INTRODUCTION

Motivation
- Slips, trips, and falls were identified as the second leading cause of fatal occupational injuries [1] costing over $180 billion annually [2].
- Not all slips result in falls. Severe slips are more dangerous than mild slips and highly likely to result in falls [1].
- Appropriate classification of the mild and severe slips will lead to identification of the persons with high risk of fall.
- Previous research has noted the potential of the kinematic variables in identification of mild and severe slips. [3]

Objectives
- To use a set of kinematic and dynamic variables, namely sagittal whole-body angular momentum ($H$), COM height ($COM_h$), and double/single support phase duration ($DS/SS$), to classify mild and severe slips during their normal gait and first 30% of their slips.

Hypotheses
- We hypothesize that $H$, $COM_h$, and $DS/SS$ differ between mild and severe slips.

METHODS

Subjects
- Eleven male and nine female young adults (age (mean±SD)=23.6 ± 2.52) participated in an IRB-approved study.

Procedures
- Subjects walked on a walkway with no information about floor being slippery.
- Starting position was adjusted to have left foot strike on the slippery surface (Fig. 1).
- The data used full gait cycle were isolated (right before the heel strike on slippery surface) plus 30% of the gait cycle time during slipping.

Data Collection
- Reflective markers were used to capture 3D position of different body segments.
- Subjects wore a harness to ensure their safety and PVC-soled shoes to avoid unwanted friction discrepancies between subjects.

RESULTS

Analysis
- The isolated normal gait for each individual was normalized to 100 points (i.e. percent). Upon slip initiation, the additional 30% of slip trial was concatenated.
- $COM_h$ and $DS/SS$ were all normalized and made dimensionless to facilitate comparison: $H$ was normalized to height, $COM_h$ to velocity, and body mass [4], $COM_h$ to height and $DS/SS$ to gait cycle.
- Using heel markers, subjects were labeled as mild or severe slips: individuals with a Peak Heel Velocity (PHV) higher than 1.44 m/s were considered severe slips [1].
- The differences between time-courses of $H$, $COM_h$, and $DS/SS$ were compared between mild and severe slips using independent t-tests with significance level of 0.05.

DISCUSSION and CONCLUSION

- Higher $COM_h$ in mild slips suggests that subjects who could maintain their COM experienced less severe slips.
- Previous research claimed a significant height drop is associated with “falls” in presence of harness [5].
- The post-slip difference in $H$ of the severe slips can clearly be due to rapid lower extremity movement.
- The regulation of $H$ around 27% post-slip coincides with rapid counterbalance hand movements to lower the $H$ [6].
- Elongated post-slip single support in mild slips may suggest that the “toe-touch” response is a crucial strategy to arrest the fall when the body lost complete control of the balance following perturbations [6].
- Future work will investigate if the observed associations are causal for severe slipping or not.

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References