Inconspicuous Ankle Foot Orthosis (AFO) for teen

September 6th - September 13th, 2024

Client: Debbie Eggleston

Advisor: Dr. Brandon Coventry

Team Members:
Anya Hadim (Team Leader)
Lucy Hockerman (BSAC)
Presley Hansen (Communicator)
Alex Conover (BPAG)
Grace Neuville (BWIG)

Problem Statement:

Ankle foot orthoses (AFOs) are designed to provide dorsiflexion support during the swing phase of walking. These devices are primarily used to treat muscular dystrophies. For this project, we are focusing on young individuals diagnosed with Facioscapulohumeral Dystrophy (FSHD), the most common type of muscular dystrophy. The team aims to design a brace for teens that assists with ankle dorsiflexion, promoting safer walking while remaining easily concealable and flexible enough to allow for functional ankle movement. The brace will be tailored specifically for the client, Maggie Eggleston. Key objectives for the device include positioning the ankle in adequate dorsiflexion, maintaining a slim, discreet design, and ensuring sufficient flexibility to minimize movement restriction.

Status Update:

The team brainstormed various design ideas for the client and developed three different types of AFOs, each with unique functionalities (different pros and cons that address each criteria). These designs will be presented to Maggie on Monday. The meeting with Maggie was scheduled to further clarify the design specifications. Additionally, the team discussed potential materials, with carbon fiber being selected for the final prototype, as well as considerations for the manufacturing process.

Summary of Weekly Team Member Design Accomplishments (Include time spent):

<u>Anya:</u>

- Researched AFO circular hinge design (1 hour)
- Continued research on AFO types (30 minutes)
- Brainstormed design ideas (1 hour)
- Met with the team to discuss design ideas, design matrix, progress report, and decide on leg measurements (1.5 hours)

Lucy:

- Communicated with my BSAC mentee (15 min)
- Met with team to discuss design ideas, design matrix, progress report, and decide on leg measurements (1.5 hours)
- Continued research on AFO designs (1 hour)
- Sketched and research one design for the design matrix (30 mins)

Presley:

- Continued research on AFO designs and materials (1.5 hours)
- Met with team to discuss design ideas, design matrix, progress report, and decide upon needed leg measurements (1.5 hours)
- Sent emails to client and advisor regarding times to meet, needed leg measurements, and progress report (20 minutes)
- Worked on written portion of the design matrix (30 minutes)

Alex:

- Met up with the team two times to discuss design ideas, design matrix, progress report, and decided what leg measurements were necessary (1.5 hours)
- Continued research on AFO types (30 min)
- Researched materials and how to use them, and what is available in the maker space (1 hour)
- Brainstormed Design Ideas individually (30 min)

Grace:

- Met with the team to discuss design ideas, design matrix, progress report, and decide on what leg measurements we needed (1.5 hours).
- Continued research on AFO materials (1 hour)
- Worked on the written portion of design matrix (1 hour)
- Brainstormed design ideas individually (30 min)

Weekly/Ongoing Difficulties

We are still deciding whether we want to prioritize aesthetics (discreetness) or function more. This will be clarified with Maggie at our next meeting.

Upcoming Team and Individual Goals

Team:

- Meet with Maggie and finalize the final design
- Order the materials needed and plan manufacturing of the first prototype
- Fill out the expenses sheet
- Prepare preliminary presentation

Individual:

Anya:

- Make the preliminary presentation and divide up the roles for each slide
- Complete my section of the presentation and practice
- Help in making the expenses sheet and ordering materials
- Plan manufacturing for the first prototype

Lucy:

- Research more on brace (non-rigid) materials and "bungee cord" options
- Prepare for the preliminary presentations for October 4th
- Work on SolidWork design for two of our three design matrix ideas and perform simulations to test material failure

Presley:

- Continue research of AFO materials and fabrication methods
- Work on and practice my section of the preliminary presentation
- Continue design ideas with team and begin fabrication as soon as possible

Alex:

