The Effects of Muscle Co-Contraction on Ankle Joint Muscle Stiffness in Maintaining Postural Steadiness using Ultrasound Elastography in Healthy Individuals

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The GOAL IS TO MAINTAIN BALANCE!

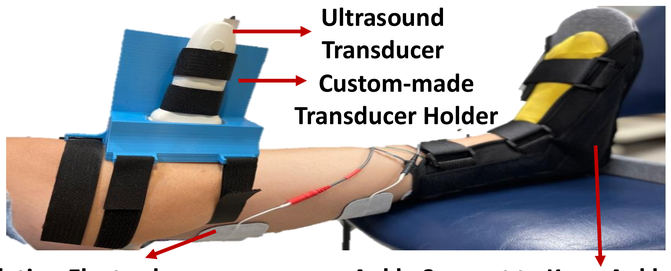
INTRODUCTION

- Individuals with incomplete spinal cord injury (iSCI), in standing
  - ✓ **Postural instability, larger postural sway**[1]
  - ✓ Utilize ankle muscles **co-contractions (e.g., soleus (SOL) and tibial anterior (TA))** to accommodate for decreased motor function.
- There is contradictory evidence about the effect of muscle co-contraction on the postural steadiness.
- Neuromuscular electrical stimulation (NMES)
  - ✓ Artificially induce muscle contraction
  - ✓ **Affect muscle stiffness**
- Muscle stiffness can directly be measured by **ultrasound shear wave elastography (SWE)** during various tasks.

This study quantitatively investigates ankle muscle stiffness's effects on the postural steadiness and the relationship between the ankle muscle co-contraction and postural sway in healthy individuals.

METHODS

- Ankle muscles (SOL, TA) of twenty young able-bodied individuals.



Acquire five SWE images

Experiment 1

At five voluntary contraction levels.

At four artificially contraction levels + each voluntary contraction level.

Experiment 2

At four artificially contraction levels + natural contraction

- **Exp.1:** Seated with extended knee
- **Exp.2:** Standing on a force plate, eyes open, hands crossed

- **The measurements**
  - ✓ Young's modulus (E) as a surrogate of stiffness for each image.
  - ✓ Center of mass and center of pressure → Evaluate body sway.[2]

PRELIMINARY RESULTS

- One-way ANOVA and Student's T-test were used to compare stiffness between and within muscles and conditions **(Figure 2)**.

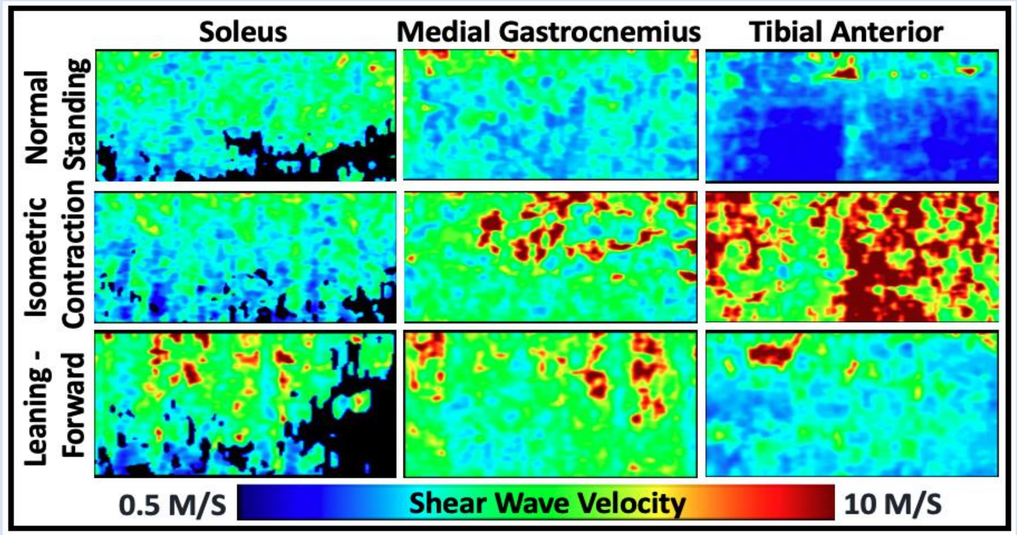


Figure 1 shows the SWE images of SOL, medial gastrocnemius (MG) and TA muscles at three conditions: normal standing, isometric contraction, and forward-leaning.

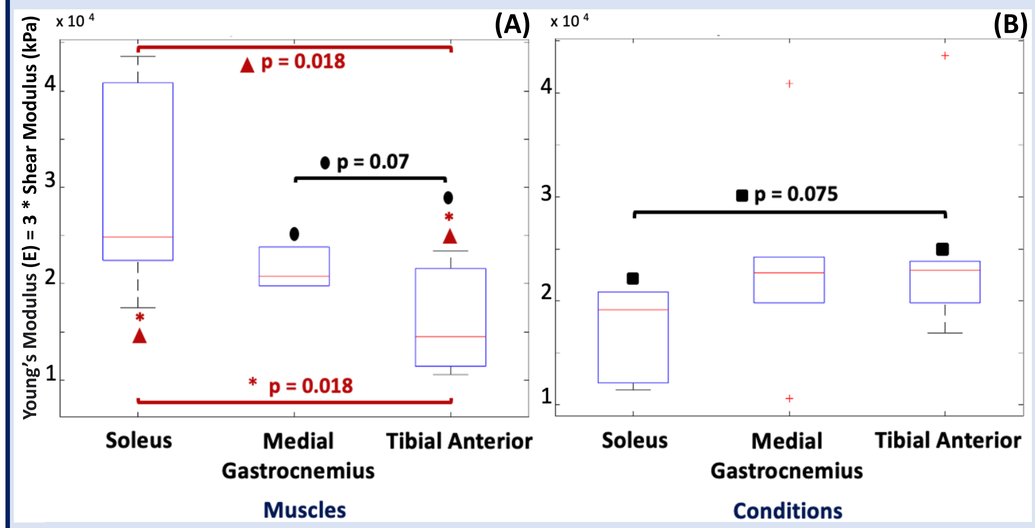


Figure 2 (A) shows stiffness comparison between muscles. **Figure 2. (B)** shows stiffness comparison between conditions.

- Please note, the red color represents the significant results ($p < 0.05$).

DISSCUSSION

- Ankle muscle stiffness can be directly evaluated using SWE as a feasible tool in quiet standing.
- A significant difference between and within the muscle agrees the importance role of SOL in maintaining balance.
- Generating sufficient tension in the plantar-flexors (e.g., SOL) to maintain balance results in changes in muscle length which has a proportional relationship with stiffness.[3]
- SWE may quantitively improve the understanding of muscle co-contractions
- Provides better proprioceptive information about postural stability in maintaining balance in iSCI individuals.
- This study could also help with the development of rehabilitation techniques for individuals with iSCI to improve their balance stability (e.g., in NMES).

CONCLUSION

- The effects of muscle co-contraction on the postural sway can be studied in healthy individuals using SWE during quite standing.

REFERENCES

1. Fok et al., "Co-contraction of ankle muscle activity during quiet standing in individuals with incomplete spinal cord injury is associated with postural instability", 2021.
2. Winter et al., "Stiffness control of balance in quiet standing", 1998.
3. Di Giulio et al., "The proprioceptive and agonist roles of gastrocnemius, soleus and tibialis anterior muscles in maintaining human upright posture", 2009.

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