Inconspicuous Ankle Foot Orthosis (AFO) for Teen

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Overview

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Background

Facioscapulohumeral muscular dystrophy (FSHD):

Directly weakens skeletal muscle tissue. In the lower body, it primarily weakens the Gastrocnemius and the tibialis anterior, the latter being specifically involved in dorsiflexion.

Client background: Debbie Eggleston, physical therapist and activist

Patient: 16 year old high school student and horseback rider

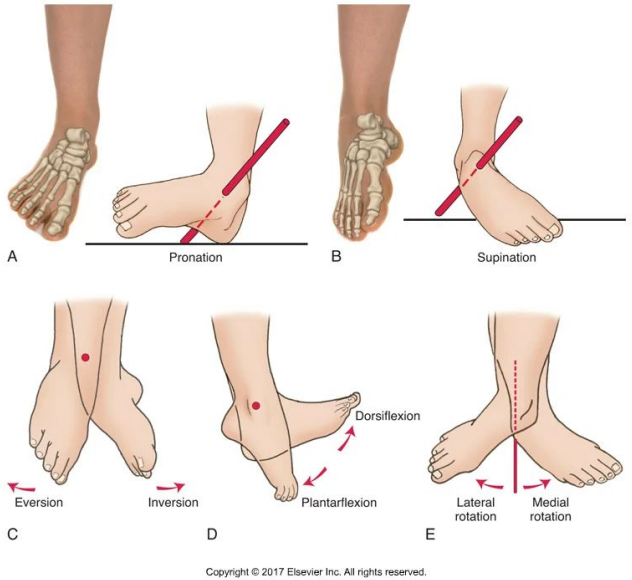


Figure 1: This image helps viewers understand foot movement vocabulary. [1]

Problem Statement

Project Description: Ankle-foot orthoses (AFOs) help support dorsiflexion during walking. For adolescents with **Facioscapulohumeral Dystrophy (FSHD)** , weakened ankle control can increase fall risk. Our project aims to design a brace that improves safety by assisting dorsiflexion, while staying **lightweight, discreet, and flexible** to allow natural movement.

Previous Work

- **Fall 2024**
  - Created initial design, focusing on dorsiflexion
    - Nylon Straps, PLA support
  - Patient testing did not happen
  - Minimal success from bungee supports
- **Spring 2025**
  - Focused on inversion prevention
    - PLA with 50% carbon fiber in-fill
  - No in-person testing, but prototype sent to client
    - Results were successful, however, the prototype did break

Figure 2: Fall 2024 final design

Figure 3: Spring 2025 final design

Competing Designs

Figure 4: PD-AFO

Passive Dynamic AFO (PD-AFO)

- Spring like bending to assist in plantar flexion and stability [2]

Figure 5: Jointed AFO

Jointed AFO

- Allows bending of the ankle while minimizing foot drop [3]

Figure 6: SMO

Supramalleolar Orthosis (SMO)

- Provides ankle stability and corrects misalignment [4]

Figure 7: VSO

Variable Stiffness AFO (VSO)

- Adjustable leaf spring to assist in foot drop and reduced toe striking [5]

Product Design Specifications

- Patient-specific dimensions
- Permit no more than 30° of foot drop from neutral
- Increase dorsiflexion and add 5-10 Nm resistance per 10° of plantarflexion
- Prevent inversion angles greater than 25°
- Brace should resist up to ± 30 Nm torque and 266 N of load
- Discrete design everyday use and horseback riding
- Comfortability

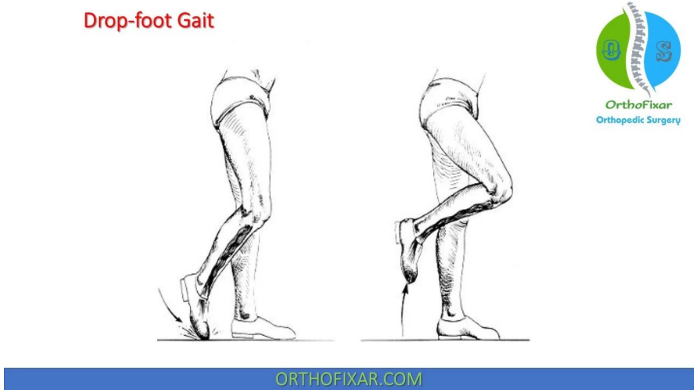


Figure 8: Foot Drop during Gate [6]

