

Brandon Alleborn\*<sup>1</sup>, Luke Berish\*<sup>1</sup>, Ben Dellmeyer\*<sup>1</sup>, Gavin Kane \*<sup>1</sup>,  
Christine Deng, BS<sup>2</sup>; Jake Fanizza, BS<sup>2</sup>; Talmadge Gaither, BE, MS<sup>2</sup>; Lorenzo Guani, BS, MPH<sup>2</sup>; Jaclyn Lo, BA<sup>2</sup>, Pramath Nath, MD<sup>2,3</sup>; Adrian Shieh, PhD<sup>1</sup>  
1 School of Biomedical Engineering, Science, and Health Systems, Drexel University, Philadelphia PA.  
2 College of Medicine, Drexel University, Philadelphia PA.  
3 Department of Emergency Medicine, St. Christopher's Hospital for Children, Philadelphia PA. \*Co-First Authors

## Need

### User and Problem

- Annually ~12,000 pediatric lower limb fractures<sup>1</sup>
- Underdeveloped motor coordination in children under seven makes them unable to use crutches<sup>2,3,4</sup>
- Additional burden on guardians

### Current Limitations

- Physical Barriers, (i.e., stairs)
- Thigh walker stability and weight

## Objective

Redesign the first-generation Thigh Walker to better meet the needs of medical teams as well as increase mobility and independence for children

## Existing Solutions

### Crutches



### Wheelchair



### Pediatric Walker



### Knee Scooter



### Thigh Walker (1st Gen)



**Acknowledgements:** Special thanks to DUCOM, Drexel's COE, DrExcel, our advisors: Technical and Engineering Faculty Mentor: Dr. Adrian Shieh, PhD; Teaching Professor Clinical and Medical Faculty Mentor: Dr. Pramath Nath, MD; Pediatric Emergency Medicine Physician

### References:

1. U.S. Consumer Product Safety Commission. 2022. NEISS Query: National Estimate of Injuries Treated in Emergency Departments by AGE, BDPT, YEAR. <https://www.cpsc.gov/glibin/neissquery/home.aspx>.
2. Heredia-Jimenez, J., & Robinson, M. A. (2019). A kinematic comparison of gait with a backpack versus a trolley for load carriage in children. *Applied Ergonomics*, 80, 28–34. <https://doi.org/10.1016/j.apergo.2019.05.003>
3. Rahman, R., Shannon, B. A., & Ficke, J. R. (2020). Knee scooter-related injuries: a survey of foot and ankle orthopedic surgeons. *Foot & Ankle Orthopaedics*, 5(1), 2473011420914561.
4. Wierenga, L., Langen, M., Ambrosino, S., van Dijk, S., Oranje, B., & Durston, S. (2014). Typical development of basal ganglia, hippocampus, amygdala and cerebellum from age 7 to 24. *NeuroImage*, 96, 67–72. <https://doi.org/10.1016/j.neuroimage.2014.03.072>

## Design Inputs

### Constraints

Cost



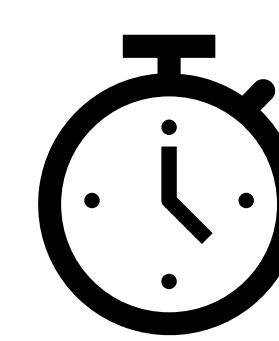
< \$200 Prototype  
< \$80 Production  
\$750 Budget

Weight



< 2 kg (4.4 lbs)

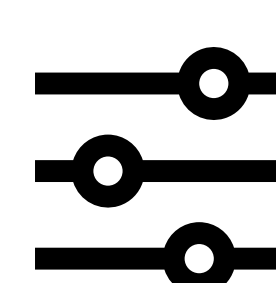
Time



37 Weeks

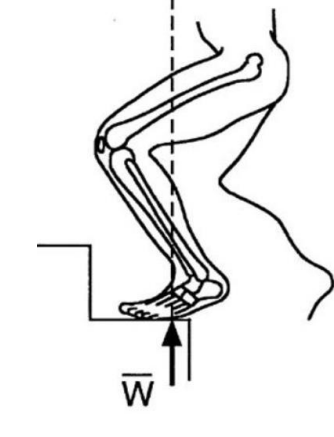
### Requirements

Adjustability



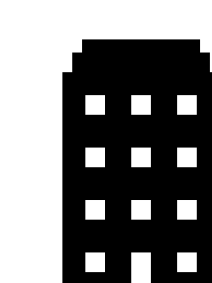
100.1 cm < H < 130.7 cm  
5-7 5-95<sup>th</sup> percentile 5-7-year-olds

