

PROBLEM STATEMENT

Ankle-foot orthoses (AFOs) are designed to **support dorsiflexion during the swing phase** of walking. They are commonly used in managing muscular dystrophies, and for this project, the focus is specifically on adolescents with **Facioscapulohumeral Dystrophy (FSHD)**. The final design should help teens achieve safer walking by assisting ankle dorsiflexion, while remaining **discreet, lightweight, and flexible** enough to allow natural ankle motion. This project has been ongoing throughout three semesters, and this semester, Spring 2026, will be the **final semester** of the project; the team is hoping to create a device that fulfills all requests, as well as displays significant data.

BACKGROUND

Client: Debbie Eggleston, physical therapist
Patient: 16-year-old high school student with FSHD
Facioscapulohumeral Dystrophy (FSHD)

- A form of Muscular Dystrophy causing progressive skeletal muscle weakness [1]
- Foot drop develops due to weakened dorsiflexion muscles in lower limb

Existing Devices

- Passive-Dynamic AFO (PD-AFO) - spring-like bending to assist in plantar flexion; patient has perscription for this device [2]
- Supramalleolar Orthosis (SMO) - provides ankle stability and alignment [3]
- All are extremely bulky and noticeable when worn



Figure 1: PD-AFO [2]



Figure 2: SMO [3]

DESIGN SPECIFICATIONS

- Fit to patient specific dimensions of the right ankle region
- 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°
- Resist up to a 1570 N load and 30 Nm torque
- Slim and sleek design built for everyday use
- Comfortable enough to be worn throughout the entire day, avoiding skin irritation
- Should be able to be used during horseback riding
- Avoid moisture buildup

