

# Compensation patterns in the ground reaction forces indicate stabilization of CoM acceleration while ascending curbs and stabilization of body pitch acceleration while descending curbs.

## Synergistic ground reaction forces during double support while negotiating a curb

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### INTRODUCTION

- Negotiating stairs or steps is a common cause of falls and injuries among older adults [1]; more falls occur while stepping down [2].
- While stepping down, momentum will likely be greater relative to stepping up. Quantifying the control of motion during weight transfer can provide new insight.
- The uncontrolled manifold (UCM) method [3] quantifies the coordination between the ground reaction forces (GRFs) under the two limbs during double support phase.

### AIM

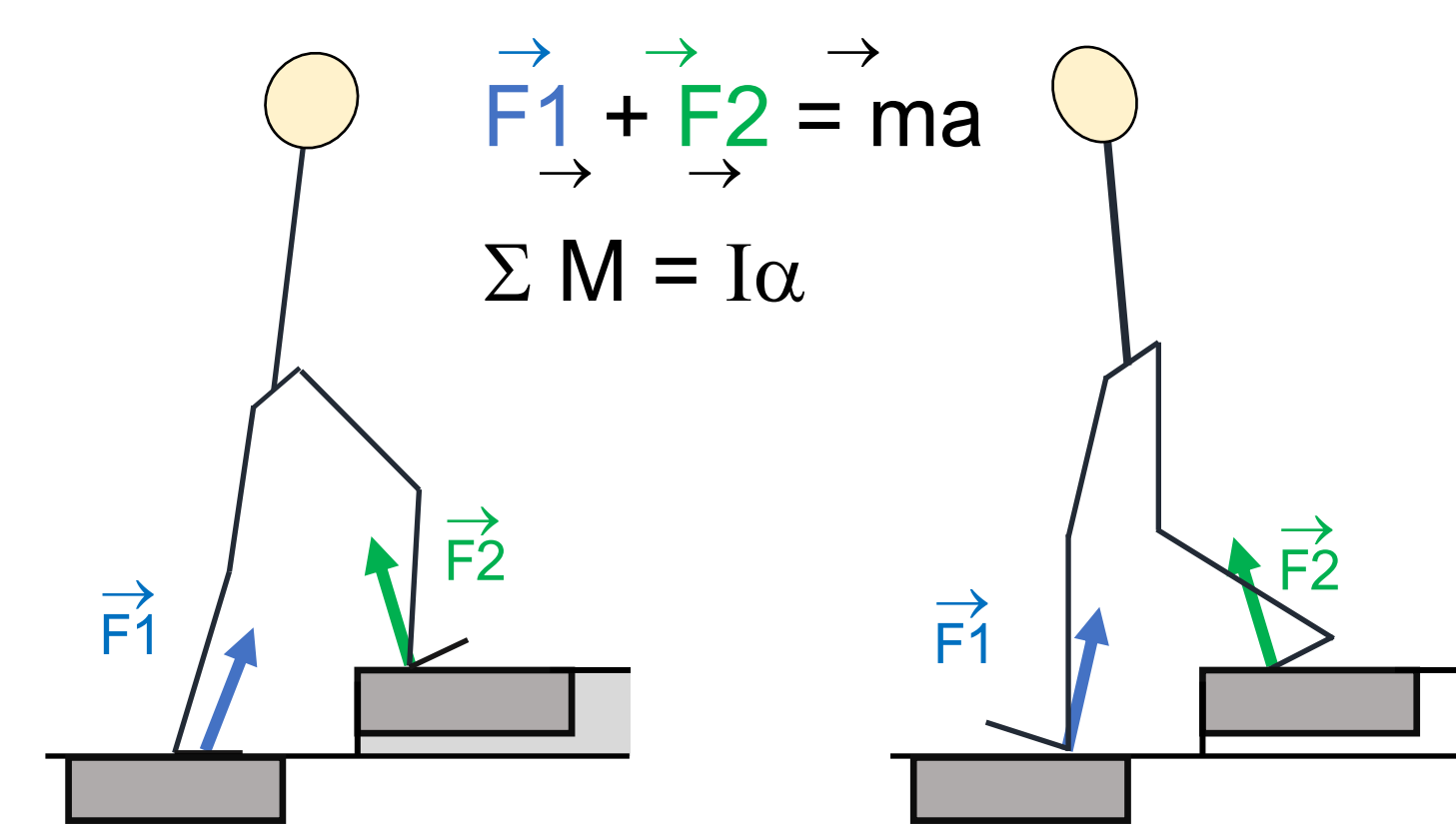
To investigate coordination in the GRFs under both limbs while ascending and descending a curb.