Strength & Force



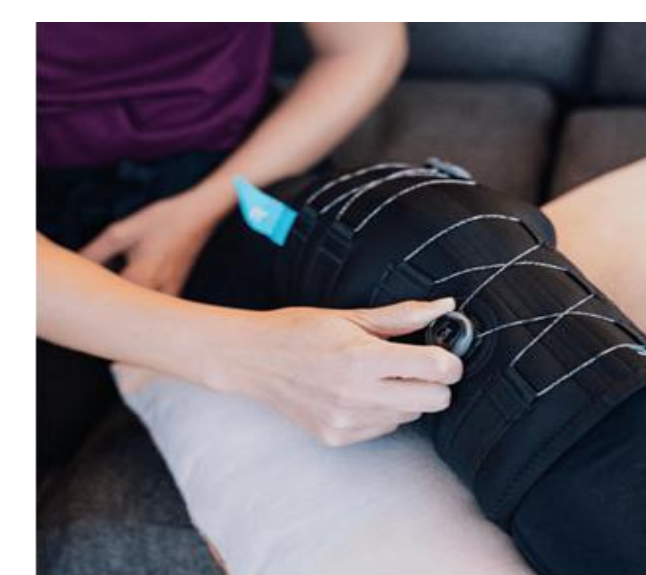
31 kg ≈ 1kN force  
5-95<sup>th</sup> percentile 7-year-old

