INTRODUCTION
The ankle is one of the most commonly affected joints in ambulatory children with cerebral palsy (CP). Common gait abnormalities include inadequate dorsiflexion during the swing phase of gait or “foot drop.” Ambulatory children with CP exhibit asymmetries in tibialis anterior muscle (TA), size between their more and less affected legs [1]. However, relationships between TA muscle architecture and gait have not been investigated. The purpose here was to examine the relationship of TA muscle thickness (MT), pennation angle (PA), and cross-sectional area (CSA) to ankle function during walking in children with unilateral foot drop.

HYPOTHESIS
TA muscle architecture on the more affected side will be related to muscle strength and gait impairments in children with CP and unilateral foot drop.

METHODS
Participants
N=20 (10 male, 10 female)
Mean age = 13.1 ± 3.5 years
17 hemiplegia, 3 diplegia
Gross Motor Function Classification System level I-II

Procedures
Participants were seated on an isokinetic dynamometer in 60º knee flexion, and 0º ankle position.
Bilateral longitudinal and cross-sectional ultrasound images were obtained at the thickest point of the TA muscle belly and analyzed with MIPAV software (Figure 2).
Participants performed 3 maximum isometric contractions (MVIC) of dorsiflexor muscles on the more affected side. The peak force was used for analysis.
3D gait data were collected during trials of self-selected (SS) and “as fast as possible” (FAST) speeds and processed in Visual 3D (Figure 3).

Data Analysis
Outcome variables representing ankle function included:
• ICDF - Dorsiflexion angle at initial foot contact
• DMxSt - Maximum dorsiflexion angle in stance
• DfTO - Dorsiflexion angle at toe off
• MTO - Plantarflexion moment at toe off
• DMxSw - Maximum dorsiflexion angle in swing
• DfMn - Mean dorsiflexion angle in swing
• velDf - Ankle dorsiflexion velocity in swing
• Step length

Results
As anticipated, TA muscle size was smaller on the more affected side than the less affected side. MT was 27.3% smaller and CSA was 34.8% smaller. PA was not different between sides (Figure 2). Gait measures were also significantly different between sides at both speeds for the majority of variables analyzed, including ICDF, DMxSt, MTO, DMxSw, DfMn, and velDf.

MT was related to CSA, strength (MVIC), step length, MTO and DMxSw during self-selected walking and to step length, and velDf during fast walking. PA was not related to strength, gait function, or any other muscle architecture variable except for ICDF during the self-selected pace. CSA was related to strength, step length, DfTO, MTO, DMxSw, and DfMn during self-selected walking, and to step length, DMxSw, and DfMn during fast walking (Table 1).

DISCUSSION
Muscle architecture partially explains the degree of impairment in ankle strength and gait function in individuals with CP. Moderate relationships between architecture and function suggest additional factors affect functional ability in CP, including disruption in neural activation [2], muscle consistency [3], variations in fiber size and type [4], and selective voluntary motor control [5]. These data also support existing evidence that the more affected TA is significantly smaller than the less affected TA [1], and that muscle size is related to strength in children with CP [6].

Interventions focused on increasing TA size and strength may lead to improvements in gait. Future research should investigate the efficacy of training programs (i.e., resistance training, functional electrical stimulation, or intense motor practice) to lessen asymmetries, and thereby improve ankle function during gait.

REFERENCES

Table 1. Relationships between measures of muscle architecture and function on the more affected side

<table>
<thead>
<tr>
<th>Variable</th>
<th>SS</th>
<th>FAST</th>
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<tbody>
<tr>
<td>MT</td>
<td>0.59*</td>
<td>0.55*</td>
</tr>
<tr>
<td>CSA</td>
<td>0.50*</td>
<td>0.48*</td>
</tr>
<tr>
<td>ICDF</td>
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<td>0.13</td>
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<tr>
<td>DMxSt</td>
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<td>0.21</td>
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<tr>
<td>DfTO</td>
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<tr>
<td>MTO</td>
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<td>0.70*</td>
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<tr>
<td>DMxSw</td>
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<td>0.64*</td>
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<tr>
<td>DfMn</td>
<td>0.36</td>
<td>0.60*</td>
</tr>
<tr>
<td>velDf</td>
<td>-0.63*</td>
<td>0.50*</td>
</tr>
</tbody>
</table>

*significant at α=0.05 level