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Ph.D. DISSERTATION DEFENSE

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Title:	Mechanics of Whole-Body Balance and Momentum Control During Straight-Line Gait and 90° Turns
Chairperson:	Dr. Antonia Zaferiou, Department of Biomedical Engineering, School of Engineering & Sciences
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ABSTRACT

Turning while walking consists of up to 50% of our daily steps, and compared to walking straight, is more likely to result in grievous fall-related injury. This dissertation reveals momentum and balance control during 90° turns to inform future diagnostic and therapeutic solutions to reduce fall-related injuries.

Healthy young and older adults performed three tasks: straight-line gait, pre-planned turns, and turning suddenly after being cued ("late-cued"). Participants' whole-body balance and momenta control in the frontal and transverse (horizontal) planes were quantified using mechanics-based metrics: linear momentum, angular momentum, and center of mass position relative to the foot or feet in contact with the ground ("base of support"). This dissertation shares how turning task, stepping strategy, biological sex, age, and gait speed influence balance and momentum control.

In the frontal plane, pre-planned turns' trajectories resembled circular walking, and the center of mass shifted near or beyond the outside edge of the base of support. The sharper late-cued turns performed by young adults showed the largest range of frontal-plane angular momentum, as participants changed direction suddenly. All metrics indicated that turns challenge balance more than straight-line gait.

In all tasks, though most strongly in late-cued turns, linear momentum in the new direction of travel was generated primarily during right single support (when only the right foot contacts the ground). Leftward transverse-plane rotation was generated primarily after left foot ground contact, during left double support, before the right foot departs the ground. Both young and older adults exhibited these gait phase-specific generation of the most linear or angular momentum. However, young adults generated more linear momentum during both single support phases, while older adults generated more transverse-plane angular momentum during all gait phases.

In faster speed pre-planned turns, young adults' momenta showed minimal differences in either plane vs. preferred-speed turns. However, the faster vs. preferred speed late-cued turns increased frontal- and transverse-plane momenta, also shifting the center of mass nearer to the base of support's edge.