Figure 9: Ankle Inversion vs. Eversion [7]

Designs

Figure 10: Design 1- Combination Design 24-25

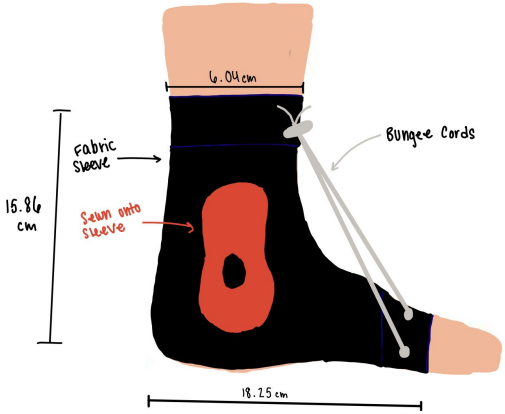


Figure 11: Design 2- Inversion with Straps

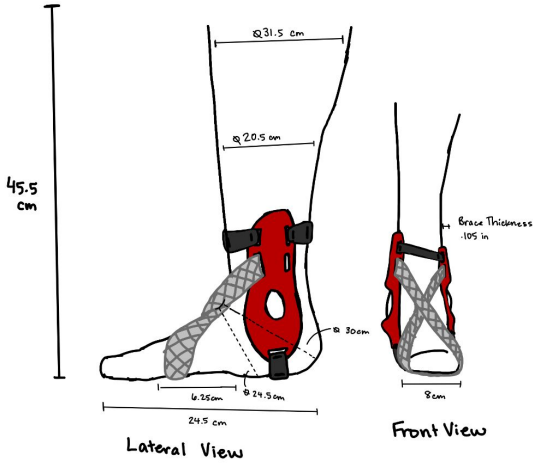
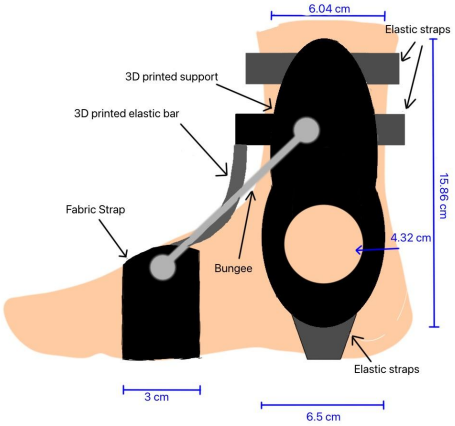


Figure 12: Design 3-



Design Matrix

Table 1: Prototype Design Matrix [8]

Design Criteria	Design 1: Combination Design 24-25		Design 2: Inversion with Straps		Design 3: In the Shoe	
	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
Dorsiflexion Support (20)	3/5	12/20	4/5	16/20	5/5	20/20
Mediolateral support (20)	4/5	16/20	4/5	16/20	4/5	16/20
Ease of user assembly (15)	2/5	6/15	4.5/5	13.5/15	3/5	9/15
Comfort (15)	3.5/5	10.5/15	4/5	12/15	4/5	12/15
Durability (10)	4/5	8/10	4/5	8/10	3.5/5	7/10
Discreteness (10)	2/5	4/10	4/5	8/10	3.5/5	7/10
Fabrication Quality (5)	3/5	3/5	4/5	4/5	3/5	3/5
Cost (5)	3/5	3/5	3/5	3/5	2/5	2/5
Total	62.5/100		80.5/100		76/100	

Figure 10: Design 1- Combination Design 24-25

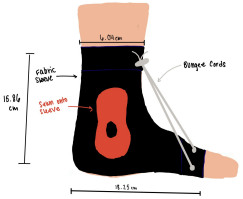


Figure 11: Design 2- Inversion with Straps

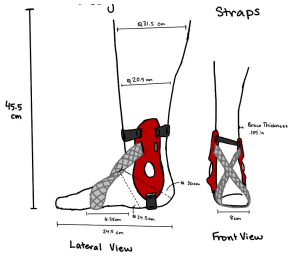
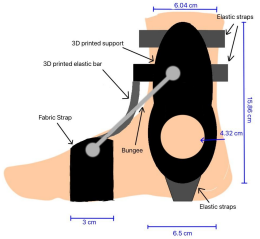


