

PEDIATRIC ARCH SUPPORT

Final Design Review | Group 11

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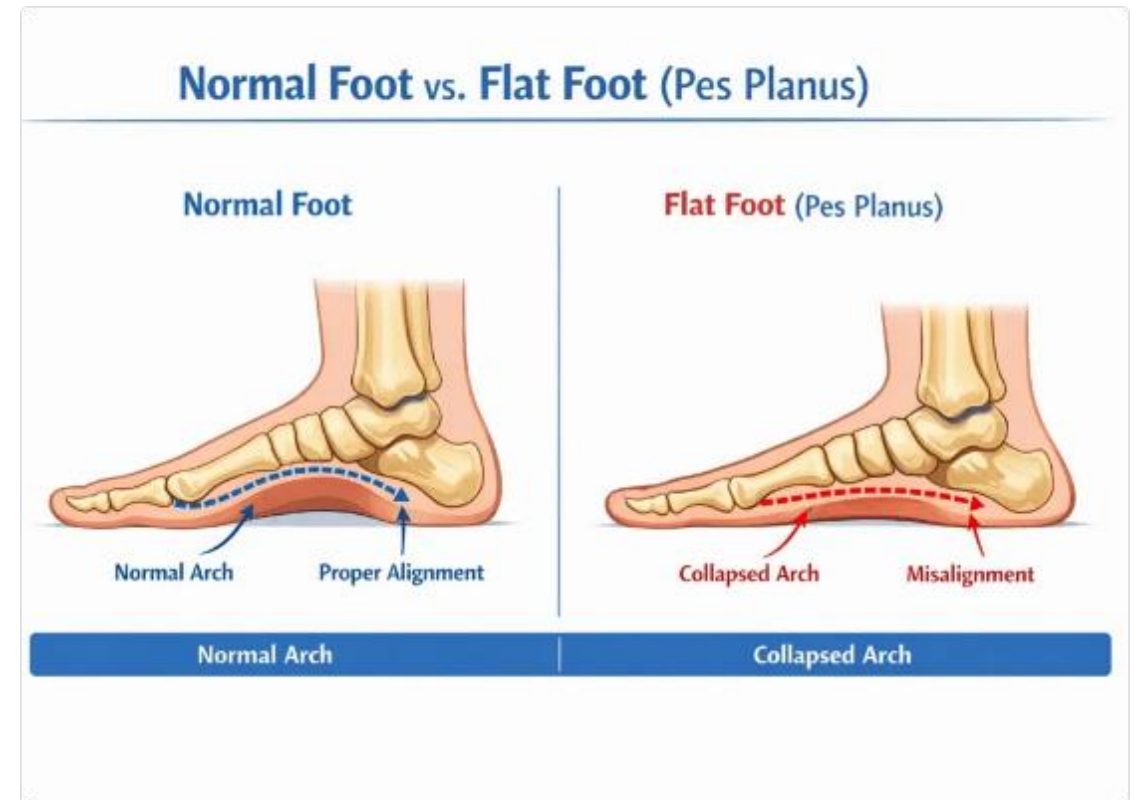
PROBLEM STATEMENT

OBJECTIVE

To design a positionally adaptable orthopedic device for growing children (ages 5-7) with symptomatic pediatric pes planus (flat foot).

CLINICAL NEED

- Alleviate medial longitudinal arch discomfort.
- Accommodate rapid volumetric foot growth.
- Provide a low-cost, non-invasive alternative to rigid orthotics.



| CLINICAL BACKGROUND & APPROACH

ANATOMY OF PES PLANUS

Characterized by the collapse of the Medial Longitudinal Arch (MLA). In children aged 5-7, the foot is in a critical developmental phase.

VALMASSY FORMULA

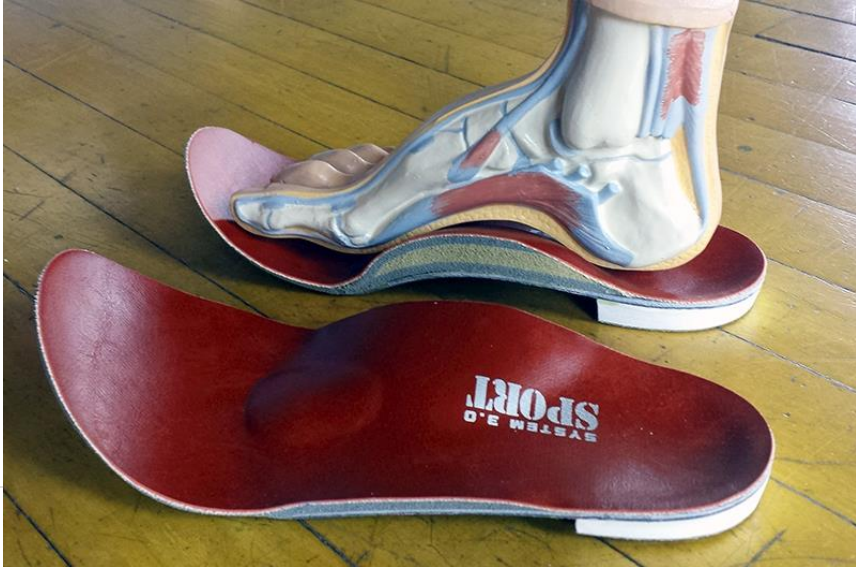
The Resting Calcaneal Stance Position (RCSP) typically corrects by approximately 1° per year until age 7.

