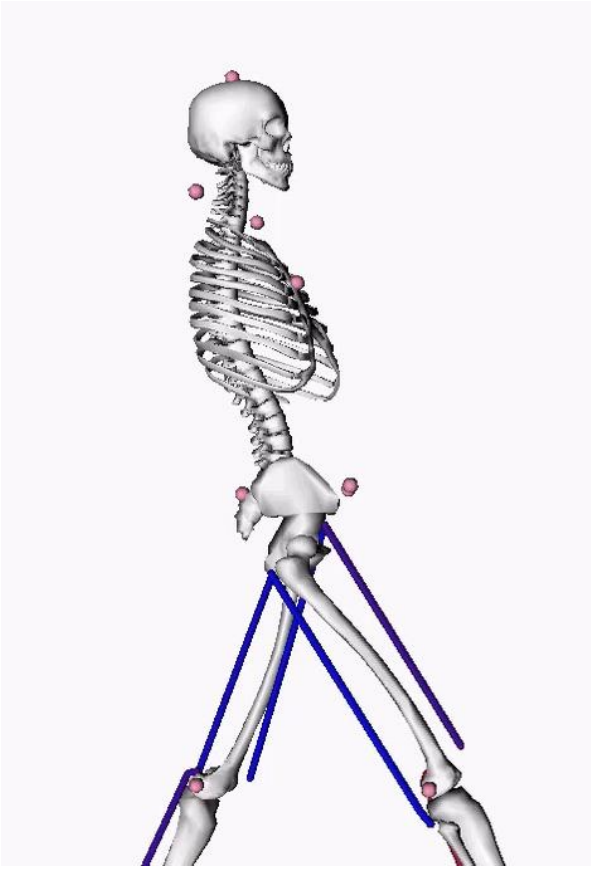
Second synergy:

Role: Hip flexor/knee extensor on slipping limb

Weight transfer to the leading limb, continuation of the gait[1]

Significantly higher activation seen in mild group





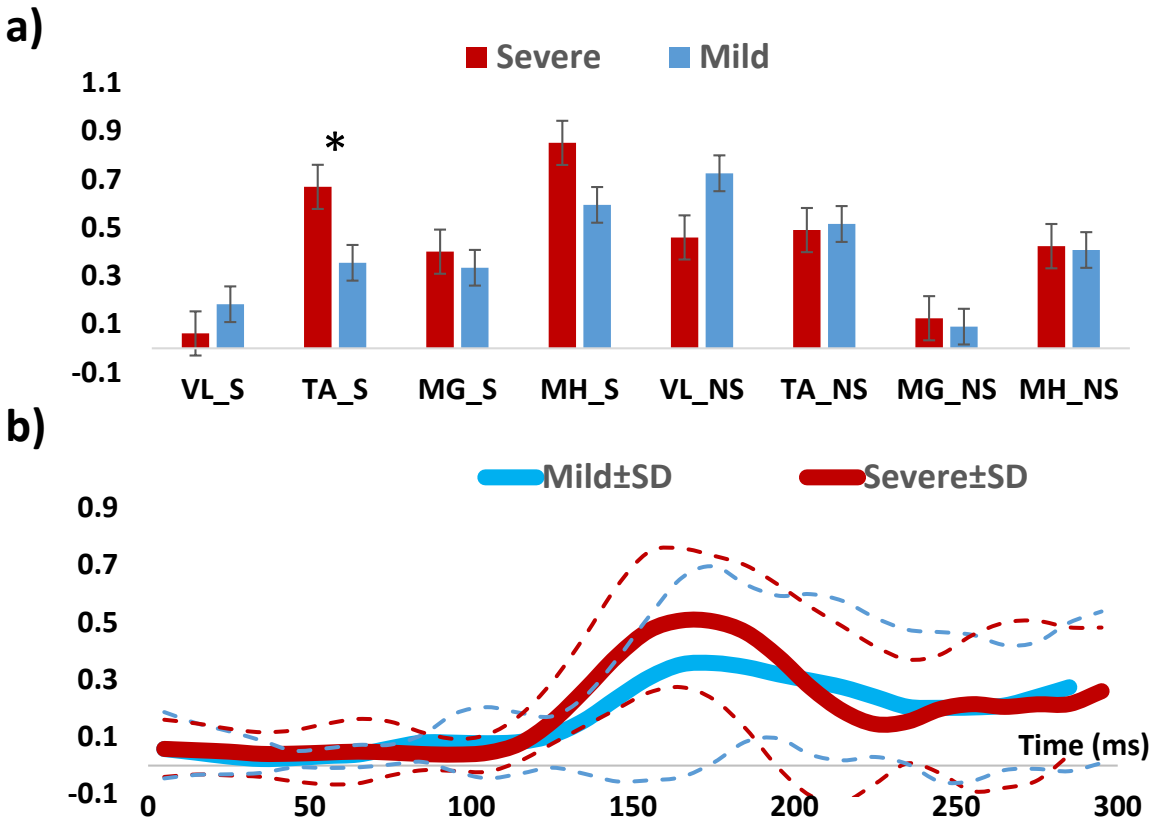
[1] Cham, R., et al. ***Journal of Biomechanics***, 2001.

