A SENSITIVE DATA ANALYSIS APPROACH FOR DETECTING CHANGES IN DYNAMIC POSTURAL STABILITY

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INTRODUCTION

The control of balance is vital for the performance of daily activities of living. Understanding the mechanisms that result in instability can aid in reducing fall risk. As a sensitive measure of fall risk, the distance between the center of pressure (COP) and center of mass (COM) is currently assessed through discrete points assumed to represent physiologically important fall mechanisms [1,2]. However, it is unclear if these discrete points are appropriate measures of fall risk. Statistical parametric mapping (SPM) is a waveform analysis technique that can assess overall movement patterns possibly allowing for in-depth interpretation of human movement [3]. **Thus, the purpose of this study was to demonstrate the ability of SPM to assess dynamic postural stability in comparison to discrete point analysis (DPA).**

METHODS

Sixteen young, healthy individuals (8 males, 8 females; Age: 29 ± 3.6 years, Height: 1.7 ± 0.9 m, Mass: 75 ± 16 kg) participated in the study. Data were collected using a 18-camera motion capture system synchronized with two force platforms embedded in a dual-belt treadmill. The following tasks were performed to disturb dynamic stability:

- Compensatory stepping after forward perturbation at two acceleration intensities: 2 m/s^2 & 5 m/s^2
- Voluntary stepping at three step lengths: 60%, 100%, and 120% of baseline step length

The first step was defined from start of the movement to initial contact of the stepping limb. The COP-COM distance was calculated throughout the defined step and time-normalized to 100%. Discrete points were extracted based on previous research as noted in table 1. Compensatory stepping was assessed through dependent *t*-tests. Voluntary stepping was assessed through a one-way ANOVA.

RESULTS AND DISCUSSION

Discrete points: For compensatory stepping, COP-COM distance at time point E and S1-S3 were significantly greater in the large perturbation ($p < 0.041$). For voluntary stepping, COP-COM distance at point E and S3 were significantly different for all comparisons ($p < 0.001$). SPM significant results are presented in figure 1 and highlighted by green boxes.

The results from this study suggest that for fall risk detection SPM analysis can detect equivalent significant differences as DPA and additional phases of interest that represent the development of the waveform. Due to inherent within- and between-subject variability, the ability to detect the position of discrete points can be difficult. Thus, SPM can increase data post-processing efficiency, reduce time-cost, and ensure analysis is completed on physiologically equivalent data.

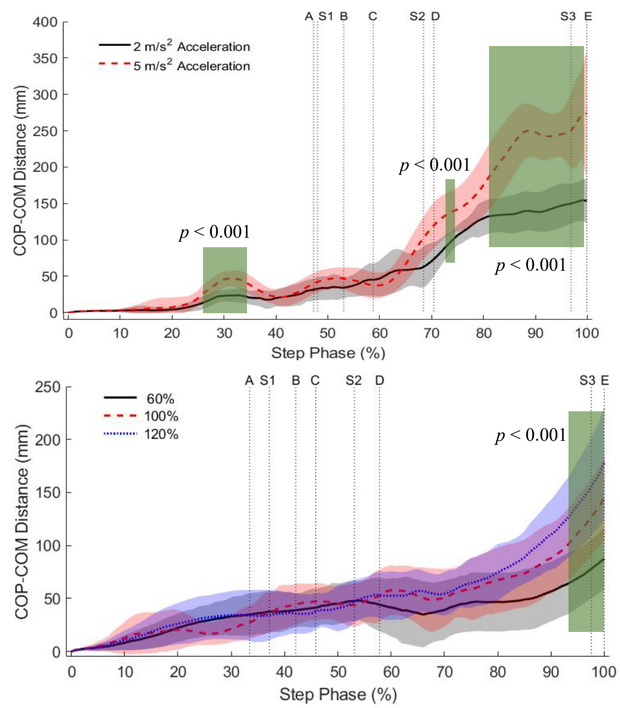

Figure 1. COP-COM distance over defined step phase. Top graph includes perturbation intensities; bottom graph includes step length variations. Vertical dotted lines are the average time that discrete measures occurred. Green highlighted phases are significant differences from SPM analysis.

SIGNIFICANCE

Utilization of SPM allows for important physiological mechanisms of fall risk to be determined without a possibly biased *a priori* approach in feature selection. Determining important measures of fall risk can aid in fall prevention.

REFERENCES

[1] Martin et al. *Phys Ther*. 2002; 82(6): 566-577.
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[3] Pataky TC. *Comput Methods Biomech Biomed Engin*. 2012; 15(3): 295-301.

Table 1. Definitions of discrete points extracted for analysis from Martin et al. 2002 [1] and Hass et al. 2005 [2]

[1] Magnitude of COP-COM distance at the following time points:		[2] Maximum magnitude of COP-COM distance within the following phases:	
Point A	Maximum lateral position of COP towards stepping limb	**S1**	Start to most lateral & posterior point of COP towards stepping limb
Point B	Maximum posterior position of COP between point A & C	**S2**	From end of S1 to the most lateral position towards the stance limb
Point C	First point after COP crosses midline and moves laterally towards stance limb	**S3**	From end of S2 to initial contact of the stepping limb
Point D	Point when shift occurs in COP from lateral to anterior		
Point E	Initial contact of the stepping limb		