- Complete certifications for the maker space and team lab, specifically in machining and working with higher-level materials.
- Work with the team to design ideas, and then begin fabrication
- Work on Preliminary Presentation for October 4th

Grace:

- Research materials that are similar to carbon fiber but more attainable
- Work on preliminary presentation and practice for October 4th
- Help plan manufacturing steps for first prototype

Project Timeline

Project Goal	**Deadline**	**Team Member Assigned**	**Progress**	**Completed**
Meet with Client	9/17/2023		100%	
→ email client with dates		Presley	100%	
→ create question list		All	100%	
→ write summary and put in notebook		All	100%	
PDS Draft	9/22/2023		100%	
→ submit draft		Anya	100%	
Design Ideas and Matrix	9/29/2023		100%	
→ create design 1		All	100%	
→ create design 2		All	100%	

→ create design 3		All	100%	
→ compare designs in matrix		All	100%	
Preliminary Design Presentation	10/06/2023		0%	
→ upload to website		Grace		
Preliminary Deliverables	10/13/2023		0%	
→ email report and notebook		Presley		
→ upload report to website		Grace		
→ peer/self evaluations		All		
Decide on Final Design	10/13/2023		0%	
→ get feedback from client on design		All		
Show and Tell	10/27/2023		0%	
→ create an initial prototype		All		
Final Poster Presentation	12/08/2023		0%	
→ invite client		Presley		
→ post on website		Grace		
Final Deliverables	12/13/2023		0%	
→ submit final notebook and report		Presley		
→ submit peer/self and client evaluations		All		

Expenses

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Component 1								
Component 2								
Component 3								
TOTAL:								**$0.00**

Design Matrix:

Scoring Criteria

Support (20%) - Support is weighted at 20% because our design must support the position of the foot and ankle, as this is one of the main functions of an ankle-foot orthosis. Our client wants the orthosis to support the heel and allow for heel strike while also providing some mobility. A higher score represents a design that offers more support for the foot and ankle.

Discreetness (20%) - Discreetness is weighted at 20% because it is very important to our client that the ankle-foot orthosis is discreet. Our client is a sophomore in high school and does not want to draw attention to her ankle. The AFO should fit inside a shoe and underneath jeans or leggings. A higher score represents a more discreet design.

Safety (15%) - Depending on the materials chosen for our design, there may be potential safety hazards. It is important that the ankle-foot orthosis is made from durable materials. If the AFO were to break, it must be ensured that it would not harm the user, which is why safety is weighted at 15%. Additionally, we must consider the effects of microplastics or any skin irritation that could be caused by the device. A higher score represents a design that is likely to be safer for the user.

Flexibility (15%) - The design and material used should be flexible enough to allow for a functional ankle range of motion, which is why flexibility is weighted at 15%. It must be flexible enough to ensure that other activities, such as squatting or descending stairs, are minimally impacted. A higher score represents a more flexible design.

Ease of Attachment and Removal (10%) - Since this device will be used daily, it is important that it is easy for the user to put on and take off. It is only weighted at 10% because a device that is harder to attach and remove can still be functional, flexible, and safe, supporting the client's main requirements. A higher score represents a design that is easier to attach and remove.

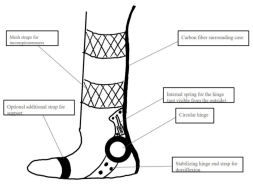
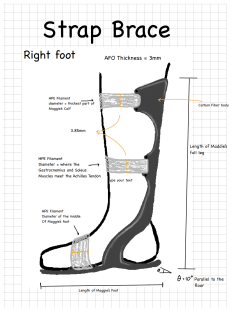
Customizability (10%) - A customizable AFO ensures a proper, comfortable fit. Customizability helps prevent discomfort and enhances functionality for ankle range of motion. An adjustable design ensures it remains effective as the user's needs evolve. A higher score represents a more customizable design. Customizability is weighted at 10% because, while important, it is more critical for the device to be functional and discreet for the user.