### METHODS

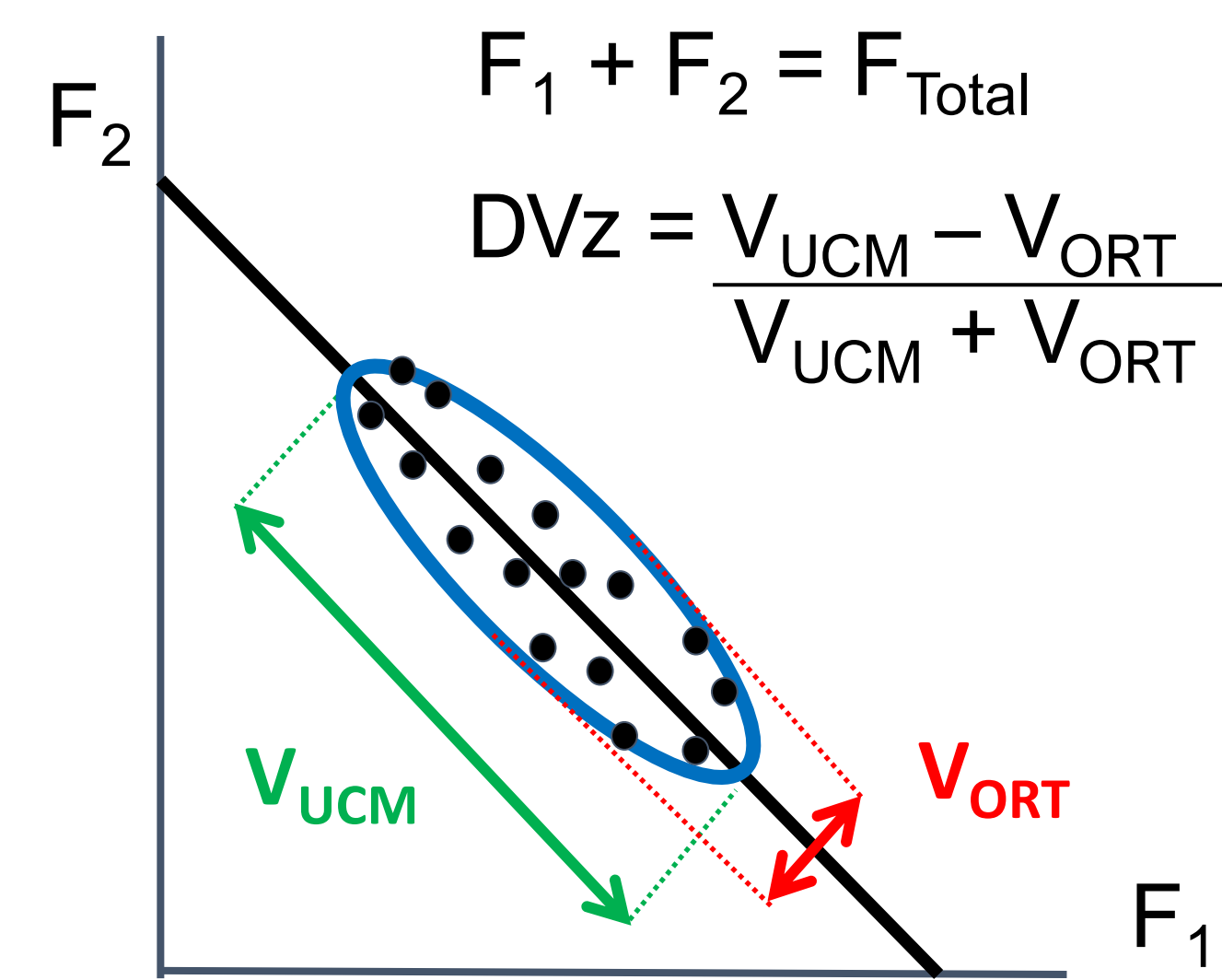
- 10 young (23.1±6.8 yrs, 3 M) and 10 older healthy adults (72.7±4.9 yrs, 3 M).
- During double support (Fig. 1), we examine two variance components (Fig. 2):
  - Along the UCM ( $V_{UCM}$ ) → compensation between two forces that stabilizes the total force, and therefore CoM acceleration.
  - Orthogonal to the UCM ( $V_{ORT}$ ) → lack of compensation between two forces.
- These variance components yield the synergy index DVz.