Figure 12: Design 3-



Final Design

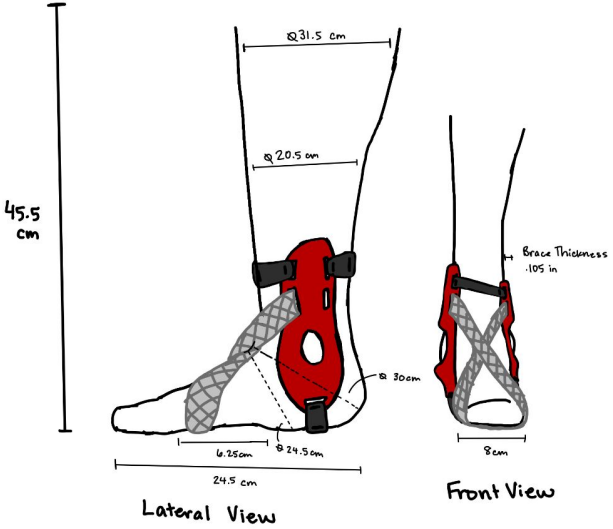


Figure 13: Inversion with Straps Final Design

Materials and Manufacturing:

- Inversion Supports: Carbon fiber PLA with 50% infill
  - 3D printing
- Straps: Polyester or TPU Filament
  - Cutting/sewing for polyester
  - 3D printing for TPU

Figure 14: Carbon fiber reinforced PLA filament

Figure 15: TPU Filament

Next Steps

Fabrication and Prototyping

- Finalize the materials
- 3D print test AFO

Fit and customization

- Placement of the straps
- Shoe integration

Testing

- Durability
- Finite Element Analysis
  - Force: 266N
  - Torsion force: ± 30 Nm
- Comfort
- Patient testing
  - Gait analysis
    - Force Plate Testing
  - Toe clearance and heel strike
  - Inversion control

Acknowledgements

Advisor

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Client

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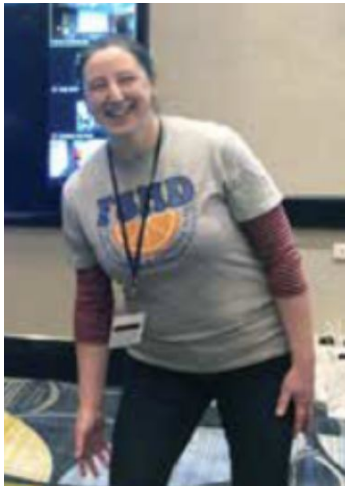

References

(1] “Decreased Ankle Dorsiflexion is Associated with Dynamic Knee Valgus,” Learn Muscles. Accessed: Sep. 28, 2025. [Online]. Available: https://learnmuscles.com/blog/2018/05/16/decreased-ankle-dorsiflexion-is-associated-with-dynamic-knee-valgus/
[2] J. Feng, J. Weiss, A. Thompson, and J. E. Meeker, “Passive Dynamic Ankle Foot Orthoses Use in Civilian Patients with Arthritic Conditions of the Foot and Ankle,” Foot Ankle Orthop, vol. 8, no. 1, p. 24730114231157734, Mar. 2023, doi: 10.1177/24730114231157734.
[3] “Jointed AFOs,” Orthotics Plus Melbourne. Accessed: Oct. 02, 2025. [Online]. Available: https://orthoticsplus.com.au/orthotics/ankle-foot-orthoses-afo/jointed/
[4] F. M. Medical, “What is an SMO Brace?,” Forward Motion. Accessed: Oct. 02, 2025. [Online]. Available: https://www.fdmotion.com/blog/what-is-an-smo-brace
[5] “Variable Stiffness Orthosis – Neurobionics Lab.” Accessed: Oct. 02, 2025. [Online]. Available: https://neurobionics.robotics.umich.edu/research/wearable-robotics/variable-stiffness-orthosis/
[6] “Gait Cycle: Phases & Biomechanics | OrthoFixar.” Accessed: Oct. 02, 2025. [Online]. Available: https://orthofixar.com/basic-science/gait-cycle/
[7] “Movement About Joints, Part 7: The Ankle.” Accessed: Oct. 02, 2025. [Online]. Available: https://www.crossfit.com/essentials/movement-about-joints-part-7-the-ankle
[8] “Design Matrix Criteria,” Google Docs. Accessed: Oct. 02, 2025. [Online]. Available: https://docs.google.com/document/d/1RubhvszKS7dHb20CbqxxnopQXpnEhTl70vQ7UrNjcpo/edit?usp=drive_web&ouid=107089724200739255682&usp=embed_facebook

Questions?