INTRODUCTION
Running at different speeds is a key component of successful athletic performance, but how humans alter the kinematics and kinetics of their lower extremity joints to maintain faster running speeds has escaped formal study. Research has described the joint kinematic and kinetic adaptations for walking at faster speeds, with clear trends in joint function[1]. This has informed our understanding of walking performance and pathology. Running research has focused on ground reaction forces, and faster runners have generally higher forces[2], but this has not lead to training protocols to achieve faster running speeds. If fact, training folklore suggests that “you cannot teach speed”. Therefore, the purpose of this study was to compare sagittal joint kinematics and kinetics at four different running speeds.

METHODS
Twelve recreationally active adult runners gave informed consent to participate in this IRB-approved protocol. The participants ran through a 20 m long calibrated volume with a full body market set (Plug-in-gait, Vicon, Centennial, CO) at 85%, 100%, 115% and 130% of their self-selected running speed. Marker trajectories were collected with a 12-camera Vicon MX system (250 Hz) synchronized with a floor-mounted OR6-6 force platform (3 kHz) (AMTI, Watertown, MA). Joint kinematics, kinetics and centre of mass (COM) were calculated in Nexus and plotted across the gait cycle. Sagittal plane hip, knee and ankle power minima and maxima were compared using a repeated measures ANOVA and Fischer’s PLSD post hoc tests in StatView (SAS, Cary, NC). It was hypothesized that faster running speeds would be achieved by increased joint moments and concomitant increases in joint powers.

RESULTS AND DISCUSSION
Participants chose to run at 2.6 ± 0.5 m/s (85%); 3.0 ± 0.7 m/s (100%); 3.3 ± 0.6 m/s (115%); and 3.9 ± 0.7 m/s (130%); approximately 10, 9, 8, and 7-minute mile paces. All trials had rearfoot or midfoot contact. Statistically significant main effects were observed across running speeds (Figure 1) in the stance phase sagittal power generation of the hip (p < 0.0001); knee (p < 0.004) and ankle (p < 0.0001). Stance phase power absorption at the hip and knee varied with running speed (p < 0.004), but ankle power absorption did not (p < 0.85). Contrary to expectations, sagittal plane moment values at each joint did not change with running speed; each individual demonstrated a unique moment pattern across running speeds: no slope, increasing slope or decreasing slope. High inter- and intrasubject variability across running speeds contributed to reduced statistical power in the hypothesis testing of joint moment patterns. This study was conducted over a relatively small range of running speeds, and 130% of self-selected running speed was well below each runner’s top speed. In this small sample of recreational runners, increases in sagittal plane peak power generation and absorption at the hip and knee, and peak power generation at the ankle appeared to be associated with increases in running speed. However, nearly all peak sagittal moment patterns did not change systematically across running speeds. Some runners chose a hip-dominant pattern with increasing hip extensor moments as running speed increased. Others chose an ankle-dominant pattern with increasing ankle plantarflexor moments as running speed increased; some chose a combined hip and ankle pattern. Most runners had increasing knee extensor moments with faster running speeds. This corresponds with previous work showing increased vertical COM excursion and greater vertical forces at faster running speeds[2]. Overall, runners had increasing knee flexor moments in early stance suggesting under-striding that appeared more pronounced at faster running speeds. This coincided with an increase in the COM ΔV, with the fastest speed having a 2% (~8 cm/s) speed change during stance phase.

CONCLUSIONS
Maintaining faster running speeds may be achieved by similar joint power patterns, but unique joint moment strategies for each individual.

REFERENCES