ReActive Comfort: Enhancing Ankle Support Through Pressure Adaption

Researcher: Prisha Nair
Advisor: Dr. Kevin Crowthers
Massachusetts Academy of Math & Science at WPI

Engineering Goal

Design a **pressure-responsive ankle brace** that automatically adjusts tension in real time to **maximize comfort and stability.**

Background

- **Ankle injuries** are some of the **most common** in the world (Alawna & Mohamed, 2020).
- Stiff, rigid braces can **decrease athlete complience** (Willwacher et al., 2023).
- **Rehabilitation methods** such as resistance bands or balance boards depend on **consistent user adherance** (Cain et al., 2020)

Methodology

Sensor and Actuator Placement: Test Sensors in different locations and map out best placement

Figure 1: *Round High Force Sensitive Resistor (FSR) - 1 ~ 100 Newton Force*

Pressure Adaption System: Establish the system where increased pressure increases support

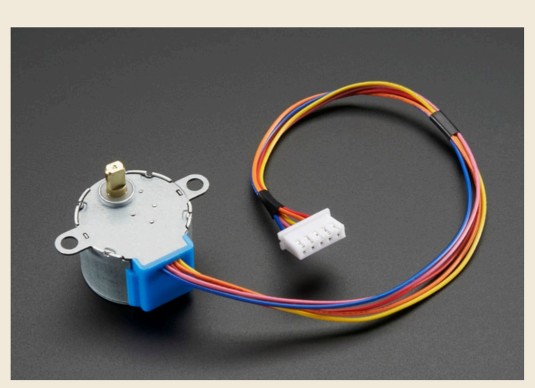

Figure 2: *Small Reduction Stepper Motor - 5VDC 32-Step 1/16 Gearing*

CAD Model: Design a brace model that accomadates the external hardware

Figure 3: *Standard Lace-Up Brace for Prototyping*

onshape

Simulation for Data Collection: Use a simulation to gather data about the brace in different situations

Implement RL: Use simulation data to train an RL model that adapts to user preferences

Up to **80% of people** will experience an **ankle sprain** at some point in their lifetime (Gaddi et al., 2022)

Results

Technique 1: Simulation

Fusion 360 was used to **simulate ankle sprains** and different loads to pinpoint **optimal stiffness** for the brace at each pressure.

