INTRODUCTION
Injuries to ankle ligaments are common in both civilian and military life, with an estimated two million ankle sprains every year [1]. In the US Army, ankle sprains were the 3rd most hospitalized injury from 1989-1994 [2]. Despite this prevalence, little is known about the mechanical function of foot and ankle ligaments. Uniaxial tension tests of ligaments are used to measure mechanical properties such as stiffness, rate dependence, and energy loss. Triangle waveforms provide a constant ramp velocity, but are mechanically challenging to enact, while sinusoidal waveforms are simple from a control perspective, but have a changing ramp velocity. We seek to establish a mechanical testing protocol to characterize the: calcaneofibular, posterior talofibular, anterior tibiofibular, deltoid, spring, and interosseous talocalcaneal ligaments of the foot and ankle. Only the mechanical properties of a pilot calcaneofibular ligament are presented here.

METHODS
A bone-ligament-bone sample was excised from a fresh-frozen cadaveric foot. Bone ends were potted in polymethylmethacrylate (PMMA). Uniaxial tension tests were performed on an Enduratech 3400 (TA Instruments, New Castle DE) sampled at 1000 Hz. The specimen was preloaded to 1N, then subjected to 31 cycles at 2 Hz. A battery of triangle and sinusoidal waveforms were then applied, with peak strain amplitudes ranging from 2% to ligament failure in 2% increments. Ligament hydration was maintained using a 0.9% NaCl solution. Data analysis was performed on the last waveform of each 31-cycle set. Tangent stiffness, peak force, and energy loss were calculated from the first waveform after preconditioning. Tangent stiffness was measured as the linear fit of the last 10% of the loading curve. Triangle and sinusoidal strain tests that had >10% difference in stiffness measurement were considered dissimilar.

RESULTS AND DISCUSSION
Plastic deformation occurred at greater than 20% strain. Peak force and energy loss increased as the displacement target increased. The triangle and sinusoidal waveforms performed similarly as strain tests whose peak strain were in the 12-22% strain range and had less than 10% difference (Figure 1a). The force displacement relationships for the increasing strain targets considered similar for both the triangle and sinusoidal displacements demonstrate the effects of increasing ramp velocity at each new target strain (Figure 1b and 1c).

CONCLUSIONS
Similarities between triangle and sinusoidal waveforms with differences in stiffness measurements less than 10% indicate that either waveforms are appropriate for higher strains. The calcaneofibular ligament failed (n=1) after the 20% strain test. Further testing using these methods will be used to characterize our test parameters and limits for additional calcaneal-fibular ligaments, and the remaining four ligaments of interest.

REFERENCES