INTRODUCTION
Investigations of motion variability have been used in previous research as a means of assessing functional characteristics of the neuromotor system [1]. Previously, motor variability has been viewed as the result of system noise, which the motor system should minimize for optimal performance [1]. More recently, greater variability has been viewed as an increased ability to adapt to environmental or task constraints, though excessively high or low variability may indicate system dysfunction [1,3]. Furthermore, decreased variability may contribute to overuse injuries, resulting from greater localized stress on anatomical structures [1,3]. Kinetic variability may therefore be worthy of stronger consideration, regarding injury potential [2]. The purpose of this study was to explore the effects of walking speed and footwear on kinetic variability in males. As a result, three casual shoes with differing midsole hardness were tested at two contrasting speeds.

METHODS
Participants included 5 male volunteers (age 25.4±3.4 yr; height 175.3±6.8cm; and mass 82.3±12.2kg). Participant informed consent was obtained as approved by the Office of Research Integrity at the affiliated institution prior to participation.

Three casual walking shoes, differing on midsole hardness, were selected for evaluation. Mechanical impact test data were acquired (Exeter; Brentwood, NH) for four sizes of each of the walking shoes, following the ASTM standard F-1614 protocol. Dependent variables included: peak force, acceleration and time, pressure and time, penetration and time, velocity, and energy return.

Kinetic variability was explored in walking for each of the three shoes at preferred (1.41±0.01m/s) and fast walking speeds (2.14±0.02m/s). Kinetic data were acquired during the stance phase of gait (5 trials per condition) via a Kistler force platform (Model # 9281C; 480Hz). Variability was expressed for 12 dependent variables via coefficient of variation (CV), including: first and second maxima (vertical force), minimum vertical force (during midstance), maximum breaking and propulsive forces, kinetic variable temporal locations, transition time (braking to propulsion), and overall stance time.

Impact test data were evaluated via one-way ANOVAs. Kinetic variability was examined using 2x3 (walking speed x shoe type) factorial repeated-measures ANOVAs for each kinetic variable. Omnibus F probability was set at α=0.05. Sidak post-hoc contrasts were conducted, as appropriate.

RESULTS
Impact test results identified significant differences among shoes for peak force, F(2,9)=72.03, p<.001, acceleration F(2,9)=72.09, p<.001, peak acceleration time, F(2,9)=7.68, p=.011, peak pressure F(2,9)=72.03, p<.001, peak penetration time, F(2,9)=7.022, p=.015, and energy return, F(2,9)=11.52, p=.003, suggesting differences among footwear.

Walk testing revealed no significant shoe x speed interaction or shoe main effect. Significant differences in variability were observed for walking speed for selected variables (Table 1).

Table 1: Kinetic Variability Differences

<table>
<thead>
<tr>
<th>Variable</th>
<th>CV (mean ± std. dev.)</th>
<th>F</th>
<th>df</th>
<th>Sig.</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>F₁ speed</td>
<td>slow 2.6±0.3 fast 9.72±1.8</td>
<td>F₁</td>
<td>14.18 (1,4)</td>
<td>.020</td>
<td>.78</td>
</tr>
<tr>
<td>F₂ min Speed</td>
<td>slow 4.6±0.7 fast 15.0±3.2</td>
<td>F₂</td>
<td>14.73 (1,4)</td>
<td>.018</td>
<td>.79</td>
</tr>
</tbody>
</table>

Note: F₁ = first maximum vertical force; F₂ min = minimum vertical force during midstance

DISCUSSION & CONCLUSIONS
The results of the present study suggest that shoe hardness did not influence kinetic variability when walking. Variability was, however, influenced by walking speed (preferred vs. fast), where faster walking speed resulted in greater kinetic variability during the first half of the support phase. Previous research has indicated that overuse injuries may be more likely in conditions of decreased performance variability, where greater system demands reduce the dynamical degrees of freedom, in turn decreasing kinematic and kinetic variability [1,2,3]. It has been suggested that preferred walking speed is less constrained and more readily adaptable, allowing greater variability, while non-preferred speeds may result in biological stress [1]. Participants in this study demonstrated decreased variability at preferred walking speed implying that the faster walking speed was more readily adaptable. Overall, changes in walking speed altered kinetic variability in males, though changing midsole properties among shoes, does not appear to influence kinetic variability. Future research is needed to examine kinetic variability among other populations and speed, for more varied footwear, over a wider range of gait speeds.

REFERENCES