INTRODUCTION
Non-contact anterior cruciate ligament (ACL) injuries are devastating knee injuries experienced by athletes who participate in sports that involve jump landings and cutting maneuvers and are 2-8 times more prevalent in females compared to males. This injury generally occurs approximately 40 milliseconds after initial ground contact while the athlete performs an abrupt, split-second decision to properly execute the high risk maneuver. The unanticipated nature of these maneuvers is often the result of overall game strategy to avoid and deceit opponents or as a response to external cues by teammates and coaches. Besier et al [1] were able to show that neuromuscular control patterns are different during unanticipated and preplanned cutting maneuvers and Landry et al [2] demonstrated sex differences in neuromuscular control patterns for unanticipated cutting maneuvers. To provide further insight into the understanding non-contact ACL injuries, the purpose of the study was to have university level soccer players perform unanticipated sidecut maneuvers on an artificial field-turf soccer field and compare neuromuscular control patterns of six lower extremity muscles between an audio cued and visual cued sidecut, for both the pre- and post-contact phases of the cut.

METHODS
Twenty seven (13 males and 14 females) university level soccer players who were injury free at the time of testing and had no previous major knee injuries participated in the study. Surface electromyography (EMG) (Myomonitor IV system, Delsys Inc.) was used to measure muscle activity patterns of the lateral and medial gastrocnemii, vastus lateralis and medialis and medial and lateral hamstrings. To amplitude normalize the linear enveloped EMG waveform data (captured at 2000 Hz and a zero-lag 4th order Butterworth filter with a cutoff frequency of 6 Hz), maximum voluntary isometric contractions were performed on a dynamometer (System 3, Biodex Medical Systems, Inc.). Two footswitches were used to determine the stance and swing phases of each stride, with this study analyzing both the pre-contact (100 msec prior to ground contact) and post-contact (100 msec after ground contact) phases of the sidecut stride separately. Principal component analysis (PCA) was used to analyze and identify features of variation in the muscle activity waveforms. A two-way mixed model ANOVA (PASW Statistics 18, SPSS Inc.) tested for a between group sex effect (male versus female), a within group cue effect (audio versus visual) and an interaction sex-cue effect for each of the 6 muscles and for both phases (pre-contact and post-contact).

RESULTS
A sex difference was identified in the pre-contact phase for the lateral hamstring (Figure 1C) with females demonstrating lower neuromuscular activity. In response to an audio cue, lower muscle activity levels were generated in the pre-contact phase of the sidecut for the lateral gastrocnemius (Figure 1A, for both sexes), medial hamstring (Figure 1D, for both sexes) and vastus lateralis (Figure 1F, for females only). A difference in the post-contact phase for the medial hamstring was also identified between the two cues that went along with the cue effect during the pre-contact phase. A greater overall activity magnitude for the visual cued compared to the audio cued sidecut was captured during the early post-contact phase and this difference diminished as stance progressed.

DISCUSSION & CONCLUSIONS
These results suggest that compared to a visual cue, an athlete’s response to an audio cue may leave them more susceptible to ACL injury as important knee stabilizing muscles were not activated to comparable levels, especially for females. Females also had reduced lateral hamstring activity, thereby potentially putting them at greater risk. Understanding neuromuscular control patterns is important to designing or enhancing preventative training regimes, as this injury often leads to accelerated osteoarthritis at the knee and requires invasive surgery for the athlete to return to sport.

REFERENCES