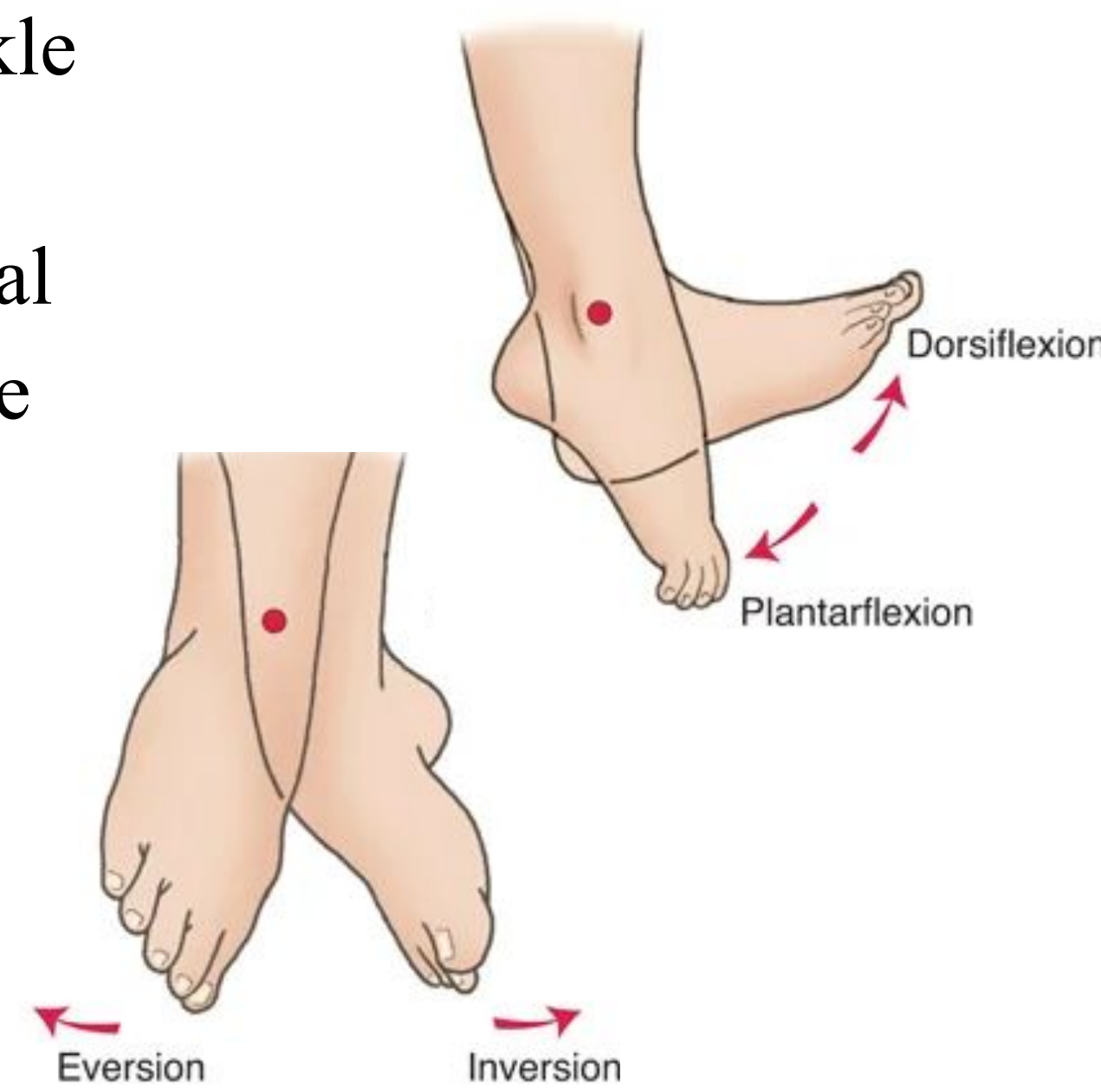


Figure 3: Anatomical ankle movements [4]

REFERENCES

[1] C. Fecek and P. D. Emmady, "Facioscapulohumeral Muscular Dystrophy," in StatPearls, Treasure Island (FL): StatPearls Publishing, 2025. Accessed: Jan. 28, 2026. [Online]. Available: <http://www.ncbi.nlm.nih.gov/books/NBK559028/>
 [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] 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>
 [4] "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/>

PREVIOUS WORK & LIMITATIONS

Fall 2024:

- Dorsiflexion support via elastic bungee cord
- Limitations include **lack of mediolateral support, ineffective bungee cord, and excessive bulkiness**

Spring 2025:

- Mediolateral supports via PLA-CF with 50% infill
- Single layer of mesh padding
- Limitations include **lack of dorsiflexion support and painful pressure points** around the malleoli when worn

Fall 2025:

- Mediolateral supports via PLA-CF with 50% infill
- Double layer of mesh padding
- Elastic polyester dorsiflexion strap
- Limitations: **downward slippage** of mediolateral supports and **backward slippage** of the dorsiflexion strap



Figure 4: Fall 2024 AFO



Figure 5: Spring 2025 AFO



Figure 6: Fall 2025 AFO

FABRICATION & FINAL DESIGN

Updates:

- Extended medial & lateral supports to reach bottom of calcaneus
- Reduced Elastic nylon by 10.16 cm to increase the tension applied

Fabrication:

- Form medial and lateral supports to imported foot casting
- Extrude cut out malleolus holes and strap slits
- Sew layered mesh and adhere with superglue to supports
- Cut mesh to fit supports including current support strap slits
- Install ballistic, velcro, and elastic straps through designated holes

Design features:

- Double layered mesh to increase comfortability
- 50% Carbon fiber PLA to ensure support strength
- Ballistic nylon straps with velcro to increase adjustability
- Double layered elastic nylon straps to support dorsiflexion
- Mesh padding ensures breathability and lack of moisture buildup

