A PASSIVE EXOSKELETON TO ASSIST WALKING IN CHILDREN WITH NEUROMUSCULAR DISORDERS

Zistatjis, JA1, Glaister, BC2 and Steele, KM1
1 Human Ability & Engineering Lab, Department of Mechanical Engineering, University of Washington, Seattle, WA USA
2 Cadence Biomedical, Inc.; Seattle, WA 98115, USA
email: zistatj@uw.edu, web: https://depts.washington.edu/uwsteele/

INTRODUCTION
Children with neuromuscular disorders, such as cerebral palsy (CP), spina bifida, stroke, and spinal cord injury, often have walking disabilities and experience motor function developmental delays. Current gait therapy options include a variety of gait trainers, robotic exoskeletons in therapy clinics, and passive at-home devices. Assistive devices for home use include ankle foot orthoses, walkers, and crutches, but these devices are not therapeutic. Even with therapy and assistive devices, children with CP get significantly less walking practice than typically developing (TD) peers [1]. Further, these children require more practice than their TD peers to learn common tasks such as walking [2]. In this study, we aim to (1) identify primary challenges with the standard of care for kids with neuromuscular disorders and (2) develop and test a therapeutic device to improve home and community walking practice for these children.

METHODS
This study was conducted in two phases. The first phase involved interviewing parents and physical therapists (PTs). Eight parents and two physical therapists were phone interviewed and asked questions regarding current devices and their effectiveness helping children learn to walk. A 15-question online survey was also emailed to therapists around the U.S. The second phase involved initial development and testing of an exoskeleton to meet the needs identified by parents and therapists.

RESULTS AND DISCUSSION
During interviews, parents commonly shared that they desire for their child to improve balance, stamina, and stability. Their children wish to keep up with their peers and siblings, be hands free, and enjoy the playground. One parent said her daughter’s “walker does not work on the playground.” Another parent said a walker and wheelchair “makes her feel more disabled.” These responses suggest that current assistive devices are not meeting mobility goals of the children and their parents.

Survey responses from 14 PTs indicated two primary needs: (1) interventional devices for use outside the clinic are needed more than in-clinic devices (Figure 1), and (2) the biggest gaps in helping children learn to walk are related to in-home practice time (Table 1). These results motivated development and testing of our device.

We designed and built a passive exoskeleton powered by exotendons [3] (Figure 2). The size of the device’s waistband, thigh, and shank segments can be quickly adjusted, enabling the device to grow with a child. To encourage early interventions, specifically when children are first learning to walk, the device adjusts for 5th percentile three year olds to 95th percentile six year olds. To withstand stresses placed on the device, we selected 7075-T6 aluminum for the support structure. Using aluminum supports, 3D-printed cuffs and belt, variable stiffness springs, and exotendons, we assembled a prototype. Testing the device on an unimpaired child (age five) verified that it fit and was comfortable.

CONCLUSIONS
Our interviews and survey indicate the need for new devices to assist walking outside the clinic and we have designed and built an exoskeleton to address this need. We need to experimentally quantify the device’s impacts on kinematics, kinetics, and energy cost of walking. Through case studies with TD children and children with CP, we will obtain both empirical data and qualitative feedback from PTs, parents, and users to improve device design and effectiveness.

REFERENCES

ACKNOWLEDGEMENTS
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Table 1: A sampling of physical therapist survey results from two short answer questions.

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
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<tbody>
<tr>
<td>What are the biggest challenges or unmet needs in helping children learn to walk?</td>
<td>“Practice”, “Time for high quality repetitions”, “More opportunities to practice in home and community settings”</td>
</tr>
<tr>
<td>What gaps are present in your current treatment options that if met would improve your patients’ functional abilities?</td>
<td>“In-home practice time”, “Ability to treat in the home”, “Hours of independent practice”, “Increasing number of steps with a good pattern”</td>
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</tbody>
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Figure 1: Responses to the survey question “Where are the greatest needs for interventional devices?”

Figure 2: Exoskeleton design with exotendons as black cables connecting hip to ankle.