Introduction
The posterior leaf spring ankle foot orthosis (PLS AFO) is a unique lower limb orthosis used to assist dorsiflexion during swing phase, ensure toe clearance, and limit falls. The design of the orthosis has changed over time with use of different materials, fabrication techniques, and trim lines. In this study, a new material consisting of a carbon-infused polypropylene composite was tested against the standard homopolymer polypropylene. The PLS design followed a previous iteration in the use of a flat blade PLS spring segment which incorporated a material doubler inserted during molding.

Method
Nine orthoses were fabricated with three varied ply discontinuous carbon-fiber infused polypropylene PLS inserts (three orthoses per carbon ply content) and three homopolymer polypropylene orthoses served as the control. Each orthosis was tested in a motorized testing device that measured resistance to torque as the orthosis was cycled through dorsiflexion and plantarflexion. The motorized device with an inline torque sensor (Transducer Tech Inc., USA) and optical encoder developed in an earlier study was used to move the AFO in the prescribed range of motion. The motor was controlled by a motor drive under speed mode in which both speed and direction of the motor rotation were modulated.

Results
The stiffness value in this study is a representation of resistance to rotation moment per angular displacement. Our results showed that both 1/8” 7-ply and 3/16” 9-ply carbon-infused polypropylene spring insert AFOs outperformed 3/16” homopolymer polypropylene AFOs in stiffness. The 3/16” 5-ply carbon-infused polypropylene PLS AFO proved to be less stiff yet restricted range of motion better than the 3/16” homopolymer polypropylene PLS AFO. Furthermore, 1/8” 7-ply carbon-infused polypropylene AFOs demonstrated greater stiffness while allowing greater range of motion than 3/16” homopolymer polypropylene AFOs. The increased stiffness of the carbon-infused polypropylene composite materials will produce a smaller index of hysteresis by allowing less deformation under increased torque thus providing greater dynamic energy return than their homopolymer polypropylene counterparts.

Conclusion
The research results followed the proposed hypothesis: PLS AFOs fabricated with carbon prenated polypropylene composite demonstrated more dynamic mechanical properties, as indicated by increased stiffness and decreased index of hysteresis than homopolymer polypropylene orthoses, thus decreasing energy loss and providing a rigid toe lever at pre-swing. The 9 Ply carbon infused polypropylene PLS AFO demonstrated a 35.14% increase in stiffness over the corresponding homopolymer polypropylene orthosis and a 21.81% reduction in hysteresis for the broad expanse of the test results. Limitations existed in the study and further research with human subjects within a clinical gait laboratory is recommended to match bench testing to potential improvements in locomotion.

References