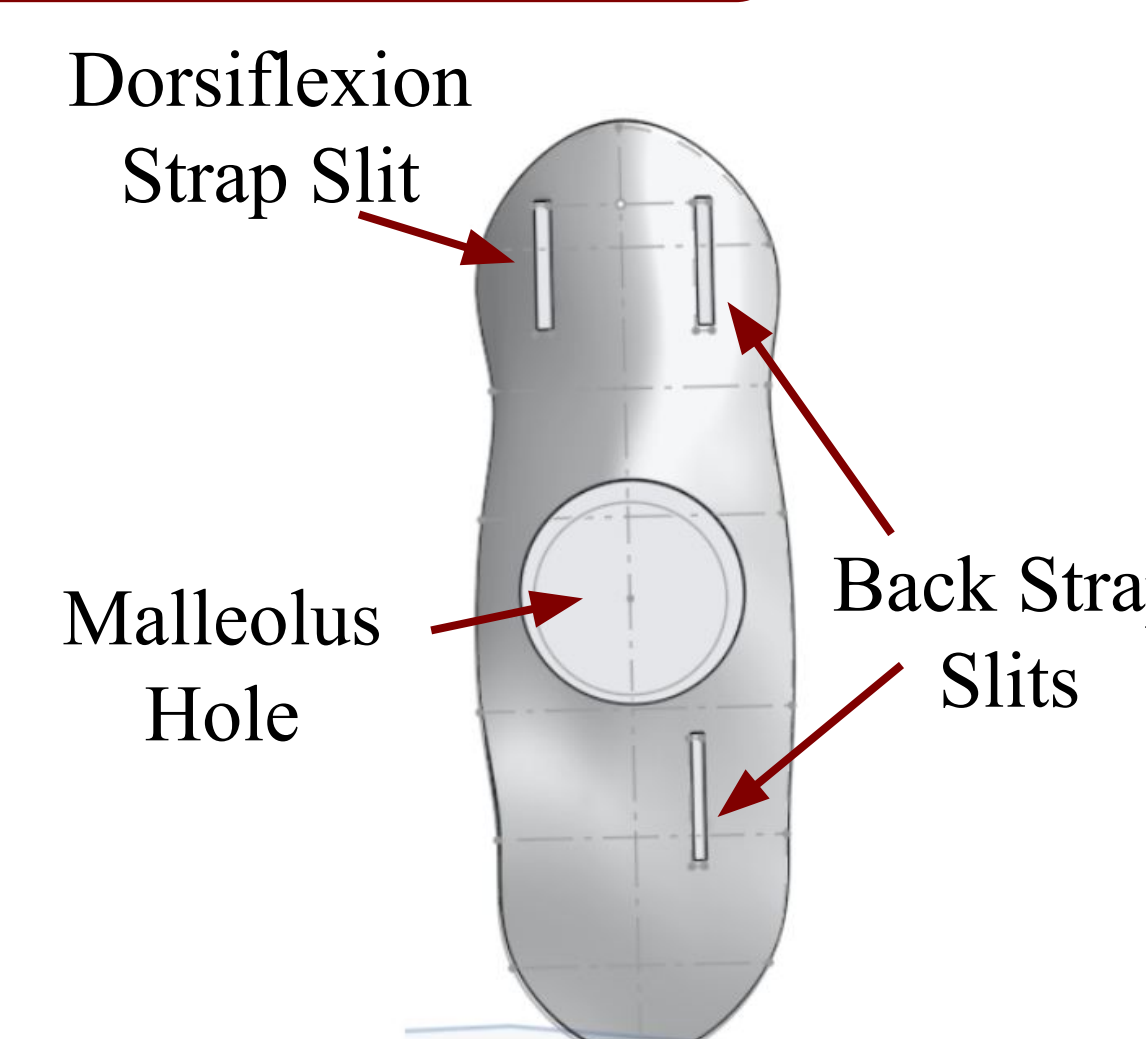


Figure 7: CAD Medial Support



Figure 8: Spring 2026 AFO

COSTS

Fall 2024
\$182.02

Spring 2025
\$37.95

Fall 2025
\$45.42

Spring 2026
\$31.93

Total 2-Year
Cost
\$304.42

DORSIFLEXION AND BALANCE ANALYSIS

Testing was performed at the University of Michigan due to the client's location. To test dorsiflexion, the team performed a gait analysis, testing heel strike and toe-off forces. For the balance analysis, stabilograms were generated, and the average path length was analyzed for multiple conditions.

