INTRODUCTION
Coordinated control of the hip and ankle is important for maintaining postural stability. The hip provides a greater degree of modulation of the body center of mass (COM), while the ankle fine-tunes the COM location and maintains effective foot contact to the supporting surface. Existing literature suggests that diminished hip muscle strength is associated with loss of postural stability, however the associated compensatory adaptations in lower extremity control have not been elucidated. It is plausible that persons with diminished hip muscle strength may exhibit increased reliance on the ankle to reposition the body COM (i.e., ankle strategy). If true, this could explain the findings of several clinical studies that have reported hip muscle weakness is often associated with recurrent ankle sprain and soft tissue injuries.

The purpose of the current study was to compare postural stability, as well as frontal plane moments and neuromuscular activation at the ankle during unipedal balance tasks in females with contrasting levels of hip abductor muscle strength. When compared to persons with stronger hip abductors, we hypothesized that individuals with diminished hip abductor strength would exhibit: 1) increased medial-lateral center of pressure (COP) displacement, 2) increased ankle inverter and evertor moments, and 3) increased activation of the peroneus longus and tibialis anterior.

METHODS
Forty-five females between the ages of 23 to 34 participated in this study. All subjects were recreationally active and free of any existing injuries, pain or history of surgery to the lower extremity and the lower back.

Hip abductor muscle strength was assessed using a previously described weightbearing method. More specifically, subjects’ hip abductor force generation capacity was assessed in a squat position (50° knee flexion and 30° hip flexion) using a force transducer connected to a non-stretchable fabric belt wrapping around the distal ends of both femurs (Figure 1).

COP, ankle kinematic and kinetic data were collected using a force platform (AMTI, MA, USA, sampling frequency = 1500Hz), and a 11-camera motion capture system (Qualisys, Gothenburg, Sweden, sampling frequency = 250Hz). EMG signals from the peroneus longus (PL) and tibialis anterior (TA) were recorded using a EMG system (MA-300, Motion Lab Systems, LA, USA, sampling frequency = 1500Hz).

Static Standing Balance Task
Participants were instructed to stand on the preferred leg with the hip and knee of the stance leg extended, and the arms folded across the front of the chest. Subjects were informed that the goal of the task was to stand as steady as possible for a duration of 20 seconds. A total of 3 static balance trials were collected.

Dynamic Step-down Balance Task
Participants were instructed to lower themselves from an elevated force platform, touch their heel on the lower step, then return to the starting position.
over a 2-second period (Figure 2). The height of the step was normalized to the each subject’s height (10% of body height). A metronome (set at 30 beats per minute) was used to guide the rate of the step-down task. One trial consisted of 5 consecutive up-and-down repetitions (10 seconds). A total of 3 dynamic balance trials were obtained.

The biomechanical variables of interest included the mean medial-lateral COP displacement, peak ankle inverter and everter moments, and PL and TA activation amplitude during each of the balance tasks. The mean values from 3 trials for each condition were used for statistical analysis.

Participants were ranked based on their hip abductor muscle strength. The top 33% of the participants were categorized as the strong group (n=15) and the lower 33% as the weak group (n=15). To determine if postural stability, ankle biomechanics, and neuromuscular activation of the ankle muscles varied between groups across the two balance tasks, 2 x 2 (group x task) mixed analyses of variance (ANOVA) tests with task as a repeated factor were performed. Significance level for all statistical procedures was set at 0.05. Effect size of the group difference in each dependent variable was presented by a Cohen’s D value.

RESULTS AND DISCUSSION
Significant group effect was observed for mean medial-lateral COP displacement, and peak ankle inverter and everter moments. When averaged across tasks, individuals with low hip abductor muscle strength exhibited greater medial-lateral COP displacement, and greater peak inverter and everter moments (Table 1). With respect to neuromuscular activation, a significant group effect (no interaction) was observed for PL muscle EMG amplitude when averaged across tasks. On average, subjects in the weak group exhibited significantly higher PL activation when compared to the strong group (Table 1). No significant main effect or interaction was observed for TA activation.

CONCLUSION
Persons with relatively weak hip abductors exhibited decreased medial-lateral postural stability and increased utilization of an ankle strategy to maintain balance. This was reflected by the findings for decreased medial-lateral postural stability as well as increased frontal plane ankle moments and increased peroneus longus activation. We propose that hip abductor weakness may, in part, explain clinical observations of increased risk of ankle injury in this population. Therefore, hip abductor muscle performance should be considered as part of the evaluation of persons with diminished balance and/or recurrent ankle injury.

REFERENCES

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| Table 2: Group differences for each variable of interest (averaged across both tasks) |
|---------------------------------|-----------------|-----------------|----------|----------|
|                                 | Weak            | Strong          | p-value  | Cohen’s D |
| Mean medial-lateral COP displacement (mm) | 13.6 ± 11.7     | 9.8 ± 6.0      | 0.046    | 0.41      |
| Ankle kinetic variable (Nm/kg)    |                 |                 |          |          |
| Peak inverter moment             | 0.31 ± 0.10     | 0.25 ± 0.11    | 0.03     | 0.57      |
| Peak everter moment              | 0.04 ± 0.06     | -0.02 ± 0.07   | 0.01     | 0.92      |
| PL activation amplitude (% MVIC) |                 |                 |          |          |
| PL                              | 0.46 ± 0.12     | 0.36 ± 0.15    | 0.003    | 0.78      |
| TA                              | 0.21 ± 0.10     | 0.18 ± 0.09    | 0.17     | 0.39      |