3000 characters including spaces/~500 words

Title: Stable passive dynamics during obstacle crossing may indicate a safety-energy efficiency trade-off in older adults.

BACKGROUND & AIM

Walking in the community requires fulfilling multiple goals simultaneously such as avoiding hazards while maintaining stable forward locomotion [1]. Stable gait in anteroposterior (AP) direction is achieved by appropriate foot placement [2]. In an uncluttered and unperturbed environment, stable gait is associated with consistent foot placements. In a cluttered environment, individuals adjust foot placements to achieve stable gait while navigating hazards. During unobstructed walking, young and older adults rely on passive rotation of the body about the stance ankle to maintain forward progression [4]; however, this reliance on the passive dynamics may change during obstructed gait and in response to increasing age [5]. Further, individuals may proactively modulate passive stability to facilitate transition between unobstructed and obstructed gait. Therefore, our aim is to determine if passive stability is modulated as a function of task, age, and during transition between unobstructed and obstructed gait.

METHODS

Twenty young (22±4 years) and nine (71±3 years) healthy older adults walked on a 6 m walkway and stepped over an obstacle when present. Each participant completed fifteen trials with and without obstacle. We recorded lower-body kinematics with a motion capture system. We quantified passive dynamic stability in AP direction at each heel contact using margin of stability (MOS_{ap}; **Fig.1A**). Positive (negative) MOS_{ap} indicate passively stable (unstable) state [3].

RESULTS

A significant three-way interaction (age × task × step) was observed for MOS_{ap} ($F_{12,243} = 47.10$; $p < 0.01$, **Fig. 1B**). Post-hoc analyses revealed that MOS_{ap} was not different in the following steps in both age groups: all steps when an obstacle was not present and three steps during the approach to the obstacle (steps-4,-3,-2). MOS_{ap} significantly increased in the step before the obstacle (step-1), and increased further during the obstacle crossing step; the obstacle crossing step was the only step where MOS_{ap} was larger for older versus young adults.

CONCLUSION

Negative MOS_{ap} for all but one step indicates exploitation of the passive forward motion of the COM to maintain forward progression. However, this behavior is altered by task, age and during transition. Healthy young and older adults rely less on passive dynamics for forward progression while crossing an obstacle compared to unobstructed walking. Furthermore, the positive MOS_{ap} for the obstacle-crossing step indicates a preference for safety over energy efficiency. Although stable passive dynamics will facilitate recovery from a potential perturbation (e.g., a trip), the higher stability also means that more energy (greater push-off force) will be required to regain speed after obstacle crossing. Older adults prioritize safety more than young adults. Finally, young and older adults proactively alter MOS_{ap} one step before the crossing step, presumably to facilitate obstacle crossing.

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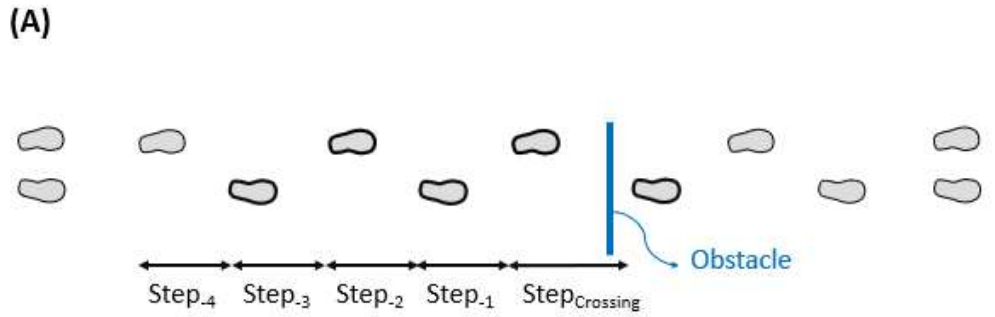

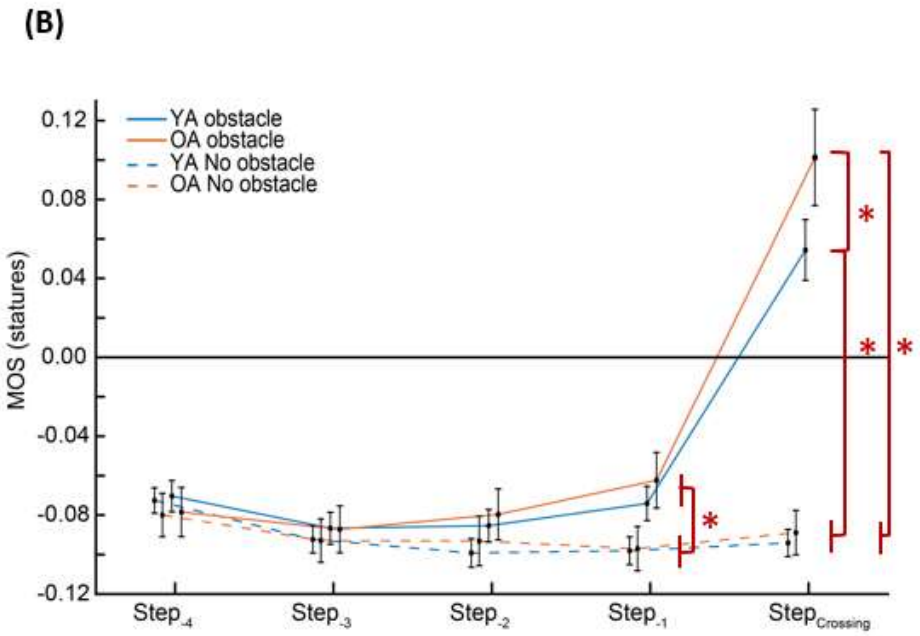

Figure 1. (A) Top view of the walkway, foot placements, and steps. Participants crossed the obstacle with their right leg first. We quantified the margin of stability at initial contact of the steps with bold margins (five foot placements), **(B)** Line plot depicts the mean and standard error of MOS_{ap} at each step during the No obstacle (dashed lines) and obstacle condition (solid lines) in young and older adults (blue and red lines, respectively). * indicates statistically significant differences ($p<0.05$).