Figure 9: Normalized heel strike and toe

- Spring brace restores heel strike and toe-off to healthy range
- Spring 2026 AFO performs best

Figure 10: Dorsiflexion force plate analysis

- No significant difference vs. healthy subject
- Brace successfully replicates normal gait

Figure 11: Stabilogram path length (balance test), the eyes closed trial was utilized to eliminate bias within the test

- Subject without FSHD is the control
- Brace shows improvement
- Indicates improved medial-lateral stability

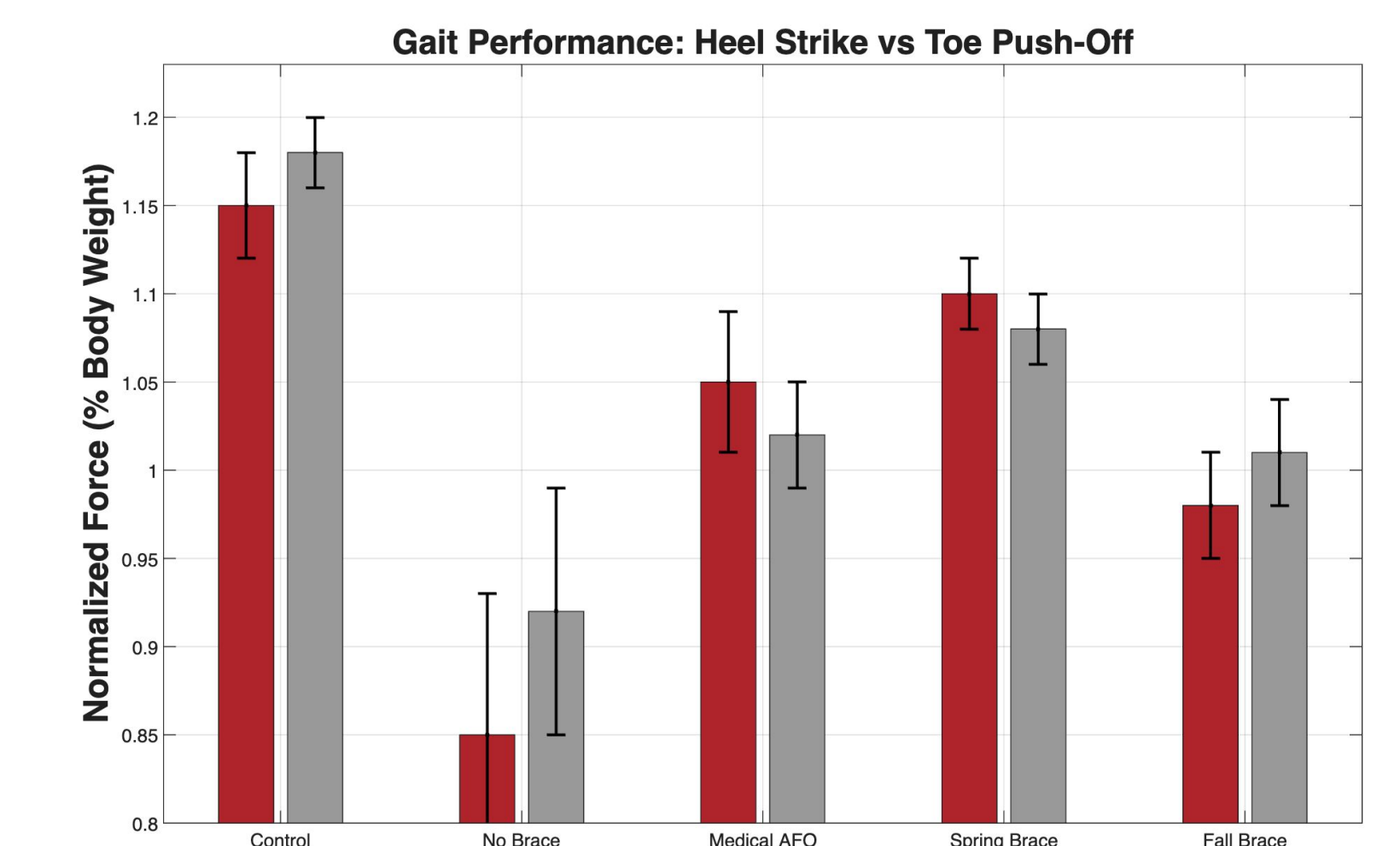


Figure 9: Heel Strike (Red) and Toe Push-Off (Gray)

