CONTROL OF DYNAMIC STABILITY DURING WALKING IN ELDERLY FALLERS

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INTRODUCTION
Dynamic balance control during walking has been assessed in terms of the interaction between position and velocity of the whole body center of mass (COM) in relation to the base of support [1], where insufficient COM momentum could be a cause for gait imbalance. Given that acceleration regulates momentum, examining COM acceleration would provide further insights on balance control. The objective of this study was to characterize differences in COM control among healthy young, elderly adults and elderly fallers using regions of stability derived by COM velocity and acceleration (ROSv and ROSa), which identify dynamic limits of balance control.

METHODS
Fifteen healthy young adults [Young], 15 healthy elderly adults [Elderly], and 15 elderly adults with a history of falls [Fallers] participated in this study. Subjects were asked to walk barefoot at a self-selected pace and their motion data were captured to calculate the COM. An inverted pendulum model, focusing on the instant of toe-off (TO), was used to define ROSv and ROSa. The ROSv in the anteroposterior (AP) direction was defined using the following equation [2]:

\[-X_{TO}^\alpha \leq \tilde{X} \leq 1 - X_{TO}^\alpha\]  \hspace{1cm} (1)

where \(\tilde{X}\) to and \(\tilde{X}\) to are normalized COM position and velocity at TO in AP direction, defined as \(\tilde{X}_{TO} = (X_{TO} - X) / L\), \(\tilde{X}_{TO} = (X - X_{TO}) / L\); \(X\) and \(X_{TO}\): the heel and toe positions, \(L\): foot length, \(\alpha\): the heel and toe positions, \(l\): pendulum length). The ROSv in the mediolateral (ML) direction was obtained in the same manner. The ROSa was defined as the region confined by peak COM acceleration needed to be generated prior to TO. The ROSa in the AP direction was defined as:

\[\frac{(\tilde{X}_{p} + A)B - X_{p}}{X_{TO} - X_{p}} < \tilde{X} < \frac{(1 - \tilde{X}_{p} + A)(1 - B)}{X_{TO} - X_{p}}\]  \hspace{1cm} (2)

where \(A = X_{p} / (\alpha L)\), \(B = \tilde{X}_{p} + (X_{TO} - X_{p}) / (\alpha L)\), \(\tilde{X}_{p}\): the normalized initial COM position (when the COM becomes its minimum prior to TO), defined as \(\tilde{X}_{p} = X_{p} / L\), \(\tilde{X}_{p}\): the normalized peak COM acceleration prior to TO defined as \(\tilde{X}_{p} = \tilde{x}_{p} / \alpha \omega_{p} \). The ROSa in the ML direction was obtained in the similar manner. One-way ANOVA was used to detect group differences (\(\alpha=0.05\)).

RESULTS AND DISCUSSION
The COM of Fallers was located significantly anterior to those for Young and Elderly groups, with significantly smaller COM velocity at TO, which placed their mean data point inside the boundaries of the ROSv (Fig.1). Similar results were obtained in the ROSa in the AP direction, where the data for Fallers were significantly closer to the forward boundary of the ROSa for Fallers group (Fig.2). Normalized peak COM acceleration prior to TO differed significantly between Young and Elderly groups (Fig.2), although no significant difference was detected in normalized COM velocity at TO between them (Fig.1). Both groups also showed similar peak COM velocity. The momentum was controlled differently even though similar momentum was observed during walking. COM acceleration could be a more sensitive measure to differentiate individuals with different balance control abilities. No significant differences were detected in COM position, normalized COM velocity at TO, or normalized peak COM acceleration prior to TO in the ML direction. Fallers appeared to use a more conservative strategy in momentum control in the AP direction, as indicated by their data located significantly closer to the boundaries of the ROSv and ROSa, but not in the ML direction.

REFERENCES