Altered Kinematic Coordination in Above-Knee Amputees May Be Key to Improving Control of Powered Prostheses

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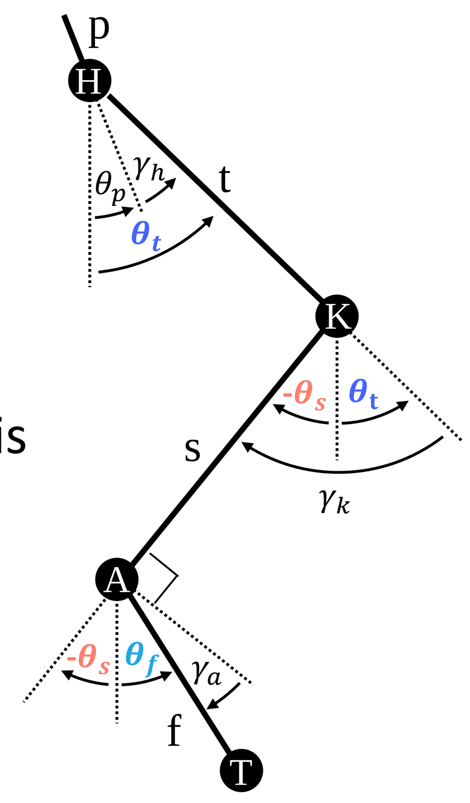
Introduction

- **Elevation angles** of thigh, shank and foot covary along a plane (**CVP**) in walking [1].
- The tilt of the covariation plane (CVP) is related to the **mechanical energy cost** [2].
- In transfemoral amputees (TFA), a major problem is elevated metabolic cost even when equipped with powered legs [3].
- Human motor control of limb axis length and orientation can explain this CVP [4].



- **Our** current **hypothesis** is that metabolic cost is elevated due to **altered** coordination by TF amputees.

Methods

- Able bodied, K3 (community ambulation), K2 (limited ambulation), powered, and passive prostheses datasets.
- Elevation angles, Principal Components, and relation to limb axis.

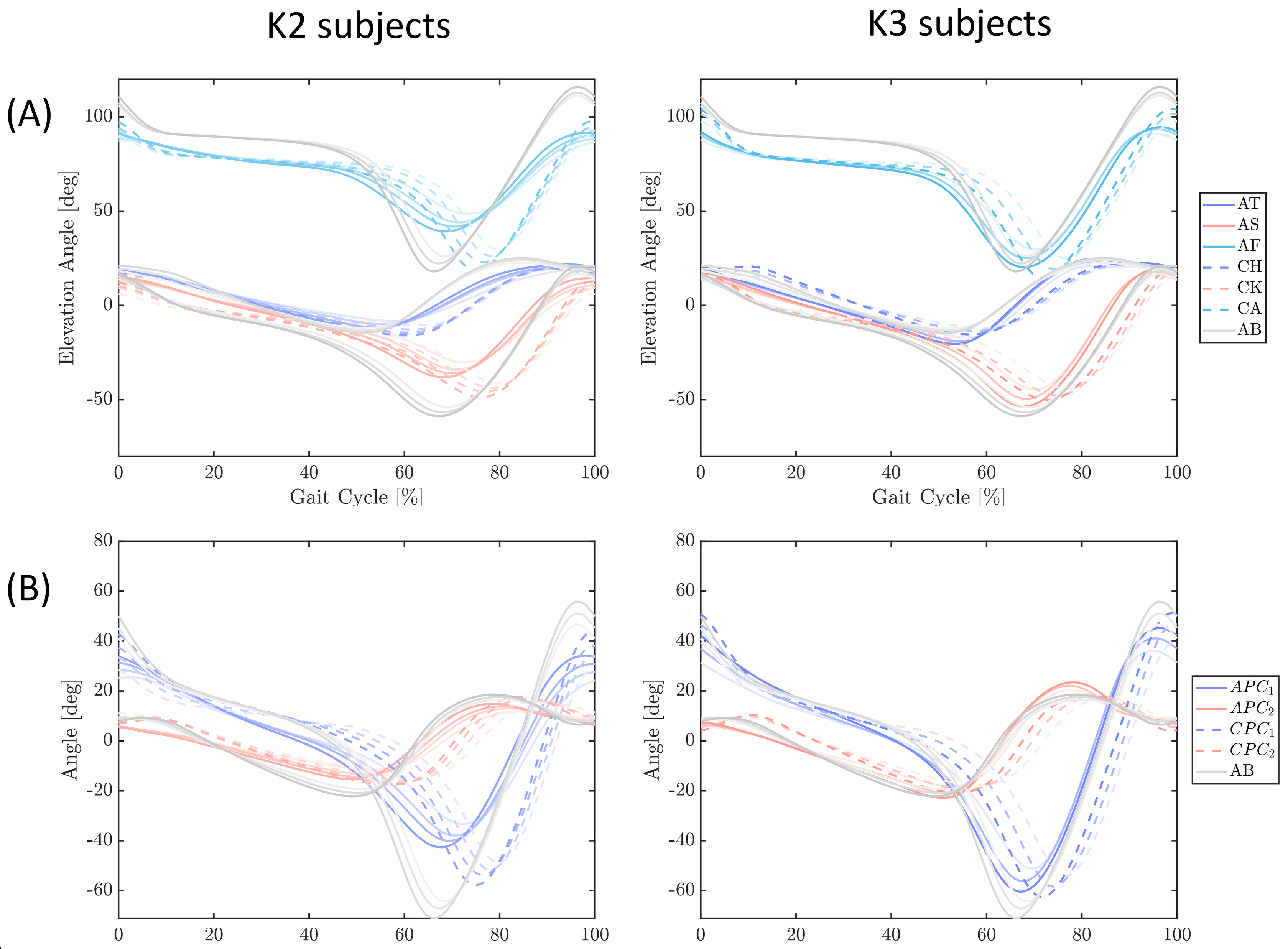


Figure 1. (A) Elevation angles and (B) PCs for TFA vs AB gait.