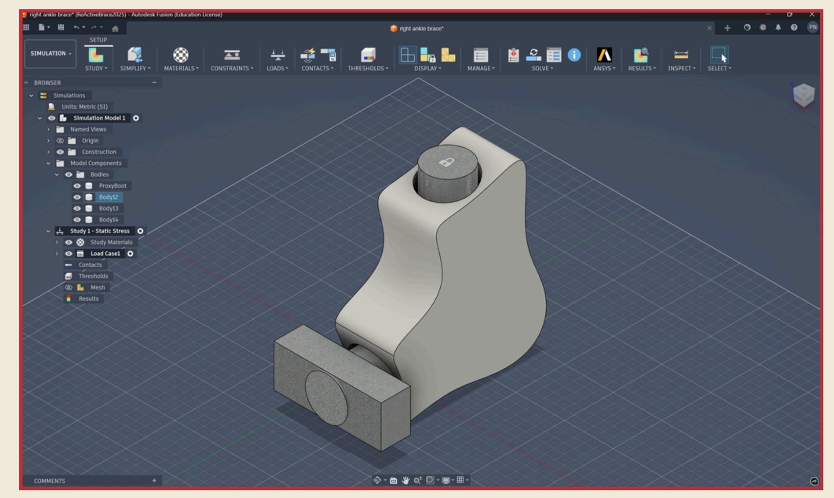

Figure 1: *Structure Used to Run Simulation*

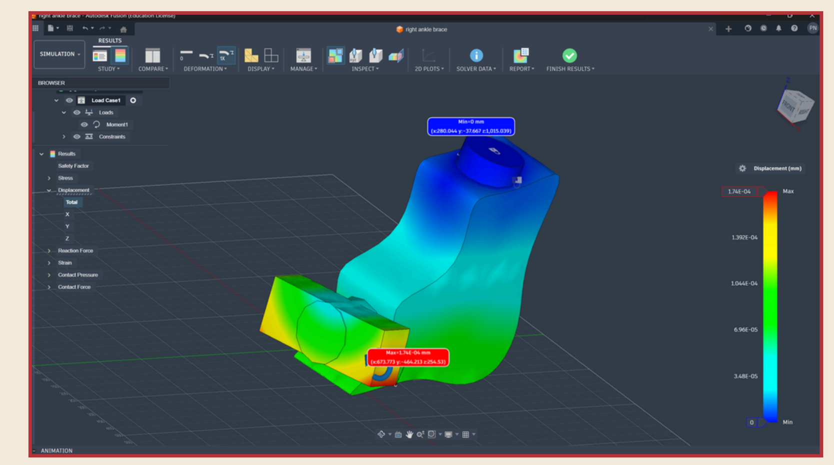

Figure 2: *Post-Simulation Displacement Results*

It shows that **optimizing pressure** is the most efficient way to keep someone's **joint safe**.

Technique 2: Physical Testing

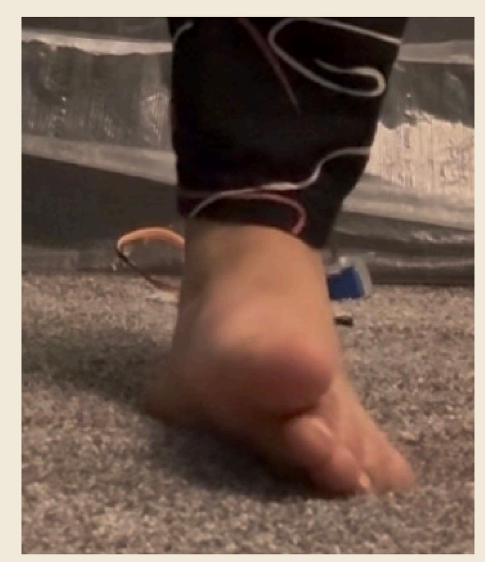

Figure 1: *Side to side Jump WITHOUT Brace*

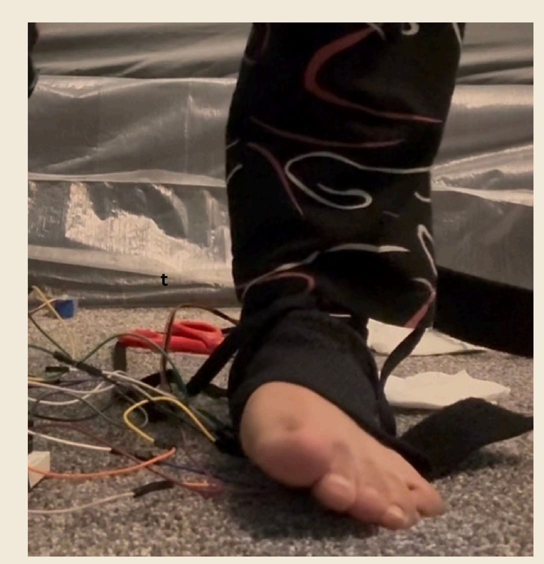

Figure 2: *Side to side Jump WITH ReActive Comfort*

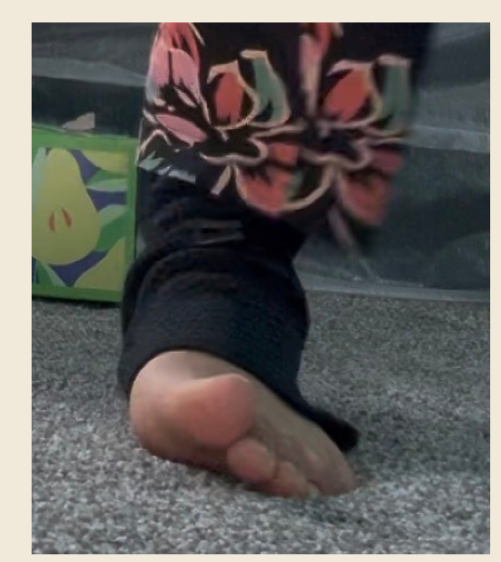

Figure 3: *Side to side Jump WITH Standard Brace*

When **self-testing** was conducted, **side to side jumps** were done without a brace, with ReActive Comfort and with a standard brace. The ReActive Comfort Brace had **more stabilization** at the **tipping point** at it tightened when the **edge FSRs sensed high pressure.**