$$\text{RCSP} = 7 - \text{Age}$$

SYMPTOM TRACKING

- Excessive pronation during gait cycle.
- Plantar fasciitis risk in early childhood.
- Muscle fatigue in the Tibialis Posterior.

COMPETITIVE BENCHMARKING



Criteria	Rigid Orthotics	OTC Insoles	Group 11 Solution
Adaptability	None (Fixed)	Minimal	High (Sleeve)
Comfort	Low (Rigid Plastic)	Moderate	High (Gel/Fabric)
Cost	\$200+ (Custom)	\$15 - \$30	\$18-\$24
Growth Scaling	Requires Replacement	Disposable	Modular Inserts

USER NEEDS & DESIGN INPUTS

User Need	Design Input (Requirement)	Verification Method
Withstands impacts in daily play.	Must withstand an impact force of 3600 lbs.	Impact Testing
Scales with foot size.	Sleeve elasticity allow 10% volume growth.	Tensile Testing
Alleviate Arch Pain.	Support 150N ground reaction force (GRF).	FMEA / Load Testing
Low profile in shoes.	Total thickness < 8mm in midfoot area.	Caliper Measure

DESIGN RATIONALE



MATERIAL SELECTION

Bleached Muslin was selected to ensure the shape of the pattern accurately fit into place.



HYBRID SUPPORT

Gel-adhesive sandwich construction:
Soft gel for immediate comfort
surrounded by adhesive to encase
and deform with the gel.



HUMAN FACTORS

Familiar design allows children to put on the insert themselves, as if it were a regular sock.

PROTOTYPE JOURNEY

V1: PROOF OF CONCEPT

Cardboard and foam inserts in standard socks.

Lesson: Verified the lift required but failed on stability.

V2: FUNCTIONAL ALPHA

Gel pads in compression sleeves.

Lesson: Improved stability; identified the need for a dedicated pad pocket. Need to refine insert topography.

V3: FINAL BETA

Custom-molded hybrid inserts with reinforced pouch.

Lesson: Ready for biomechanical validation.

