**Does Inadequate Angular Momentum Regulation Cause Falls?**

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## Summary

A total number of 20 young adults participated in a walking trial followed by an unexpected slip. The COM height, single/double stance phase duration, and angular momentum where calculated and compared between mild and severe slippers, during a full gait cycle and an additional 30% of gait cycle time length during slipping. There were significant differences found in all three variables. There was a time-lead observed in differences. First, the angular momentum started deviating between mild and severe slippers, followed by COM height deviation. Subsequently, we suspect the excessive angular momentum of severe slippers to be responsible for their COM drop and fall. Later, the angular momentum was drastically declined in severe slippers, simultaneous with a change from single to double support in severe slippers (toe-touch response). Hence, the angular momentum seems to be the key variable in controlling slips.

## Introduction

Angular momentum (*H*) is a quantity representing the movement of rotation of an object. Previous studies [1] indicated that severe slippers, who are more prone to fall [2], had significantly higher *H* following a slip, compared to mild slippers. This study examines the possible causes of such an association by studying the walking and slipping behaviour of mild and severe slippers and comparing their COM height ($COM_H$), single/double support duration, and *H*. We hypothesize that a time-lead over $COM_H$ would indicate a causal relationship to severe slipping, and hence, falling.

## Methods

Twenty young adults participated in this IRB-approved study.

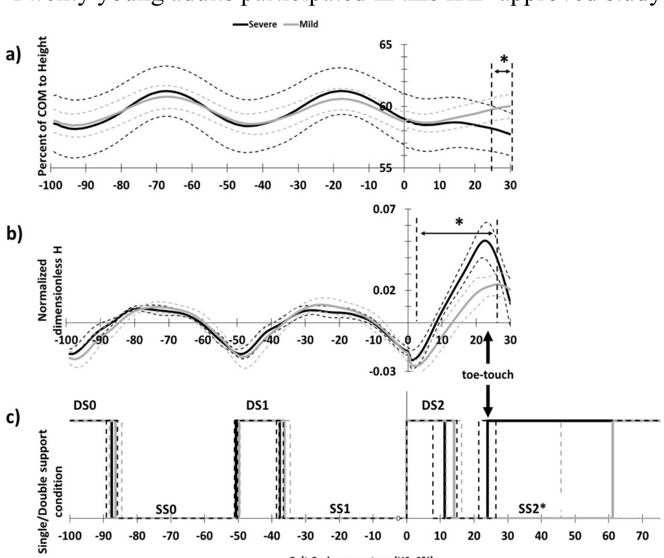


**Figure 1**: $COM_H$, *H*, and single/double support (SS/DS) phase for a full gait cycle and 30% into slipping (slip onset at 0%). Asterisks show significant differences. Dashed lines are SD

They were instructed to walk in a walkway at their convenient speed. Unexpected by subjects, after four trials a slippery contaminant (25% glycerol, 75% water) was applied to the walkway to record a novel slip data. The kinematics were recorded at 120Hz using Vicon 612 motion capture (Oxford, UK) and processed as described in [1]. Subjects with a Peak Heel Speed (PHS) larger than 1.44m/s were considered severe slippers [2]. Single/Double stance phase was derived from markers' data. $COM_H$ and *H* were calculated using segmental method and anthropometric data [1]. Data was analysed for a full gait cycle (i.e. 100%), plus an additional 30% of gait time length into slipping (total of 130%, except single/double support duration which was analysed for 75% after slip initiation, Fig.1c). An independent *t*-test (α=0.05) was used to identify inter-group differences between mild and severe slippers (SPSS, IL, USA).

## Results and Discussion

There were significant differences found between mild and severe slippers in all three variables (Fig,1). Mild slippers tend to maintain their $COM_H$ higher around 24%-30% into slipping. Severe slippers had a larger *H* from 3% to 27% during slipping. Also, severe slippers had a shorter single support phase and exhibited a toe-touch response early into slip, around 23% (Fig.1c).

We argue that the excessive rotation of the body, represented by a higher *H*, causes the drop in $COM_H$ rather than a direct vertical collapse on the legs, substantiated by the time-lead observed in the deviations of *H* over deviations of $COM_H$. Also, the differences may suggest that *H* is a key variable in controlling slips. In other words, the CNS may choose to change its control method and incorporate the toe-touch response as a new measure to re-establish the balance, or even take a safer fall, supported by the shortened single support phase, happening ***sooner*** than deviation of $COM_H$. Also, toe-touch could be caused as a measure to constrain and lower *H*, since *H* can only be changed via a torque around the body's COM (caused by toe-touch of the swing limb).

## Conclusions

$COM_H$, *H*, and single/double support phase duration were compared between mild and severe slippers during walking and slipping. Significant differences were found, and the time lead observed in deviations suggests that *H* may be a main control variable in controlling slips.

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**References**

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