Analysis

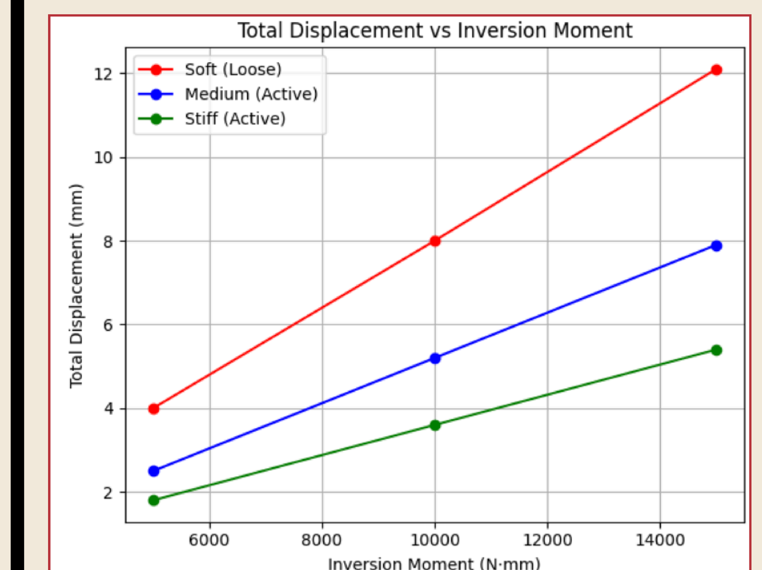

Figure 3: *Total Displacement vs Inversion Moment*

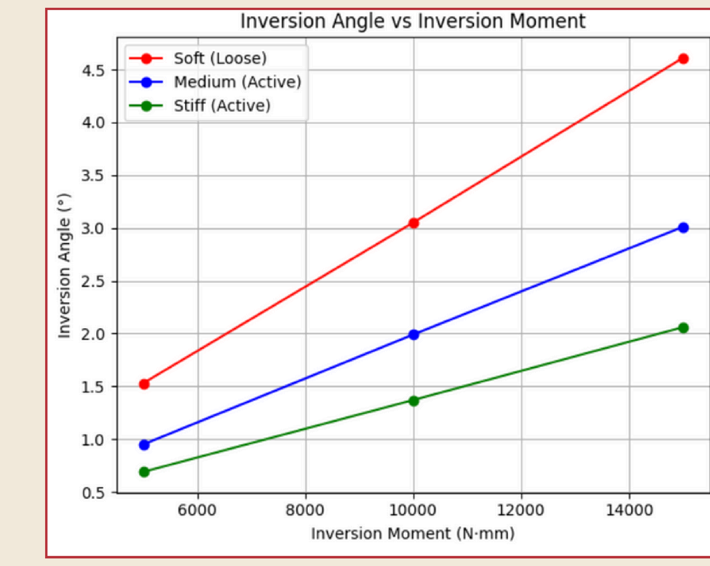

Figure 4: *Inversion Angle vs Inversion Moment*

Figures 3 and 4 present **simulated displacements and inversion angles** across three brace stiffness conditions under increasing inversion moments. A **Friedman repeated-measures analysis** showed a statistically significant effect of brace condition on inversion angle **($p < 0.05$)**, with **higher stiffness consistently reducing ankle motion.**