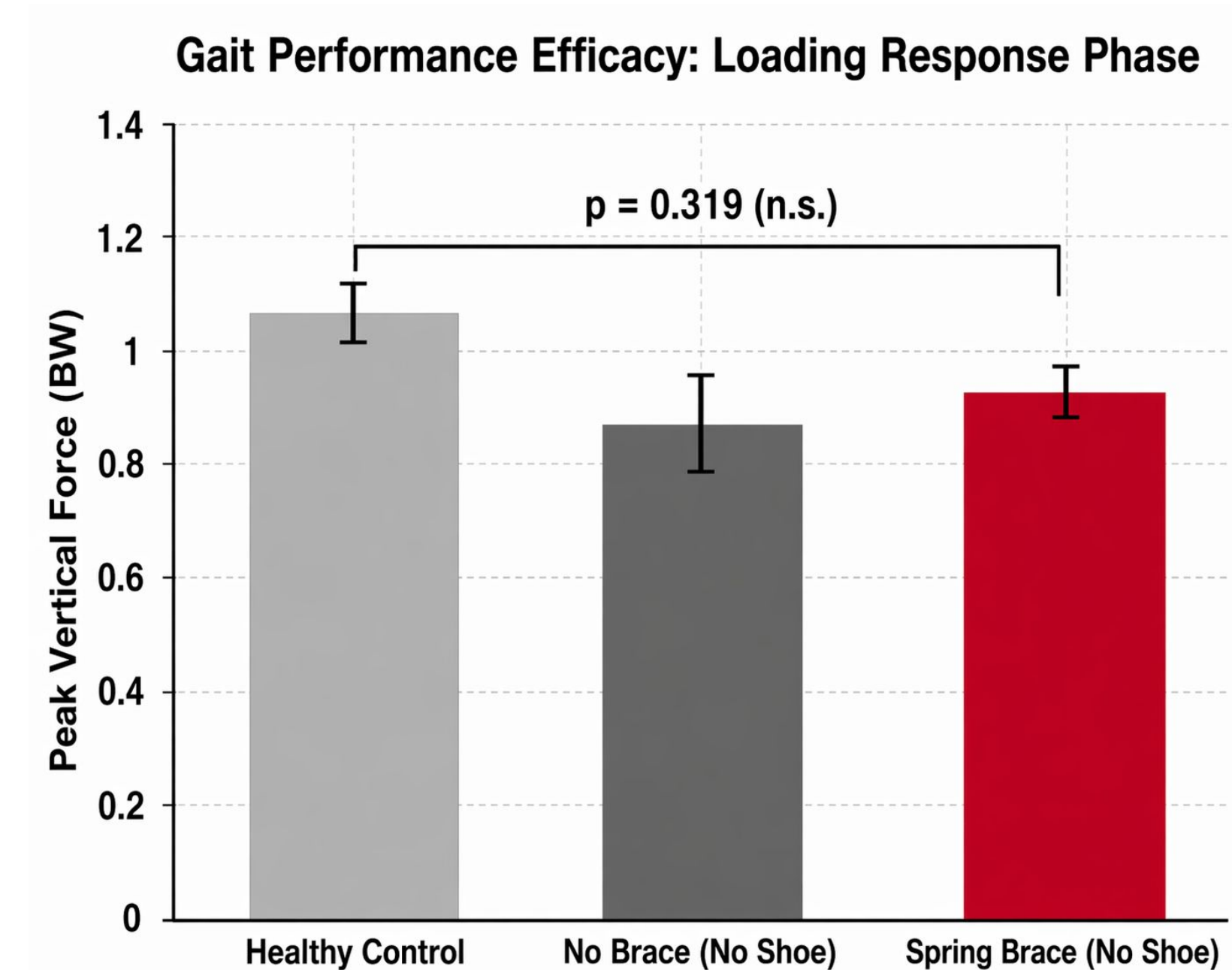


Figure 10: Gait Statistical Analysis Average Center of Pressure Path Length (Eyes Closed)