Stability



Rotation < 10°  
Longitudinal < 15 mm

## Prototype



### Adjustable BOA Fit Thigh

### Calf Support on Aluminum Frame

- Limits leg swing
- Increase comfort
- Strap to secure leg



### Adjustable Knee Angle

- 15°-50° set by doctor
- Stainless steel



### Telescope Tubing

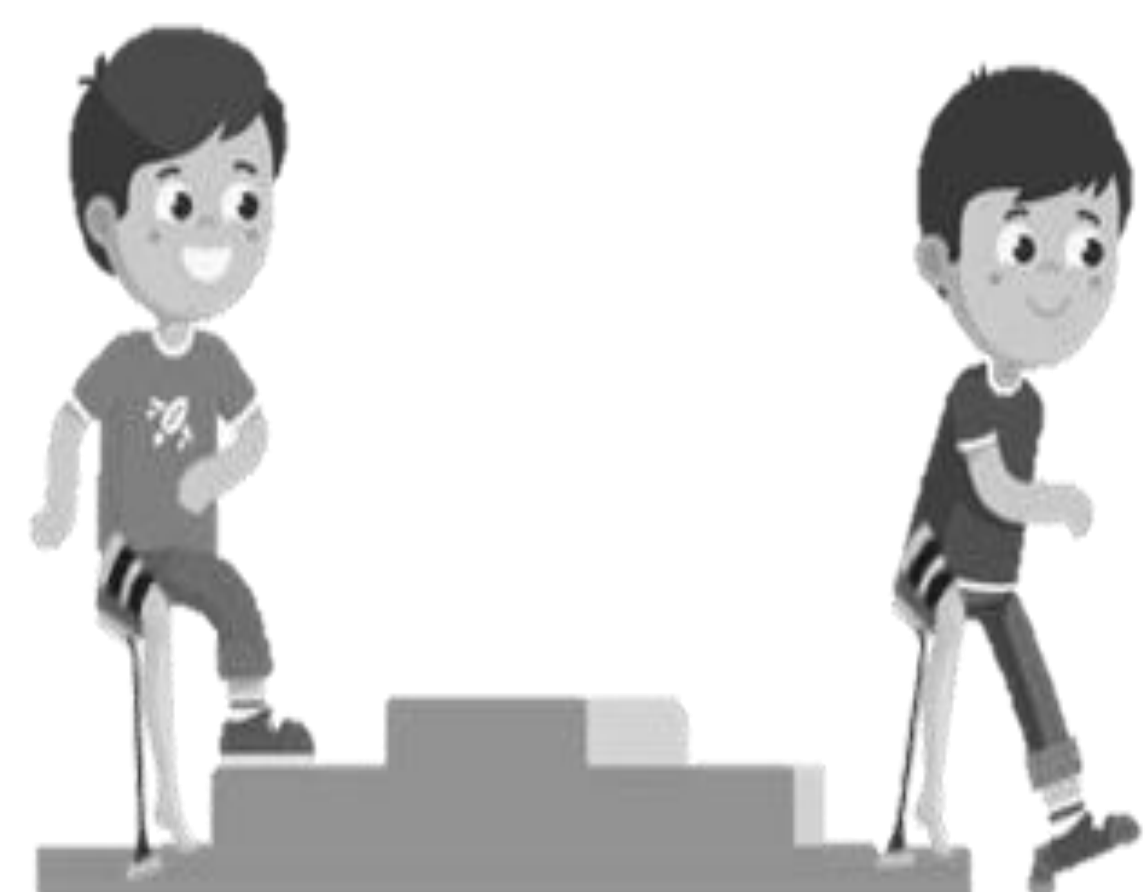
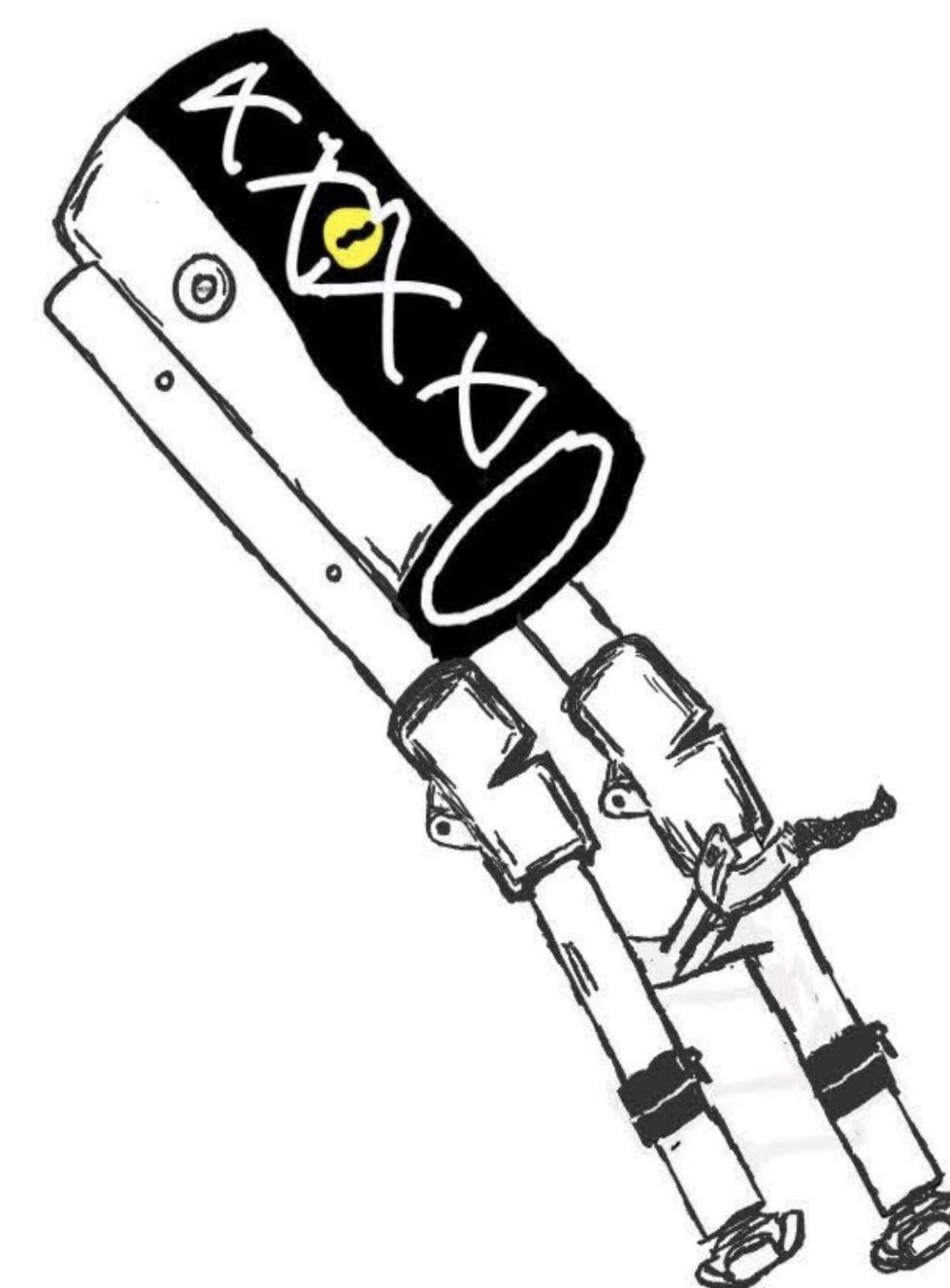
- Easy height Adjustability