Cost (5%) - Considers the amount of money needed to fabricate and maintain each design. Low scores indicate a higher cost and higher scores indicate a lower cost. Cost is only weighted at 5%

because the client is flexible with the budget depending on the necessity and functionality of the design.

Ease of Manufacture (5%) - Considers how easy each design is to fabricate, including the accessibility of materials, machinery, and the time required for fabrication. A higher score indicates greater ease of manufacture. Ease of manufacture is weighted at only 5% because, although the design needs to be practical to produce, there is considerable flexibility in the time, materials, and fabrication processes that can be used.

Design Matrix Table

Criteria	Weight	Design 1 Hinge Design 		Design 2 Brace Bungee Design 		Design 3 Strap Design 	
		Score |	Weighted Score	Score |	Weighted Score	Score |	Weighted Score
Support	20	3/5	12	3/5	12	5/5	20
Discreetness	20	3/5	12	5/5	20	4/5	16
Safety	15	3/5	9	4/5	12	4/5	12
Flexibility	15	4/5	12	5/5	15	3/5	9
Customizability	10	4/5	8	5/5	10	3/5	6
Ease of Attachment and Removal	10	2/5	4	3/5	6	4/5	8
Cost	5	4/5	4	5/5	5	4/5	4
Ease of Manufacture	5	5/5	5	4/5	4	3/4	3
Total	100	66		84		78	

Design Matrix Discussion

Support - Design 3 offers the most support because the orthosis covers ¾ of the bottom of the foot and travels about halfway up the calf, which will fully support the ankle. Design 1 and Design 2 do not support the ankle as much because it allows for more mobility. The hinge in Design 1 and the bungee system in Design 2 will allow for plantar flexion.

Discreetness - Design 2 is the most discreet because it will easily fit inside a shoe and underneath pants. The strap gives a sock-like appearance, so this device would not draw too much attention. Design 2 is slightly more discreet than Design 1 because of the circular hinge and additional strap. However, both designs would fit underneath pants and inside a larger shoe.

Safety - Design 2 and Design 3 were ranked the highest for safety for different reasons. Design 2 is safe because of the soft material so it will not harm the user. Whereas Design 3 could potentially break and harm the user, but the design is the most supportive and durable because of the carbon fiber design. Design 1 is the least safe because the design could break and harm the user because of the plastic design, and there could be microplastics. Additionally, it is not as supportive because of the hinge mechanism, so the user, depending on muscle strength, could potentially miss a heel strike.

Flexibility - Design 2 is the most flexible design because the bungee system allows for plantar flexion, and the soft fabric material is less rigid than plastic or carbon fiber. Design 1 is slightly more flexible than Design 3 because the hinge mechanism allows for more mobility; however, they are both rigid because of the use of plastic and/or carbon fiber.

Ease of Attachment and Removal - Design 3 is the easiest design to use, as it will only contain straps to attach to the leg, which will be made of a stretchy, flexible material, such at TPU filament, or another type of 3D printing filament for ease of use and ease of construction. Design 1 has many moving parts that could make the attachment more difficult. Design 2 will have a lace-up design, or a bungee-like cord through the sleeve, which may be difficult to get on due to the lack of dorsiflexion in the patient.