Conclusions

- **Coordination is altered** for amputee gait with both Powered and Passive prostheses.
- This alteration is tied to control of limb length → increased energetic cost might result from greater need to "lift" the center of mass [5].
- Altered coordination among K2 subjects (with worse gait outcomes) is due to reduced motion of the shank versus the foot.
- **Powered** prostheses may be unsuccessful for reducing metabolic cost versus passive since their current control seems to **worsen limb coordination**.

Results

- **Phase shifts** between Amputated and Contralateral legs.
- Lower range of motion of the limb axis orientation PCs.
- **Prosthesis controllers** may be following a correct joint angle trajectory, but they are **not coordinating** correctly.

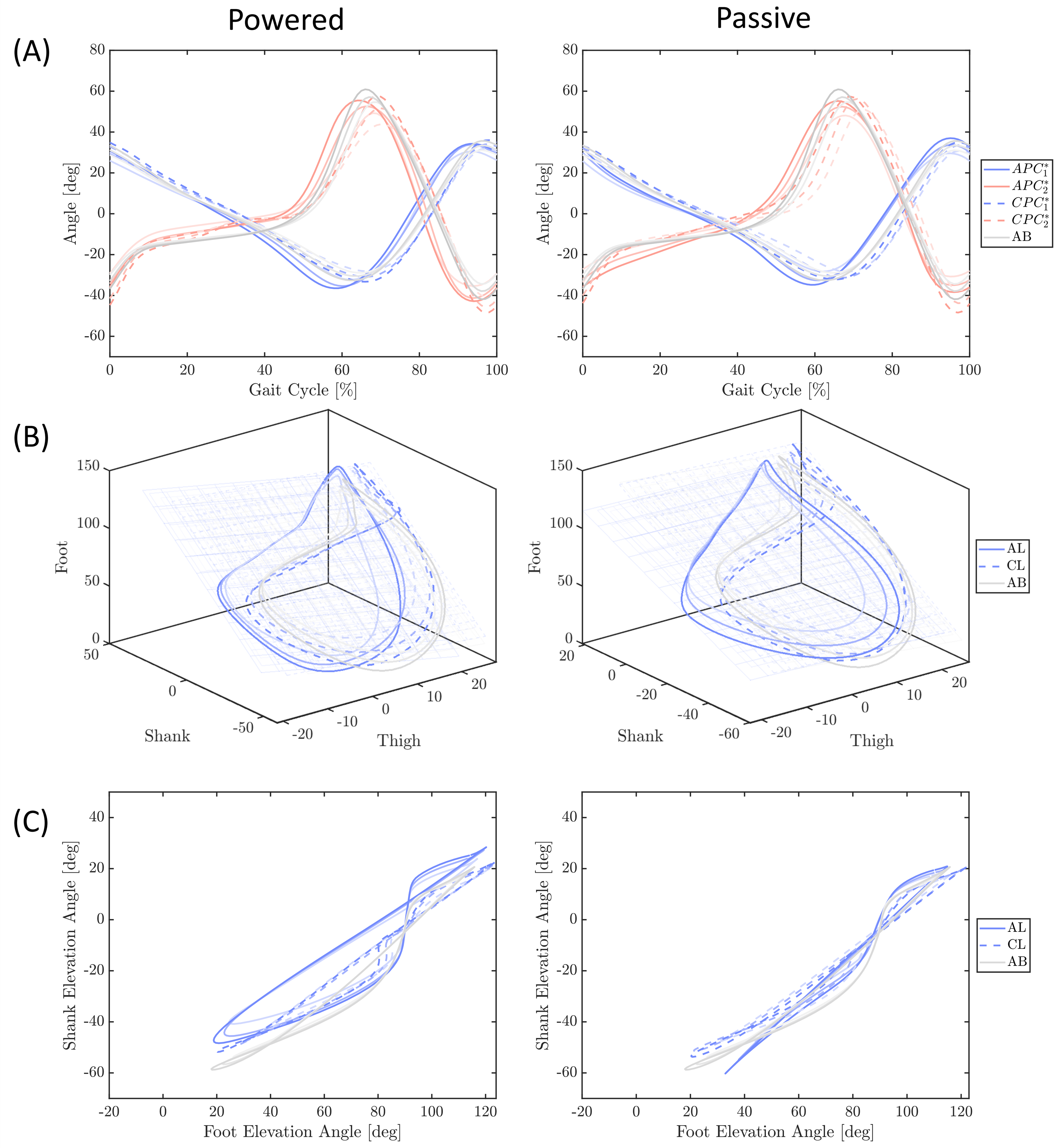


Figure 2. (A) Limb axis PCs*, (B) Covariation Plane, (C) Shank Foot Coordination for TFA vs AB gait.

Can control of prosthetic legs lower metabolic cost by using limb coordination as a virtual constraint?

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* Limb axis PCs computed by projecting the [1,1,1] direction on the CVP and finding its normal vector on the plane.
** Background image taken from https://www.shutterstock.com/search/amputee-leg c