INTRODUCTION
Falling becomes increasingly common and damaging as we age, so it is important to determine who is at risk for falls. The Harmonic Ratio (HR) is a measure of gait smoothness previously correlated with fall risk [1]. The HR is calculated using a Fourier transform on the vertical, anterior-posterior (AP), and medio-lateral (ML) trunk acceleration within a stride to calculate the ratio of constructive to destructive acceleration harmonics. For the vertical and AP axes, even harmonics are considered to be constructive, as they are in phase with the two steps within a stride, and odd harmonics are considered to be destructive, working against the two-step cycle of a stride. This is opposite for the ML axis (odd harmonics are considered to be constructive), since ML motion cycles once for a two-step cycle within a stride. Smoother gait has a high HR, indicating that harmonics that are in-phase with the two-step cycle of a stride dominate. There is an advantage to long, uninterrupted trials of straight-path walking to produce consistent results for variables that describe the cyclic motion of gait [2], making the treadmill appealing for use to study the HR. The treadmill, though, is known to increase the metabolic costs of walking [3,4], increase step width [5], and reduce the variability of step width [5] and step time [6]. The purpose of this study was to determine if the treadmill would be suitable for the study of gait smoothness. The null hypothesis tested was: the harmonic ratio would not be different between overground and treadmill walking.

METHODS
Participants (n = 39, mean age: 81 [SD 6]) from independent living and retirement communities walked overground (OG) and on a treadmill (TM). Trunk accelerations were measured using a wireless triaxial accelerometer (G-Link, LORD Microstrain) taped to the skin overlaying L4. OG walking was performed on indoor walkways at self-selected speeds, with one normal and one dual-task walk (mean distance: 23.9 [SD 0.67] m, mean number of steps: 34 [SD 4] steps). Two TM trials were performed at two different speeds: the average speed from the normal OG walk (TM at OG speed, n = 29), and a preferred TM speed (PTM, n = 37), since not every senior has achieved the OG speed on a TM in previous research, since a natural walking speed on a TM is slower than walking OG [4,7]. The PTM speed was determined by averaging a participant’s upper and lower bounds of comfortable, normal TM walking [4,7]. Signal processing was performed in Matlab R2013a using custom-written code. Steps were defined using AP peaks in acceleration. The HR was calculated as a ratio of the sum of in-phase and out-of-phase acceleration harmonics calculated using a Fourier transform with the stride frequency as the fundamental frequency. The HR was calculated along each axis for each stride and then averaged for all strides in a trial. Statistical analysis was performed in SYSTAT 13 and required two main tests: an Analysis of Variance comparing OG, OG with dual-task, and PTM conditions, and a Wilcoxon ranked sum test of the OG and the TM at OG speed conditions.

RESULTS AND DISCUSSION
PTM walking reduced HR compared to normal OG walking along the vertical and AP axes (p < 0.001), but not for ML. TM walking at OG speed preserved the vertical and AP HR compared to OG walking, but significantly increased the ML HR (p < 0.05). OG dual-task walking reduced AP and ML HR (p < 0.05), but did not significantly differ from PTM (p > 0.05).

While TM walking at OG speed maintained vertical and AP smoothness compared to OG walking, it actually increased gait smoothness along the ML axis, in keeping with other TM induced changes in ML control previously reported [5]. Additionally, 8 participants could not reach their OG speed on the TM. For the harmonic ratio to be useful as an indicator of gait smoothness related fall risk, the test must be accessible to lower functioning participants, and they are most likely to be unable to safely reach their OG walking speed on the TM. Additionally, TM walking at the slower PTM speed, similar to dual-task OG walking, disrupted gait smoothness.

CONCLUSIONS
TM walking is problematic for the study of gait smoothness, since TM walking at both the OG speed and PTM speed disrupted the HR.

REFERENCES

Table 1: Mean (SD) harmonic ratio for each axis during OG and TM walking conditions.

<table>
<thead>
<tr>
<th>Harmonic Ratio</th>
<th>OG</th>
<th>OG: Dual-Task</th>
<th>TM: OG Speed</th>
<th>TM: PTM Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>3.62 (0.72)</td>
<td>3.33 (0.67)</td>
<td>3.57 (0.89)</td>
<td>2.97 (0.87)</td>
</tr>
<tr>
<td>AP</td>
<td>3.54 (0.90)</td>
<td>3.23 (0.80)</td>
<td>3.70 (0.92)</td>
<td>2.88 (0.94)</td>
</tr>
<tr>
<td>ML</td>
<td>2.41 (0.71)</td>
<td>2.22 (0.58)</td>
<td>2.75 (0.80)</td>
<td>2.39 (0.62)</td>
</tr>
</tbody>
</table>