INTRODUCTION
According to the CDC, falls are the leading cause of injury-related deaths in older adults. With more than one-third of adults over the age of 65 falling at least once a year [1], it is important to understand the fall risks associated with different locomotor tasks. Depending on the task, such as stair walking and ramp walking, the variables utilized to assess fall risks differ.

Falls often occur because of medial-lateral (ML) instability, anterior-posterior (AP) instability, or improper toe clearance. For healthy individuals walking on a level surface, increasing step width (SW) is a strategy used to manage ML instability [2]. Similarly, AP instability, due to increased shear forces [3], is mitigated by spending a greater percentage of the gait cycle in stance. Lastly, increases in the activation of the tibialis anterior (TA) during swing indicates the increased importance of toe clearance during walking [4].

The purpose of this study was to compare the risk of falling associated with the ascent and descent of ramps and stairs. We expected the gait pattern of ramp walking to exhibit changes indicative of maintaining ML and AP stability, as well as proper toe clearance. Specifically, we hypothesized that SW and percentage of time in stance would increase on the ramp. In addition, because of the elevated risk of tripping during ramp walking, we hypothesized that TA activity would also be greater during swing.

METHODS
Seven healthy, college-aged men (age = 22 ± 2 yr) completed the protocol of level, ramp and stair walking (Figure 1). A motion analysis system tracked the position of markers on the first metatarsal of each foot. Electromyography data of the TA were collected using surface electrodes. Five successful trials for each condition were captured and the values averaged. All data were measured for one stride from left toe-off to left toe-off. The uphill conditions were: level to step 1 (L→1), level to step 2 (L→2), step 1 to step 3 (1→3), step 3 to plateau (3→P), and step 2 to plateau (2→P). The downhill conditions were: plateau to step 3 (P→3), plateau to step 2 (P→2), step 3 to step 1 (3→1), step 1 to level (1→L), and step 2 to level (2→L).

RESULTS AND DISCUSSION
Contrary to our hypothesis, there was no significant difference in SW between ramp walking and stair walking. However, when compared to level walking, the uphill conditions for both the ramp and stairs showed narrower SW. This change most likely accommodates the increased need for propulsion [5]. Conversely, the downhill conditions showed larger SW than level walking, indicating a greater need for ML stability (Figure 2).

We observed a greater time in stance for ramp walking when compared to stair walking (Figure 3). This result may indicate the need for propulsion going uphill and the need to maintain AP stability.
going downhill. It is also possible that the greater time in swing on the stairs, a result of the shorter time in stance, could be explained by the need for additional time to properly place the foot.

Figure 2: Step Width
There was no significant difference in SW between the stairs and the ramp. However, SW was consistently less when walking uphill than downhill (p<0.05).

Figure 3: Percent Time in Stance
The time in stance on the ramp was on average 5.4% greater than on the stairs. For the significant conditions, the average was 6.5% greater with the greatest change of 11% occurring on the P→3 condition (* indicates significance).

The downhill P→2, 3→1, and 2→L conditions on the ramp showed greater TA activity (Figure 4). However, we are unsure if we can attribute this result to toe clearance. It is more likely that the difference in TA activation is explained by the unique gait patterns for ramp and stair walking. During downhill ramp walking, like level walking, participants use the typical heel strike to toe-off gait pattern. However, when walking on stairs, participants utilize a toe-strike to toe-off pattern. When the ankle is extended, TA activity is not necessary or expected.

Figure 4: Mean TA Activity during Swing
The mean TA activity during swing on the ramp was on average 32% greater than on the stairs. For the significant conditions, the average was nearly 46% greater with the 2→L condition showing a 72% increase (* indicates significance).

CONCLUSION
Our data demonstrate that ramp and stair walking provide different challenges to ML and AP stability in addition to toe clearance. The results of this study suggest that, at similar slopes, stair walking appears to be a safer method of changing elevation than ramp walking.

In the future, we hope to further identify additional risk factors for falling during ramp and stair walking. We also plan to expand this research to other walking tasks and participant populations.

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REFERENCES