### RESULTS

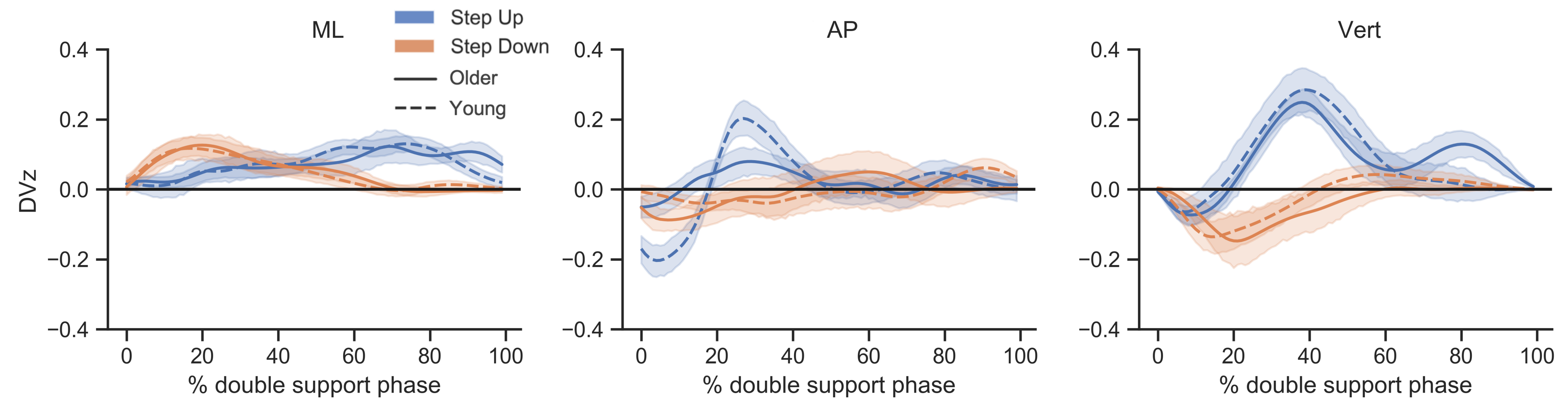
- Peak DVz was different from zero for the all three directions and age groups ( $p < 0.01$ ).
- Peak DVz was higher for step up than step down in AP direction ( $p = 0.017$ ).
- For vertical direction, peak DVz was significantly larger for step up than step down for both young and older adults ( $p < 0.01$ ).