### Rotational Cane Tip

- Mimics human ankle through flexion
- Reduces bending (0.5 lbs)

**Total Weight:** 2.2 kg  
(4.85 lbs)



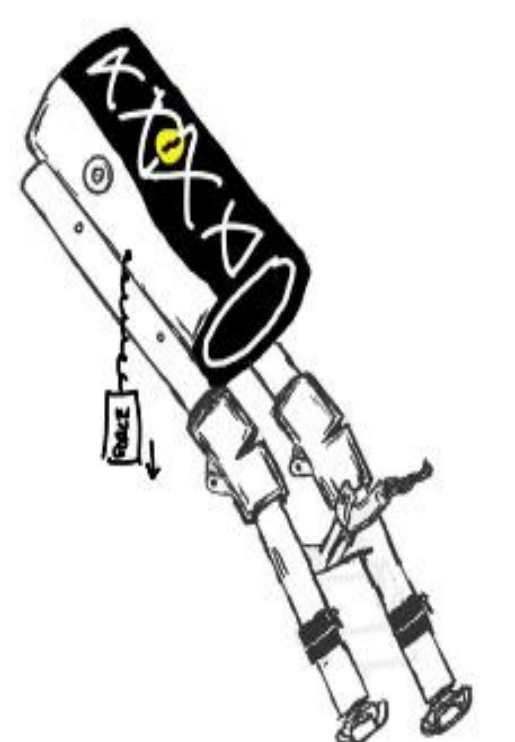
## Verification/Validation

### Engineering verification testing includes:

- Vertical load testing for maximal weight-bearing capacity (signs of structural deformation or stress under vertical force)
- Longitudinal and rotational slippage tests for thigh stability
- Sleeve displacement for slippage (under various clothing fabrics)

