Title: Age-related difference in modulation of margin of stability during curb descent in response to a subsequent precision stepping demand

BACKGROUND AND AIM

Community ambulation requires negotiating surface elevations and precision stepping. Compared to level-ground walking, kinetic energy increases when descending steps, and demands greater stability control. Furthermore, since stability control is primarily achieved via foot placement [1], environmental constraints on foot positions challenge stability. We quantified investigated control over several steps in a multi-feature environment in healthy adults. The purpose is to examine age-related changes in stability control for curb descent in response to a subsequent precision stepping task.

METHODS

18 young (24±4 yrs) and 10 older adults (70±6 yrs) walked on an 8 m walkway and stepped down a 15 cm curb halfway down the walkway. Two blocked conditions were examined: Baseline (no target; used to identify preferred foot placement) and Target (located at preferred foot placement, visible throughout trial, Fig. 1A). Kinematic data was used to compute the margin of stability (MoS) in AP and ML directions at foot contact for 6 foot placements (fp-3,-2,-1,1,2,3). Greater positive MoS indicates higher passive dynamic stability.

RESULTS

We observed a significant *Foot placement x Age x Block* interaction for MoS_{ML} ($F_{5,4598}$=2.3, p=0.04). MoS_{ML} for fp 1,2 are smaller than other foot placements. Older adults have larger MoS_{ML} than young adults for fp 1,2 for the target condition only. MoS_{ML} increased for target condition compared to baseline for fp -2 and -1 for young adults but for fp -1,1,2, and 3 for older adults.

We observed significant *Foot placement x Block* ($F_{5,4598}$=9.7, p<0.01) and *Foot placement x Age* ($F_{5,4598}$=45.1, p=0.01) interactions for MoS_{AP}. MoS_{AP} for fp 1 is smaller than all other foot placements, and it increased for fp -2,-1,1,2 or the target condition for both groups. Older adults had larger MoS_{AP} than young adults for fp 1.

CONCLUSION

Lower passive stability while stepping down (fp 1) indicates utilization of the kinetic energy gained during descent to passively propel the body forward in both groups. However, older adults prioritized safety over energy efficiency. Higher MoS for fp1 in older adults provides a stronger buffer against external perturbations and helps counter age-related declines in muscle strength.

MoS for the target condition increased for steps leading up to the target, even when the target was placed at the preferred foot location, indicating more rear and medial CoM position and/or lower CoM velocity. These changes increase the space and time available to accurately position the foot on the target. Higher MoS during approach suggests that these gait characteristics must be altered over multiple steps.

The preparatory modulation in MoS_{ML} is delayed in older adults. This delay may reflect decline in adaptability with ageing [2], or a superior strategy for achieving precision. Further investigation is required to distinguish between these possibilities.

REFERENCES: [1] Winter 1995; [2] Caetano et al. 2016

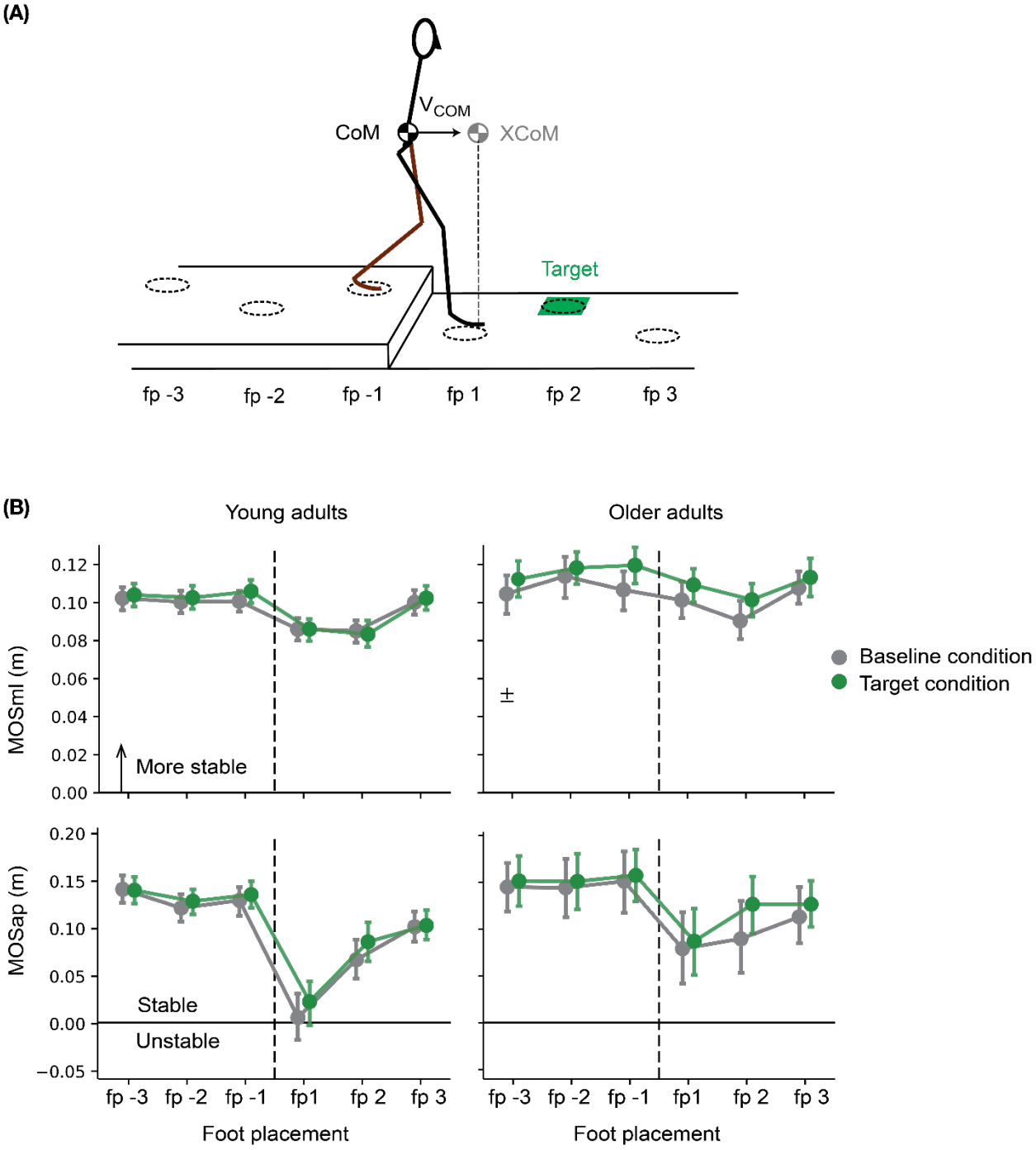

Figure 1. (A) Illustration of the walkway and the analyzed steps. Target is present for the target block at the preferred foot landing area for fp 2 only. The stick figure illustrates MOSap at fp 1, calculated as MOSap = Anterior border of base of support (BOS) – velocity extrapolated center of mass (XCoM) position. Anterior border of BOS is defined as the lead toe marker. Similar definition is used for MOSml, with lateral border of the BOS defined as lead 5th metatarsal marker. (B) Mean±SE of MOS in ML and AP direction for the six foot placements for young and older adults. The vertical dotted line indicates location of the curb edge. Positive MOS indicates passively stable gait for that step.