Interventions in gait symmetry and walking speed can serve as important clinical markers of recovery in rehabilitation and in understanding the effect of an intervention such as orthotic prescription [1-5]. Unilateral deficits that occur after stroke are likely to result in gait asymmetry, decreased walking efficiency, and potentially decreased activity level and functional ambulation [6]. Gait speed is reflective of gait performance but it does not explain mechanistic changes in gait due to hemiplegia [7]. Very few investigations (<10) have focused specifically on the implications of asymmetry in hemiplegic gait and most were based on very small sample sizes. Esquenazi et al. found that the use of an ankle foot orthotic (AFO) significantly improved walking velocity and the symmetry of several temporal-spatial parameters of gait in a population of 42 hemiparetic patients [8], however, the underlying mechanism that brought about the change was not discussed. The purpose of this investigation was to measure the affect of AFO use in a hemiparetic population on gait velocity and temporal-spatial outcomes in relation to changes in limb kinematics in order to understand the biomechanical mechanisms underlying gait improvement.

Clinical Significance
Understanding the biomechanical mechanisms through which orthotic intervention improves markers of gait performance such as walking speed and temporal spatial symmetry, may benefit future orthosis design and gait rehabilitation strategies.

Methods
Fifteen (11 male, 4 female) individuals with hemiplegia (age 54.2 ± 9.02 y, height 173.7 ± 12.2 cm, mass 114.9 ± 52.5 kg), secondary to stroke with symptoms lasting more than 6 months and currently using an AFO during ambulation (at least 50% time) were recruited for participation. Participants completed five walking trails per condition (with and without the AFO). Kinematic data was collected (Vicon, Oxford Metrics, Oxford, UK) and sampled at 60Hz for further analysis. The main outcome measures were temporal-spatial parameters, symmetry ratios as described in Patterson et al [6], walking speed and limb kinematics.

Results
On the affected side (Figure 1) time spent during Initial Double Support (IDS) (9.97±33.44%) and Single Support (SS) (3.86±8.60%) increased with the addition of the AFO and decreased during Terminal Double Support (TDS) (-20.16±14.57%) and SWING (-5.04±10.45%). Mean walking speed (20.50±27.38%), step length (unaffected: 27.28±47.51% and affected: 8.24±9.38%), and stride length (12.86±10.17%) increased with the use of the AFO. The mean overall temporal symmetry (OTS) ratio improved from 2.01±0.52...
Mean foot velocity during the SWING phase increased on both limbs (unaffected: 8.53±7.73% and affected: 19.00±15.84%) with the AFO. Mean hip sagittal angular velocity during the SWING phase increased on the affected side with the AFO (30.14±28.41%), while the unaffected side showed little change. Compared to the unaffected limb, a large increase in the correlation between hip sagittal angular velocity and foot velocity was observed on the affected limb with the addition of the AFO (Figure 2 A, B).

**DISCUSSION**

Redistribution in phase timings is seen within the gait cycle, however, the overall gait cycle time remained largely unchanged with the addition of the AFO. An increase in walking speed, step length, and stride length with the AFO is indicative of a more functional gait pattern. With little change in gait cycle time, the increase in walking speed is potentially due to the increases in step lengths on both limbs. The mechanisms adopted to achieve greater step lengths were different for the unaffected and affected limbs. With the AFO, the affected limb was spatially driven due to altered kinematics with greater hip range of motion, hip angular velocity and foot velocity primarily responsible for an increase in step length. On the other hand the unaffected limb was relatively more temporally driven with greater SWING time (due to greater SS time on the affected limb) resulting into a significant increase in step length. These modifications to gait biomechanics suggest the mechanisms by which AFO use leads to increased temporal spatial symmetry and walking speed are spatially driven on the affected limb and temporally driven on the unaffected.

**REFERENCES**