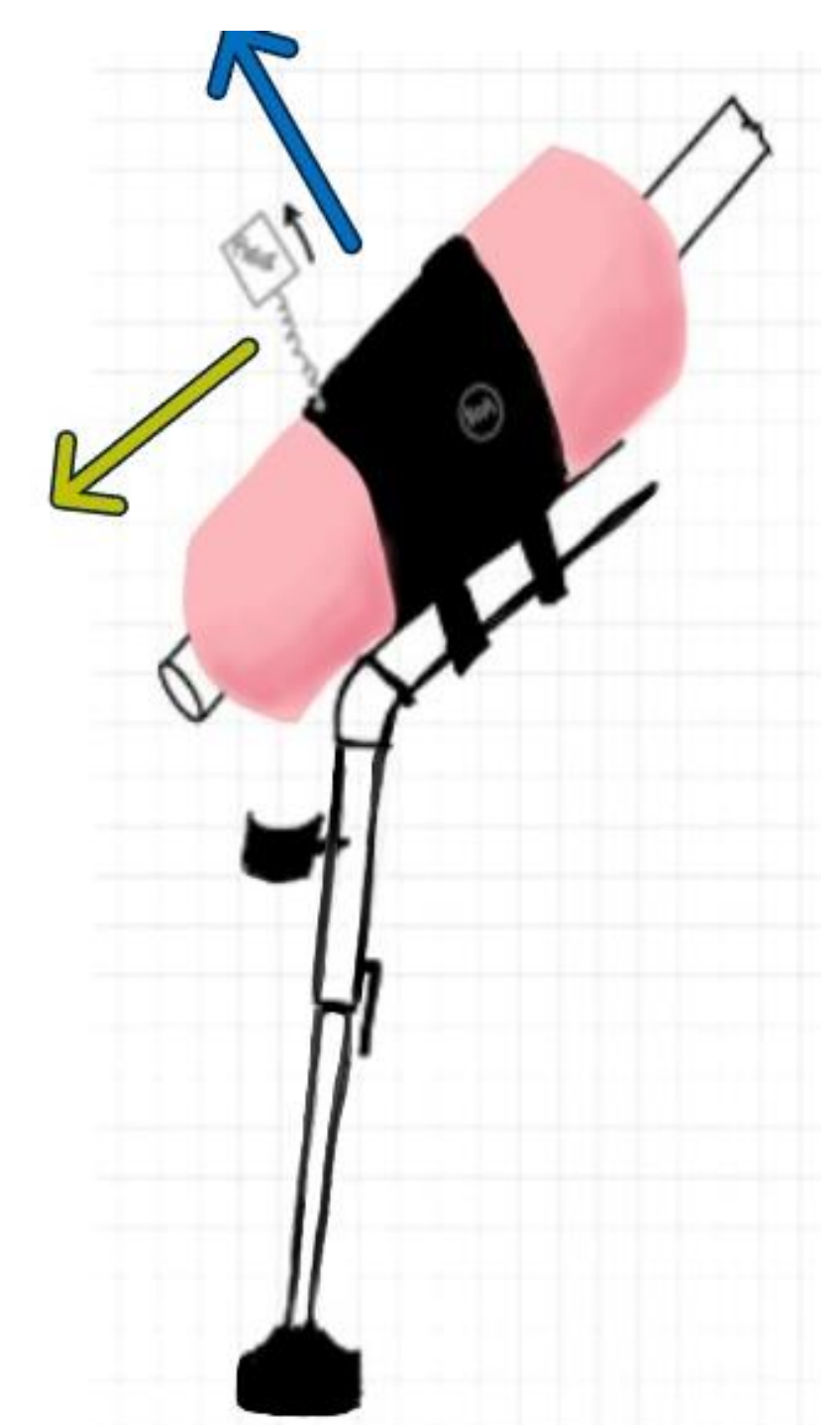
### Vertical Load Test

- Evaluate through hanging weight directly downwards from the PVC portion of the device.
- Fails when Plastic Deformation is detected



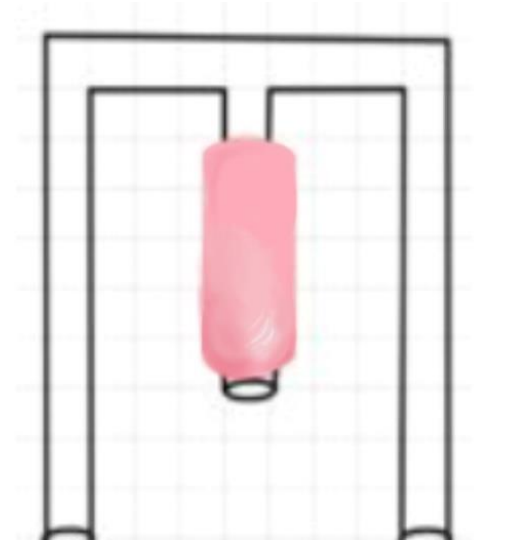
### Longitudinal & Rotational Slippage

- Evaluate and minimize slippage to enhance patient safety, optimize functional use, and ensure user comfort
- Longitudinal test (yellow) ends at a pull strength of **691N** or **15mm** of brace displacement at 15 degrees of knee flexion
- Rotational test (blue) ends at a rotation greater than **10 degrees** relative to ankle



### Market Research Analysis

- 30 healthcare professionals responded
- 100% reported ≥ 8/10 safety is highest priority
- 53% reported ≥ 8/10 increase ADLs
- 37% reported ≥ 8/10 in comfort
- 90% willing to pay < \$400



## Conclusion and Impact

Overall, the product integrated the clinical and developmental considerations of a mobility device specifically for pediatric patients with lower limb injuries.

2<sup>nd</sup> generation model improves comfort, adjustability, and mobility. Future directions include incorporating market analysis feedback, mobility testing, and refinements to deliver a safer, patient-centered assistive walking device.