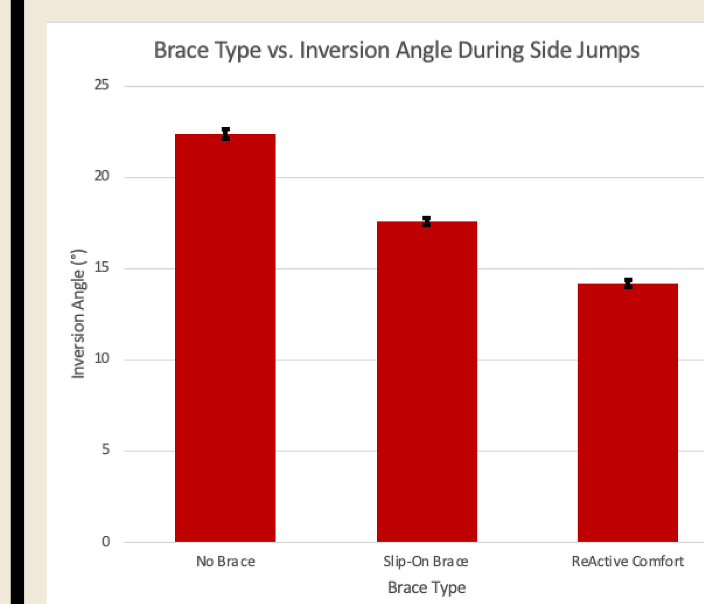

Figure 4: *Inversion Angle vs Brace Type*

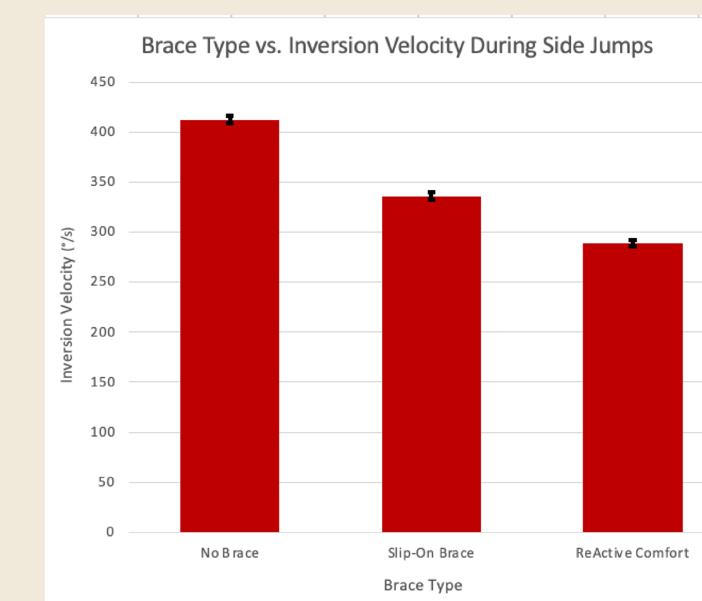

Figure 5: *Inversion Velocity vs Brace Type*

In **figures 12 and 13** the **Friedman test** revealed significant differences between brace conditions for **both inversion angle and velocity ($p < 0.05$).** The **ReActive Comfort** brace resulted in the **lowest mean inversion angles and velocities**, indicating the most effective stabilization.

Pugh Chart

Evaluation Criteria	Lace Up Brace	BetterGuard	ReActive Comfort
User Comfort	0	+	+
Pressure Distribution	0	0	+
Wearability/Compliance	0	+	+
Ankle Stability	0	+	+
Adaptability to Movement	0	+	+
Bulk / Weight	0	+	0
Net Scores	**0**	**5**	**5**

Figure 13: *Criteria and Comeptitor Analysis Chart*

- Criteria was designed through background research and **interviews with prospective clients**
- The ReActive Brace measured up to the **BetterGaurd** (its competitor)
- The ReActive Brace could become better than the BetterGaurd when **material optimization** is applied

Future Work

- **Long-Term Wear Testing:** Conduct extended trials over multiple days or weeks to evaluate comfort, skin irritation, and user compliance during daily activities.
- **Expanded User Testing:** Test the brace on a larger and more diverse group of users with varying foot sizes, activity levels, and ankle conditions to assess generalizability.

Conclusion

This project demonstrates that an **adaptive, pressure-responsive ankle brace can improve user comfort** by adjusting support based on real-time pressure changes. Increased comfort has the potential to **encourage consistent brace use**, which is critical for injury prevention and recovery.