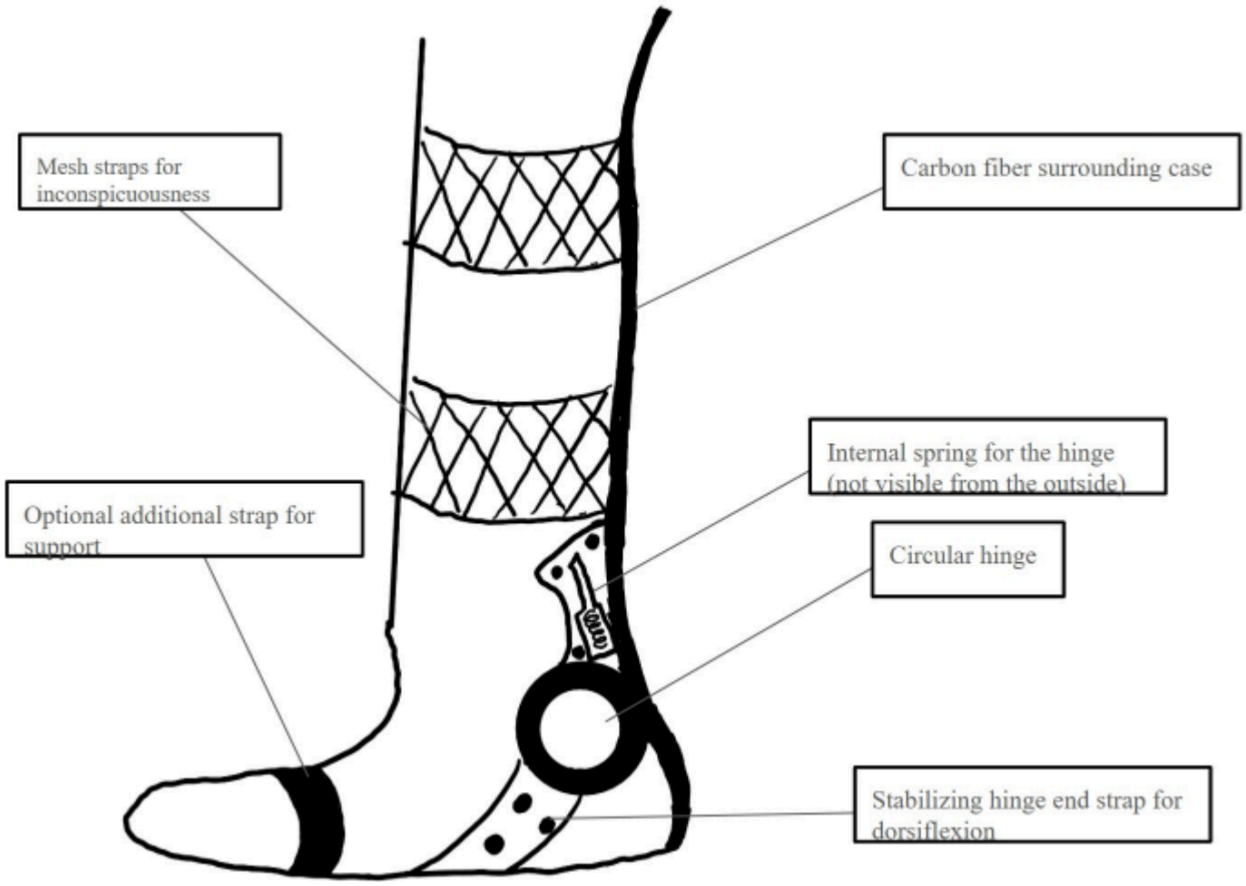
Customizability - Design 2 will be the most customizable, both in terms of level of stability and support and in exterior aesthetics. Design 2 can be tightened to various levels of support, while still maintaining an inconspicuous profile, and would be color-customizable. Design 1 scored the

next highest, as it also has a high level and range of support available, but would be less inconspicuous due to the hinge, and not as customizable exteriorly. Design 3 scored the lowest, as it is the simplest, and provides the least amount of customizable support. It maintains a decent level of inconspicuousness, but cannot be customized exteriorly any more than the color of the straps.

Cost - Design 2 will be the most cost-effective. Our budget for the initial project is $300; Design 1 potentially involves more testing and prototyping due to the hinge mechanism, and Design 3 would be the most expensive because of the cost of carbon fiber.

Ease of Manufacture - Design 1 would be the easiest to manufacture. The hinge would provide some level of difficulty, but there is no other technical level of difficulty beyond basic machining. Design 2 would involve lots of experimenting to design the best bungee mechanism inside of the base, but overall would still be less difficult than Design 3. The 3rd design would involve the manufacturing of carbon fiber, which none of us have the current skill-set to do, and would need to learn; therefore, giving design 3 the lowest and design 1 the highest score.

Design 1 Full Image



Design 2 Full Image

Design 3 Full Image