Third synergy:

Role: Stiffening joints

More activation of TA_S was associated with severe slips

High Foot Floor Angle (FFA) has been reported in severe slips[1]



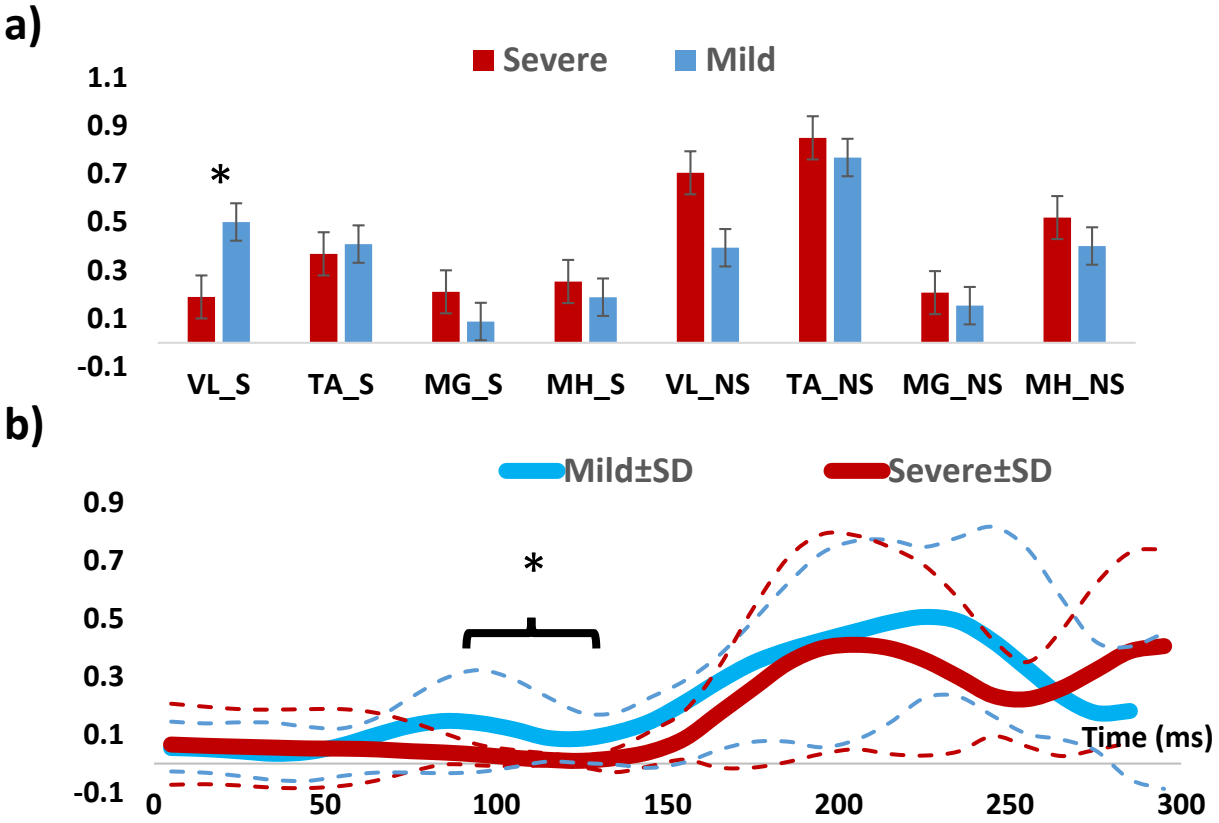
[1] Moyer, B. E., et al. (2006). ***Ergonomics***, 2006.

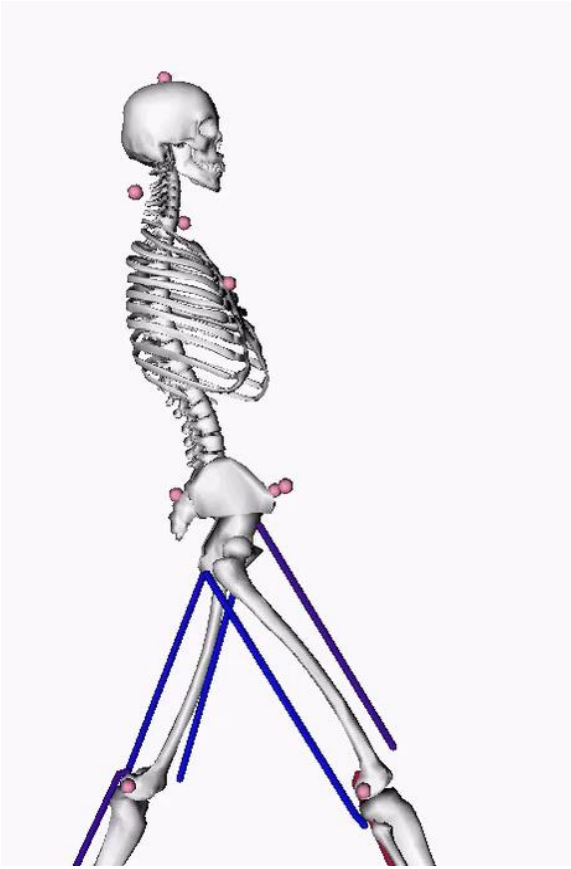
Fourth synergy:

Role: hip flexor/ knee extensor on both limbs

Weight transfer to the slipping limb, and prevents tripping[1]

Mild slippers activated this synergy faster and with more contribution of VL_S





[1] Marigold, D. S., et al. ***Journal of Neurophysiology***, 2003.

Conclusion

Findings:

- **Inter-group differences found in synergies of mild and severe slippers**
- **We found different interlimb coordination for different severity groups**
- **Phasic sub-function of each synergy was studied using forward simulation**

Applications:

- **Design of an exclusive training to target and rehabilitate the impaired synergy[1]**

Future works:

- **Study the effectiveness of such targeted motor rehabilitations on severe slippers**

[1] Dipietro, et al. ***Journal of Neurophysiology***, 2007.

Acknowledgements

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We also thank Delsys® for the sponsoring us for this conference

Thanks for your attention!
Questions?