Using Time-to-Contact to Predict Stepping Behavior After Postural Perturbations in Older Adults

Christopher J. Hasson, Graham E. Caldwell, and Richard E.A. Van Emmerik

The center of mass (CoM) time-to-contact (TtC) is a spatiotemporal measure that the postural control system may use to predict future instability. Previously we described a quadratic relation between the minimum CoM TtC and the magnitude of upper-body postural perturbations in healthy young adults (Hasson et al., in review). The minimum vertex of the quadratic was predictive of the transition from a stationary support base to a stepping behavior. The purpose of this study was to determine if minimum TtC information could also predict stepping behavior in response to perturbations in older adults. Twelve young (Y: 27±3 yrs) and nine older (O: 71±5 yrs) subjects were strapped to a lightweight wooden backboard and given a series of sequentially increasing upper body perturbations using a spring-loaded 15 kg pendulum. Subjects were to resist the perturbation, stepping only when necessary to prevent a fall. The postural challenge was computed as the peak pendulum velocity divided by subject mass. The instantaneous TtC was computed using CoM position (relative to support boundary), velocity, and acceleration, with the minimum TtC selected for further analysis. For both age groups, quadratic equations fit the minimum TtC vs. postural challenge relation well (R^2: Y = 0.97±0.25; O = 0.96±0.27); the vertices of the equations accurately estimated the challenge level (error: Y = 0.17±0.13; O = 0.11±0.07 deg/s/kg) and the minimum TtC (error: Y = 7±3; O = 9±14 ms) in the trials that elicited stepping behavior. The older adults transitioned to a stepping response at significantly lower postural challenge levels compared to younger subjects (1.1±0.3 vs. 1.8±0.2 deg/s/kg). For a given challenge level, the older adults tended to have a shorter minimum TtC, largely due to higher peak CoM acceleration. The minimum TtC occurred ~110 ms after perturbation onset in both groups. This short latency suggests that the different group responses may be due to differences in pre-perturbation musculoskeletal states (e.g. plantarflexor and/or total body stiffness). [Funding: NIH R03AG026281]