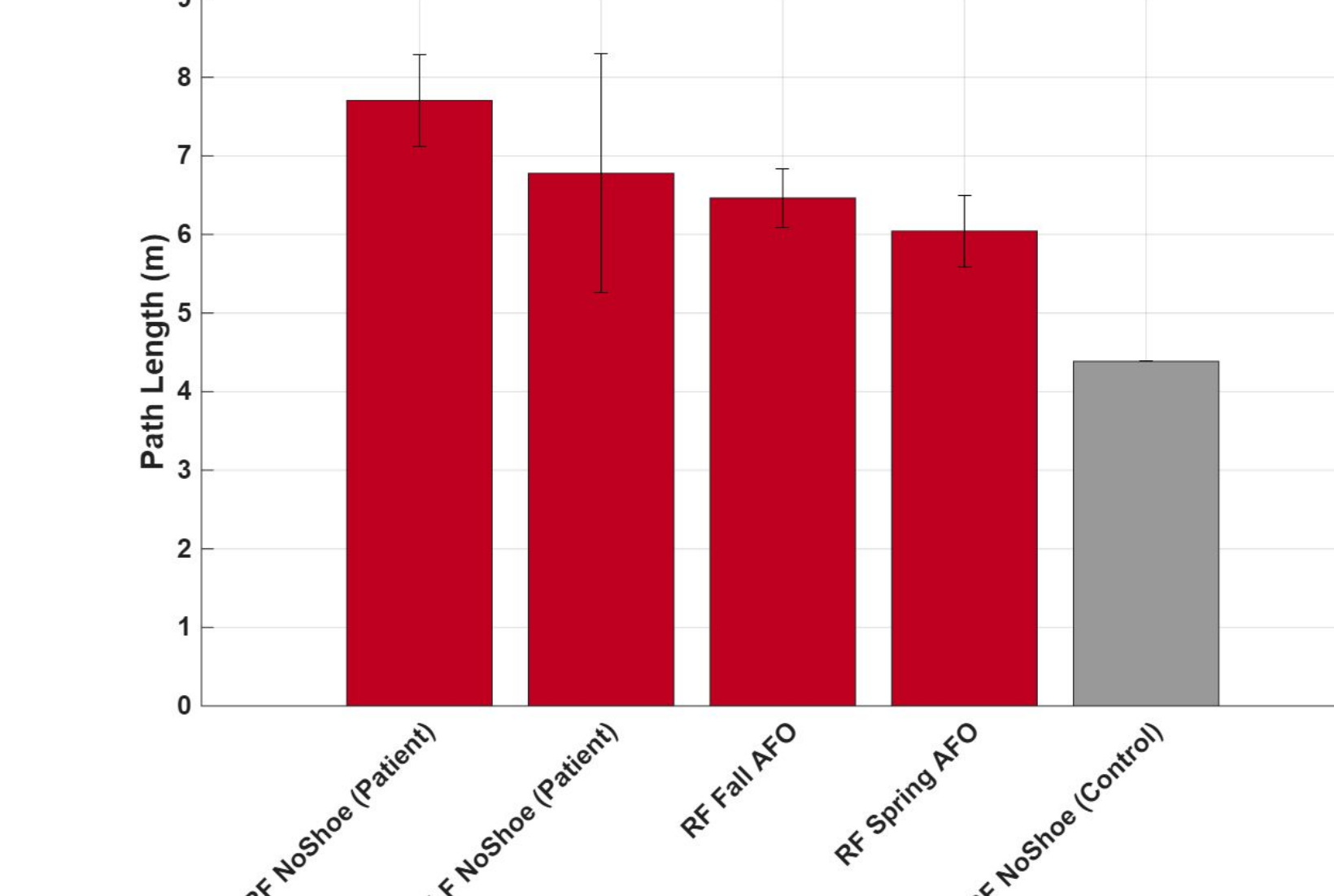


Figure 11: Stabilogram Path Length Analysis

DISCUSSION

Comfortability Testing

- Patient recommended improving ease of use in putting on the device
- Previously reported discomfort on the malleolus has been completely eliminated
- The slippage of the dorsiflexion strap over the foot has been minimized

Did it work?

- **Yes!** The patient reported that the brace felt more effective than previous iterations, improving foot lift and preventing foot drop while walking
- The healthy patient data compared to the Spring AFO did not show any significant differences, meaning that the Spring AFO gait is statistically the same as the healthy gate, proving the device provides significant dorsiflexion support

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