INTRODUCTION
Weak hip muscles have been suggested as contributing factors for several running-related injuries [1]. It has also been reported that injured runners display abnormal hip and pelvis kinematics compared to healthy controls [2], leading researchers to hypothesize that weak hip muscles may be causing these abnormal biomechanical patterns.

Some studies, however, have reported that strengthening these weak muscles did not significantly alter running kinematics, calling into question this hypothesis [3]. Additionally, little research currently exists on the relationship between hip strength and trunk kinematics in runners [4]. Therefore, the purpose of this study was to further investigate the relationship between hip strength and hip, pelvis, and trunk kinematics in healthy runners.

METHODS
Inclusion criteria for this study were running over 20 miles per week and being injury-free at the time of testing. Based on these criteria, 60 runners were included for analysis (age: 29.1 ± 10.4 years).

Reflective markers were placed on subjects who ran continuous laps of ~40 meters in the laboratory at their normal training run paces. Whole body kinematic data were collected at 200 Hz using a 10-camera motion capture system (Motion Analysis Corp.).

Hip abduction, flexion, external rotation, and internal rotation strengths were measured bilaterally using a Biodex System 3 dynamometer (Biodex Medical Systems). For the abduction test, subjects pushed against the dynamometer with maximal force three times for five seconds standing with the hip at 10-degrees of abduction. Flexion strength was measured similarly, but with the hip at 30-degrees of flexion. External and internal rotation strengths were measured seated with the hip and knee flexed to 90-degrees. Mean torque was calculated for each limb separately and normalized by body mass for analysis.

Pearson correlation coefficients were used to assess the relationship between hip strength and hip, pelvis, and trunk kinematics during stance phase for the following parameters: range of motion, angle at contact, peak angle, percent stance at peak angle, and angle at toe-off. Significance level of $p < .05$ was used for all tests.

RESULTS AND DISCUSSION
For the range of motion parameters, moderate but significant correlations were found between hip abduction strength and both hip abduction ($r = -0.32$) and pelvic rotation range of motion ($r = -0.35$), and between hip external rotation strength and trunk rotation range of motion ($r = -0.38$) (Figure 1).

For the angle at contact parameters, moderate but significant correlations were found between hip abductor strength and pelvic rotation angle at contact ($r = 0.32$), and between hip external rotation strength and both trunk flexion ($r = 0.32$) and trunk lean angle at contact ($r = 0.31$).

Moderate, significant correlations were also found between hip flexion strength and peak trunk flexion ($r = 0.30$), and between hip abductor strength and the percent of stance at peak pelvic rotation ($r = -0.41$).

CONCLUSIONS
While moderate correlations were found between certain measures of strength and kinematics, no causal conclusions can be made. More research is needed to clarify the effect of hip strengthening on running kinematics. Because of the relationship between hip strength and knee injuries [1], future studies should also explore the relationship between hip strength and knee kinematics during running.

REFERENCES

Figure 1: Scatterplots of the significant correlations between (A) hip abductor strength and hip adduction range of motion, (B) hip abductor strength and pelvic rotation range of motion, and (C) hip external rotation strength and trunk rotation range of motion.