Active Ankle-Foot Orthotic: Tethered Air Muscle

P13001

**Project Members:**
Nathan Couper- Mechanical Engineering
Bob Day- Mechanical Engineering
Patrick Renahan- Industrial Engineering
Patrick Streeter- Mechanical Engineering
Dr. Beth DeBartolo- Faculty Guide

**Project Sponsor:**
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**Project Customer:**
Dr. Beth DeBartolo

**Project Members:**
Patrick Streeter
Nathan Couper

**Background Information**
The aim of this project is to develop an air muscle powered ankle foot orthotic that address the symptom of foot drop. Foot drop is a very common condition present in patients who are suffering from degenerative nerve diseases (ALS, MS), stroke, or trauma to the Peroneal Nerve, and ultimately leads to an inability to dorsiflex the foot while walking. Current technology in the form of ankle-foot orthotics (AFOs) is available to aid clients, however these devices are restrictive and make navigating stairs and ramps especially difficult. This is due to a restricted ability to plantarflex the foot and “point” the toes. Our focus will be to modify an existing dorsi-assist orthotic to include a controlled, air muscle-actuated, plantarflexion when navigating uneven terrain.

**Customer Requirements:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Objective Number</th>
<th>1 - 9 rating of importance</th>
<th>Customer Objective Description</th>
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</thead>
<tbody>
<tr>
<td>Safe</td>
<td></td>
<td></td>
<td>Follow safety guidelines and standards</td>
</tr>
<tr>
<td>Flat Terrain</td>
<td></td>
<td>9</td>
<td>Support regular gait cycle</td>
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<tr>
<td>Comfort</td>
<td></td>
<td>9</td>
<td>Support foot drop over obstacles</td>
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<tr>
<td>Special Terrain</td>
<td></td>
<td>9</td>
<td>Correct interprets sensor information</td>
</tr>
</tbody>
</table>

In addition to the above Customer needs, there were several engineering specifications that involved Sensory Information (i.e. measure angle of foot or accept input from terrain sensing mechanism), Movement specifications (i.e. foot position and gait speed), Force specifications (i.e. torque on foot and force to secure orthotic), and Safety specifications (i.e. harm to equipment and harm to user).

**Detailed Design Concepts**

Un-Actuated air muscle with dorsi-assist AFO holding foot 90 degrees from floor (Top Left)

Actuated air muscle with foot fully plantarflexed (Top Right)

While the average person experiences 47 degrees of motion while walking down stairs, our AFO is capable of achieving up to 64 degrees and is customizable based on the specific client. (Right)

**Patient Assumptions**
In order to define the scope of this project, several patient assumptions were made: The patient was assumed to maintain zero muscle control over both dorsi- and plantarflexion, was not prone to "tone-lock," had an appropriately calibrated dorsi-assist AFO to hold their foot above 90° when in mid-stride, and lastly, due to the nature of a tethered system, that they would use the orthotic in a clinical setting (i.e. pool or treadmill). To perform our calculations, Anthropometric Data from the ANSUR database was used for a 50° percentile male and there were no resistive or friction forces in the joints.

**System Level Physical Decomposition**

Model of Dorsi-assist AFO (Pictured Left)

Distal Muscle Attachment Assembly, excluding AFO (Pictured Right)

Exploded Proximal Attachment (Pictured Far Right)

Future Interaction with Terrain Sensing System (above)

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