SUMMARY
This study investigated age-related changes in postural sway of working-aged men, as well as compared results obtained from traditional and nonlinear measures to determine if the nonlinear measures provided additional information regarding the movement of the center of pressure during quiet standing.

INTRODUCTION
Measures of balance control have been shown to differ between younger and older adults [1]. Deterioration of the sensorimotor systems involved in postural control (e.g. visual acuity, reaction time, proprioceptive sensitivity) is believed to contribute to the increased incidence of falls in the elderly [2]. A clear delineation of when these declines begin to negatively influence postural control has not yet been established. The purpose of this study was to assess if age-related changes in postural control exist for healthy working-aged men and compare results obtained from traditional and nonlinear measures of postural sway.

METHODS
Forty-five healthy men between the ages of 18 and 65 years old participated in a single session laboratory experiment. Mean (SD) age, height and body mass of the participants were 40.5 (14.8) years, 1.77 (0.07) m and 83.6 (14.1) kg, respectively. Participants were asked to stand as still as possible with each foot centered on a forceplate, arms at their sides, shoes on, feet placed shoulder width apart and eyes focused on a target located 7 m away at eye level for a period of 60 s. Three trials were completed by each participant.

Center of pressure (COP) data was recorded using two 40 cm x 60 cm force plates (Model # 9286AA, Kistler Instruments AG, Winterthur, Switzerland). Data was sampled at 50 Hz prior to low-pass filtering (zero-lag second-order 12Hz low-pass Butterworth filter). The first 10 seconds of each trial were omitted from analyses to minimize any influence of movement adjustments made by the participants. Postural sway measures were calculated for each trial and then averaged across the values obtained for each participant (three values per measure) to minimize the influence of an erroneous trial.

COP data from a stabilogram was used to compute the 95% Elliptical Area (EA), Path Length (PL), and Normalized Path Length (PLn). The antero-posterior (AP) and medio-lateral (ML) COP data was used to create the resultant vector distance (RD) time series, from which nonlinear (Sample Entropy; SEn), fractal (Detrended Fluctuation Analysis; DFA), and spectral (Mean Frequency; MF) measures were calculated.

An examination of the data indicated a linear relationship between the postural sway measures and age of the participants. Therefore, age as a continuous variable was correlated with each of the postural sway measures and Pearson correlation coefficients calculated.

RESULTS AND DISCUSSION
Overall means and standard deviations were calculated for the postural sway measures (Table 1). Scatterplots illustrate the linear relationship between age and the postural sway measures (Figures 1 – 6).

Table 1. Overall means and standard deviations (SD) across all participants.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% Elliptical Area (mm²)</td>
<td>247.68</td>
<td>155.54</td>
</tr>
<tr>
<td>Path Length (mm)</td>
<td>829.77</td>
<td>137.90</td>
</tr>
<tr>
<td>Normalized Path Length (au)</td>
<td>293.62</td>
<td>85.43</td>
</tr>
<tr>
<td>Detrended Fluctuation Analysis (au)</td>
<td>1.68</td>
<td>0.077</td>
</tr>
<tr>
<td>Sample Entropy (au)</td>
<td>0.95</td>
<td>0.24</td>
</tr>
<tr>
<td>Mean Frequency (Hz)</td>
<td>0.33</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Traditional postural sway measures examine the displacement of the COP over time as 2-dimensional measures related to the distance travelled or area encompassed by the movement. Neither of the traditional measures (path length and 95% elliptical area) examined were significantly correlated to the age of the participants (Figures 1 and 2). Pearson correlation coefficients for 95% elliptical area and path length were r = 0.044 and r = -0.099, respectively. Results indicate that the area and amount of postural sway did not change significantly in healthy working-aged men.
Normalized path length is the path length calculated after the AP and ML COP data are normalized to unit variance. Due to this important manipulation, normalized path length reflects the coordinate curvature of the COP, thus indicating structural changes in the COP, rather than indexing the overall amount of movement [3,4]. Normalized path length was significantly correlated with age (r = -0.387), indicating a decrease in coordinate curvature with an increase in age (Figure 3).

Detrended fluctuation analysis indicated an increase in fractal persistence as age increased in participants (r = 0.451; Figure 4). Analyses of sample entropy and mean frequency applied to the COP data indicated an increase in age related to decreases in temporal complexity (r = -0.364; Figure 5), and power spectral frequency (r = -0.490; Figure 6).

CONCLUSIONS
Loss of balance may be the cause of many falls but it has yet to be determined how postural control, which may directly influence an individual’s ability to maintain balance, changes over the lifespan. Correlations regarding traditional measures of postural sway indicated that increases in age were not associated with changes in the amount of postural sway, although increases in age were associated with decreases in COP temporal complexity (SEn) and spectral frequency (MF), and increases in fractal persistence (DFA). These results might reflect the adoption of a more deterministic, and possibly less adaptive, postural control with increases in age.

REFERENCES