CENTER OF MASS ACCELERATION AND SLIP OUTCOME

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INTRODUCTION

Slip, trip, and fall accidents result in 20-40% of disabling injuries in industry with as many as half of these coming from slipping alone (Courtney et al., 2001). The number of incidences and resulting injury severity increases with age (Courtney et al., 2001).

Center of mass (COM) position and velocity with respect to the base of support (BOS) are important in recovery from a slip perturbation during sit to stand tasks (Pai and Patton, 1997) and walking (Bhatt et al., 2006). Bhatt and colleagues have used an inverted pendulum model of the body to show that the saggittal plane angle and angular velocity of the COM with respect to the BOS are important predictors of "stability" during slipping (Bhatt et al., 2006). Intuitively, angular acceleration of the COM with respect to the BOS at heel contact (HC) may also be important as it affects angle and angular velocity measures. Yet, this variable has not been investigated in previous research.

Thus, the purpose of this study is to examine differences in COM angular acceleration at HC between slip-recovery and slip-fall outcomes in young and older adults.

METHODS

Subjects: The study included 18 young subjects (10 female, 8 male) aged 20-35 years old and 13 older subjects (8 female and 5 male) aged 55-70 years old. Written informed consent was obtained and subjects were excluded based on neurological, orthopedic, cardiovascular, and pulmonary abnormalities that would affect balance or gait.

Equipment: Subjects walked across a vinyl tile floor wearing the same brand/model polyvinyl chloride soled work shoes. Slips were induced using a diluted glycerol contaminant (75% glycerol/25% water). Motion of 79 markers was captured using an 8 M2-camera Vicon 612 motion capture system with a sampling rate of 120 Hz. Subjects were harnessed to prevent contact with the ground in case of an irrecoverable balance loss.

Protocol: In order to induce an unexpected slip, subjects were told that the first few trials would be dry. After three dry trials and without the subjects' knowledge, the glycerol contaminant was applied to the floor inducing an unexpected slip.

Data processing: Marker data was low-pass filtered using a zero-phase 6 Hz elliptical filter. The body was modeled as a rigid body link of 15 segments and the body COM position was derived from the weighted average of the individual segments' COM. The BOS was determined as the projection of the heel marker onto the plane of the floor. The vector from the BOS to COM is projected into the saggital plane and the angle from the resulting vector to vertical is θ (Fig 1).

Slips were categorized as falls if the midpoint of their hips fell below 5% of

their local minimum during dry trials similar to work done by Pai and Patton (1997).

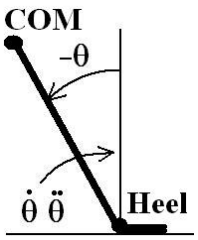

Fig. 1: Inverted pendulum model used to determine angle (θ) and its derivatives

RESULTS AND DISCUSSION

Four subjects were excluded from the analysis for various experimental or technical problems. Subjects who fell during the slip had larger deviations in the profile of their angle, angular velocity and angular acceleration from baseline dry (Fig. 2). Also, initial conditions at HC were different between fall and recovery events (Fig. 2).

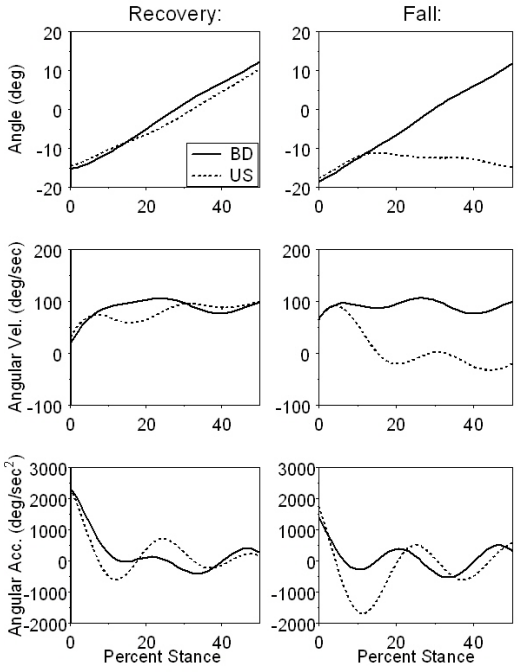

Fig 2: Typical angle, angular velocity, and angular acceleration. BD is baseline dry (solid) and US is unexpected slip (dashed). HC is 0% stance.

As mentioned previously, the focus of this abstract is on angular acceleration at HC. ANOVA was used to compare angular acceleration at HC between outcomes and age groups.

An average 34% reduction in angular acceleration at HC was found in fallers compared to non-fallers ($p<0.05$) (Fig. 3). Age group and its interaction with outcome were not significant effects. Thus, fall-recovery differences in angular acceleration at HC were similar in both age groups.

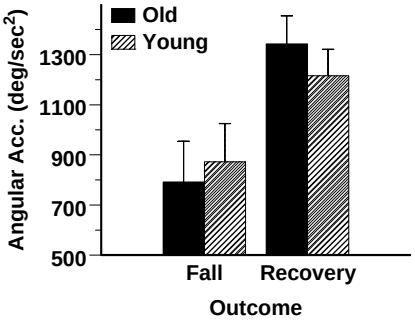

Fig 3: Angular acceleration stratified by age and outcome (SE bars)

"Thrust" push off force generated by the trailing leg produces forward and upward COM acceleration. This may be the underlying reason for the differences in angular acceleration at HC between recovery and fall outcomes, i.e. a potential predictor of slip and fall events is reduced push off thrust needed to move the COM over the BOS.

SUMMARY/CONCLUSIONS

The results of this study demonstrate that angular acceleration at HC may be a predictor of the outcome of a slip.

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