GAIT STABILITY DURING STAIR DESCENT IN OLDER ADULTS
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INTRODUCTION
Epidemiological studies of falls have shown that most falls during some forms of locomotion. Stair negotiation is among the most challenging and hazardous locomotion for older people. There are about 10% of fall related deaths occurred on stairs (National Safety Council, 1992). Stair decent has been reported as a more challenge task during stair negotiation for elderly (Tinetti et al., 1988). Loss of balance and tripping are the primary two reasons that causing fall on stairs in the elderly. Therefore, a better understanding on how stair negotiation perturbs gait stability is critical to reducing the incidence of falls among older people.

Gait stability could be assessed using the motion of the whole body center of mass (CoM) and its relative position to the center of pressure (CoP) of the supporting foot. A greater CoM-CoP separation was reported during stair descent than stair ascent and level walking in young adults (Zachazewski et al., 1993). However, the coordination between CoM and CoP during stair negotiation is still unknown for elderly. A recent study reported that instantaneous CoM-CoP inclination angles could exclude inter-subject variability and better detect gait instability in the elderly (Lee and Chou, 2006). Elderly patients with balance disorders demonstrated a significantly greater medial CoM-CoP inclination angle than healthy elderly adults.

In this study, sagittal and frontal plane CoM-CoP inclination angles were assessed during stair descent in healthy young and elderly adults. It was hypothesized that elderly adults would demonstrate a greater medial inclination angle than young adults during stair descent.

METHODS
Twelve healthy elderly adults, (4 males and 8 females; 72.2±3.8 years; 170.8±8 cm; 80±17.3 kg) and thirteen healthy young subjects (6 males and 7 females; 21±2.4 years; 170.8±10 cm; 72.8±10 kg) were recruited for this study. Subjects were instructed to perform stair descent at a self-selected pace while barefoot.

The stair apparatus was composed of three individual steps. Each step had a raise of 7’’ and a tread of 12’’. A force plate was mounted on the first two steps. The third step included a three-meter extended walkway. The extended walkway allowed subjects reaching steady pace before stepping downstairs. The other two force plates were embedded in series on the level ground and aligned to the first step. This design allowed kinetic data collection during the stair descent phase and the transition phase to the level ground. A complete gait stride was examined for each of the phases. Whole body motion analysis was performed with an 8-camera motion analysis system (Motion Analysis Corp., Santa Rosa, CA). Twenty-nine reflective markers were placed on bony landmarks of each subject. Three-dimensional marker trajectory data were collected at 60 Hz. Whole body CoM position data was calculated as the weighted sum of each body segment, with 13 segments representing the whole body. The CoP position was calculated from the ground reaction forces/moments collected from four force platforms (AMTI, Watertown, MA) at 960 Hz.
Instantaneous inclination angles in the sagittal and frontal planes were defined by the linkage between CoP and CoM, and the vertical line. Effects of subject group on peak sagittal and frontal plane CoM-CoP inclination angles were assessed using a one factor ANOVA analysis with the significance level at 0.05.

RESULTS AND DISCUSSION

Peak anterior and medial inclination angles occurred right before swing limb heel strike. Peak posterior inclination angles occurred right after swing limb toe off.

![Figure 1: SD indicates steady state stair descent phase. Transition indicates transition phase from steps to level ground.](image)

There were no significant group differences on the gait velocity, step width, peak anterior and posterior CoM-CoP inclination angles during both the stair descent and transition phases (Table 1). However, elderly adults demonstrated a significantly greater peak medial CoM-CoP angle and shorter stride length than young adults during transition phase (Figure 1).

**Table 1:** CoM-CoP inclination angles and temporal gait measurements, group means (SD)

<table>
<thead>
<tr>
<th></th>
<th>Stair descent phase</th>
<th>Steady state descent</th>
<th>Transition (steps-level ground)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Healthy elderly</td>
<td>Healthy young</td>
<td>Healthy elderly</td>
</tr>
<tr>
<td>Peak medial angles (Deg.)</td>
<td>5.2 (1.1)</td>
<td>4.8 (1.0)</td>
<td>5.0 (1.1)*</td>
</tr>
<tr>
<td>Peak anterior angles (Deg.)</td>
<td>7.0 (1.1)</td>
<td>6.6 (1.3)</td>
<td>12.5 (3.0)</td>
</tr>
<tr>
<td>Peak posterior angles (Deg.)</td>
<td>5.5 (1.6)</td>
<td>5.0 (1.2)</td>
<td>7.0 (1.6)</td>
</tr>
<tr>
<td>Gait velocity (m/s)</td>
<td>0.6 (0.1)</td>
<td>0.7 (0.1)</td>
<td>0.7 (0.1)</td>
</tr>
<tr>
<td>Stride length (cm)</td>
<td>76.0 (9.0)</td>
<td>78.1 (6.3)</td>
<td>104.7 (15.0)*</td>
</tr>
<tr>
<td>Step width (cm)</td>
<td>10.5 (4.0)</td>
<td>11.5 (3.5)</td>
<td>9.1 (3.8)</td>
</tr>
</tbody>
</table>

* Significant group difference, p<0.05

Results of this study indicated that, compared to young adults, gait stability of the elderly was perturbed more significantly during the stair-level ground transition phase. Previous study (Lee and Chou, 2005) showed that both healthy elderly and young adults had similar medial inclination angles (~4°) during level walking. Stair descent resulted in a greater medial inclination (~ 5°) than level walking for both groups. Young subjects were able to adjust the medial inclination angle back to its normal magnitude during the transition to level ground walking. However, during this transition phase, the frontal plane stability of elderly adults was found to be further perturbed.

SUMMARY/CONCLUSIONS

The greater medial CoM-CoP inclination angle observed in elderly adults may indicate their deficiency in balance control which could result in a higher risk of accidental falls than young adults during the transition phase of stair descent.

REFERENCES

Falls in the home and community, (1992) National Safety Council