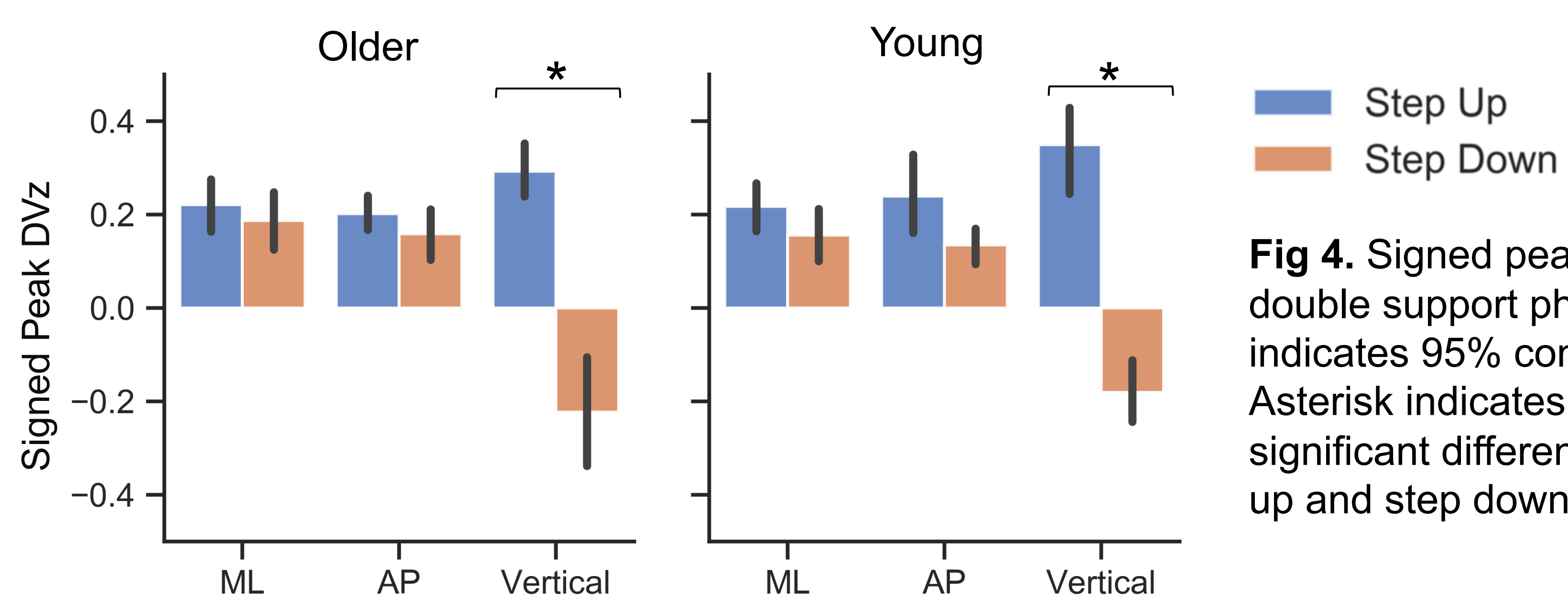
**Fig. 1** 10 young and 10 older adults stepped up or down a 15 cm curb for 20 trials.



**Fig. 2** UCM analysis. DVz > 0 indicates the presence of a kinetic synergy between the two GRFs stabilizing the CoM acceleration.



**Fig. 3** Across-subject mean ± SE of the synergy index (DVz) of 3D GRFs during double support phase.



**Fig. 4.** Signed peak DVz during double support phase. Error bar indicates 95% confidence interval. Asterisk indicates statistically significant difference between step up and step down.

### SUMMARY

- No age group difference observed in the peak synergy index, indicating that both young and older adults share similar coordination patterns of the GRFs during curb negotiation.
- There exists kinetic synergy that stabilizes the CoM acceleration in ML and AP directions during the double support phase of stepping up and stepping down.
- Vertical CoM acceleration is stabilized for stepping up, but not stepping down.
- The anti-synergy (Fig. 2) indicates that vertical CoM acceleration is variable across repetitions, and that body pitch acceleration might be stabilized while stepping down.

### ACKNOWLEDGMENTS

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### REFERENCES

- [1] Startzell et al., J Am Geriatr Soc, 2000
- [2] Tinetti et al., N Engl J Med, 1988
- [3] Scholz & Schöner, Exp Brain Res, 1999