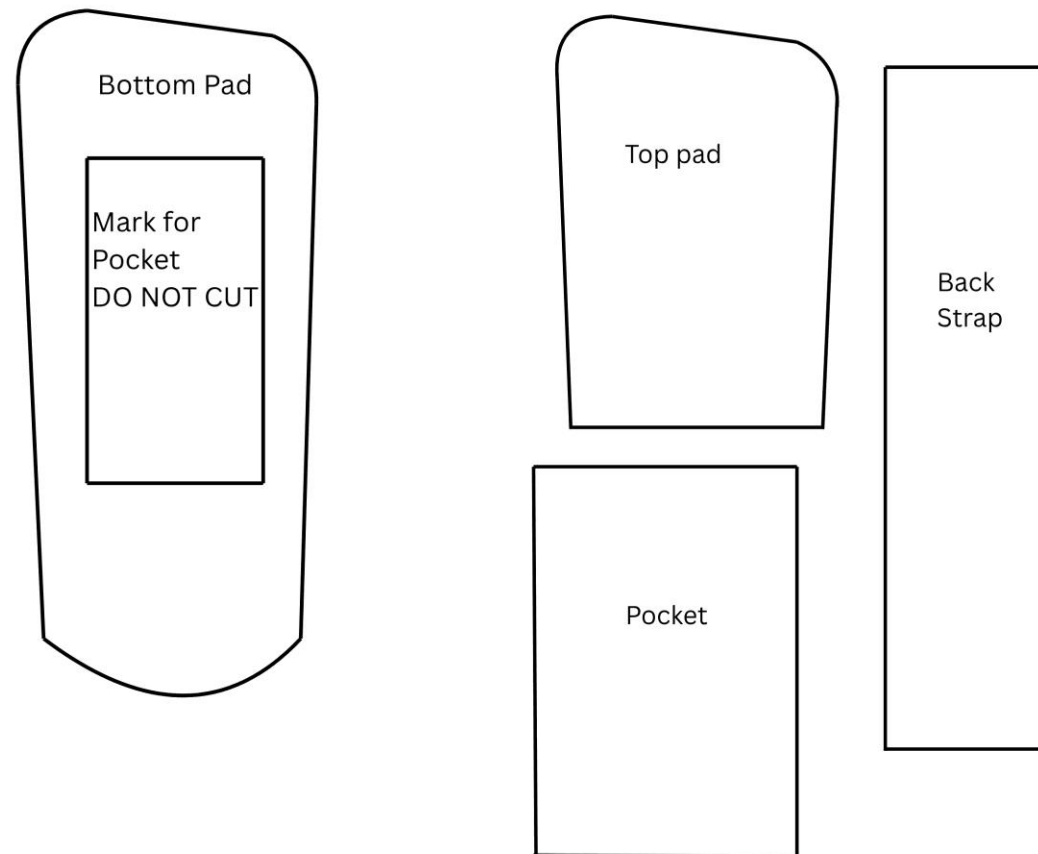
FINAL DESIGN DETAILS

ASSEMBLY OVERVIEW

- **Sleeve:** Breathable Muslin.
- **Strap:** Elastic Band
- **Pocket:** Reinforced internal stitching.
- **Insert:** Gel-Adhesive Combination.

Instructions

1. Print the pattern on standard 8.5x11" paper and cut your fabric to each shape. You will need one of each shape.
2. Iron all pieces of fabric to remove any wrinkles and folds. Mark the pocket on your bottom pad.
3. Fold $\frac{1}{4}$ " seam on all sides of the pocket and iron it down.
4. Sew along the pocket seam onto the right side of the bottom pad, leaving one side open for the insert.
5. Sew wrong sides of the bottom and top pads together with $\frac{1}{2}$ " seam allowance. Leave $\frac{1}{2}$ " fabric unsewed at the bottom corners of the top pad, this is where the top pad will connect to the strap.
6. Cut small slits into the long end of the strap, ~ every $\frac{1}{4}$ ".
7. Sew the long side of the strap to the heel of the bottom pad. Make sure the wrong sides are together.
8. Sew the ends of the straps to the $\frac{1}{2}$ " unsewed portions of the top pad.
9. Turn the sock inside out so the right sides are showing.
10. Place the insert into the pocket.
11. Hand-sew the pocket shut.



ENGINEERING ANALYSIS

ARCH BIOMECHANICS

Modeled as a Windlass Mechanism. The tension (T) in the plantar fascia is related to the ground reaction force (F_g) and arch height (h):

$$T = \frac{F_g \cdot L}{4 \cdot h}$$

(L = Foot length, h = Arch height)

MATERIAL STRESS

Tensile stress (σ) on the sleeve during a 10% strain (ε) cycle to ensure safe elastic limits:

$$\sigma = E \cdot \epsilon = E \cdot \frac{\Delta L}{L_0}$$

Calculated Elastic Modulus (E) for the textile blend: 10-100 MPa. Based on stitch vs cross stretch

RISK ANALYSIS (FMEA)

Failure Mode	Effect	Severity	Mitigation
Pad Slippage	Loss of arch support	Medium	Non-slip pocket lining
Material Tearing	Device failure	High	Industrial Sewing
Circulatory Constriction	Pain / Numbness	Extreme	Limited compression gradient
Hygiene (Sweat)	Skin irritation	Low	Antimicrobial mesh choice
Pad Burst	Loss of support, Device Failure	High	Reinforcing gel casing

VERIFICATION TESTING

PROCEDURE

- Place the insert and Sleeve on a flat, supported surface
- Place a 30lbs dumbbell on the insert for 1 minute
- Drop the 30lbs dumbbell on the insert from a distance of 1 foot

Rational

- The purpose of this test is to see if the insert is able to withstand the forces it will be exposed to during normal use.
- A 1 minute static hold is used to simulate the insert being used at rest.
- The drop test simulated how the insert reacts in high-impact situations, such as sports.

Success Criteria

In both the static loading and impact testing the insert must remain fully intact. This means no gel should seam outside the pouch, no stitching should come undone, and none of the fabric should tear.

RESULTS

Test	Pass	Fail	Comments
Static #1	X		Insert Unaffected
Static #2	X		Insert Unaffected
Static #3	X		Insert Unaffected
Impact #1	X		Insert Unaffected
Impact #2	X		Insert Unaffected
Impact #3		X	Insert slightly damaged, but contained, slight leakage

VERIFICATION TESTING



| NEXT STEPS & LEARNINGS

KEY LEARNINGS

- Adhesive may struggle to contain gel after loading
- Sleeve tension and elasticity must be balanced against tissue compression limits.
- The "Growing Child" constraint is a material science problem.

FUTURE IMPROVEMENTS

- TPU printed encasement
- 3D Scan-to-Print workflow for custom inserts.
- Flexible elastic fabric integration
- Longitudinal gait analysis with actual pediatric subjects.

QUESTIONS?

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| IMAGE SOURCES



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Source: www.ceas.uc.edu



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Source: www.pediatricfootankle.com
