

Problem Statement

Knee crutches are assistive devices used to help non-weight-bearing patients recovering from a lower limb injury move efficiently and comfortably. Current devices available target assistance with walking, but are not suitable for ascending or descending stairs. The improved knee crutch will provide ample stability and assistance for stair climbing without the additional use of crutches, to ensure the users can be independent in their homes. The goal is to create an improved version of an existing prototype that will provide users with sufficient mobility and stability when climbing stairs.

Motivation and Background

- Our client, Daniel Kutschera, needs a safer stair-climbing knee crutch for patients with lower-limb injuries.
- Patients currently struggle with stability and natural movement when using existing devices on stairs.
- Existing devices force awkward, unstable movements that increase strain and fall risk [1].
- A new knee crutch solution is needed to help patients regain independent stair-climbing ability [2].



Fig 1. Amputee patient using the client's current prototype

Design Criteria

- Performance/safety: device must be able to safely ascend ~10 steps at a time daily with a weight limit of 115 kg.
- Size/ergonomics: device must be able to fit comfortably on a standard stair, and be adjustable for patients between about 1.50-1.75 meters tall.
- Weight: device must weigh 2.25 kg or less.

Material Costs

Base Materials	\$105.20
Knee Rest Materials	\$116.61
Handle Materials	\$59.48
Total Cost:	\$281.11

This total cost is well under the client's budget of \$500.

Final Design



Fig 2. Final Knee Crutch Prototype, shown with the 5cm adjustability block

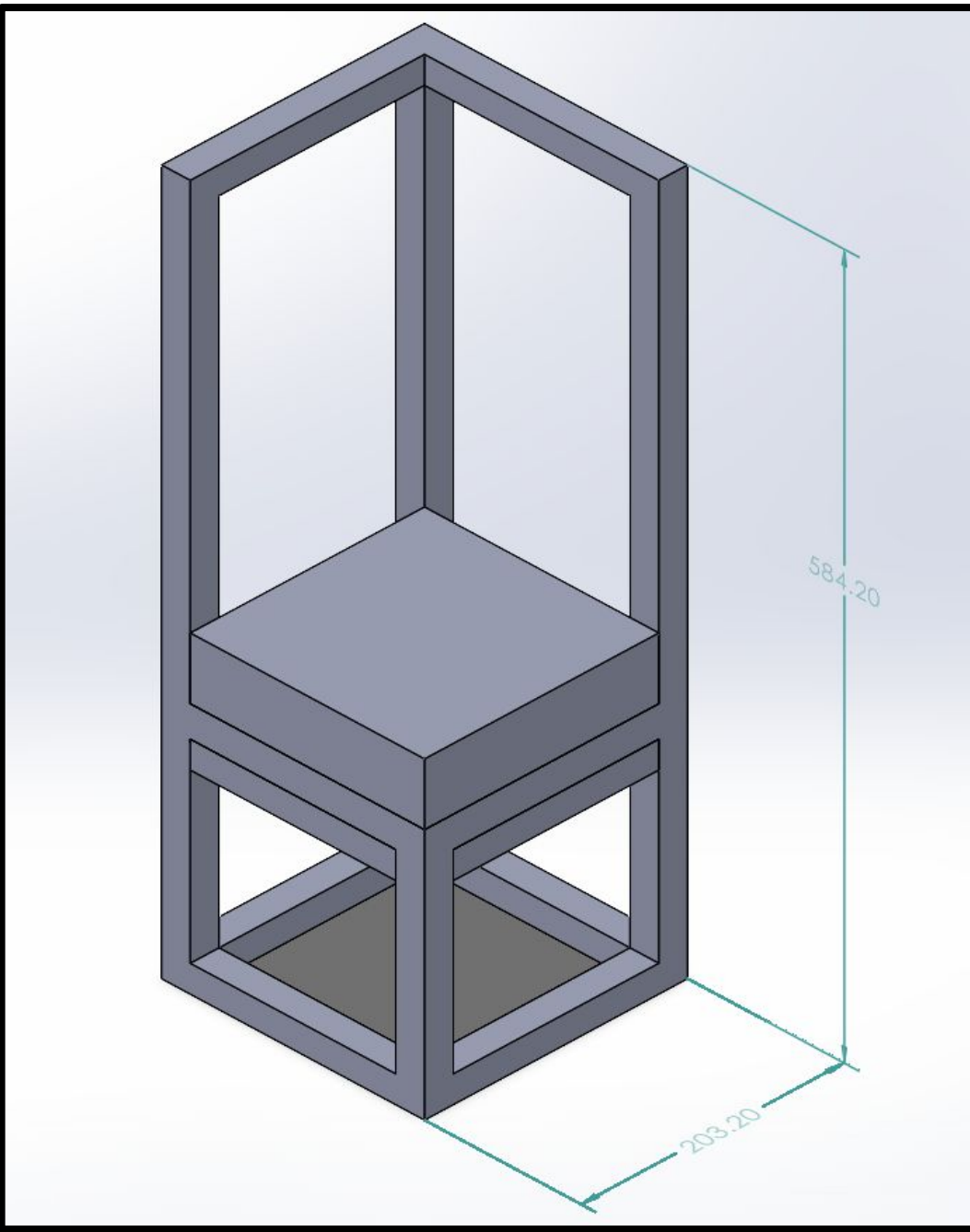


Fig 3. SolidWorks drawing of final design with dimensions in mm



Fig 4. Team member shown using the final knee crutch prototype

Testing and Results

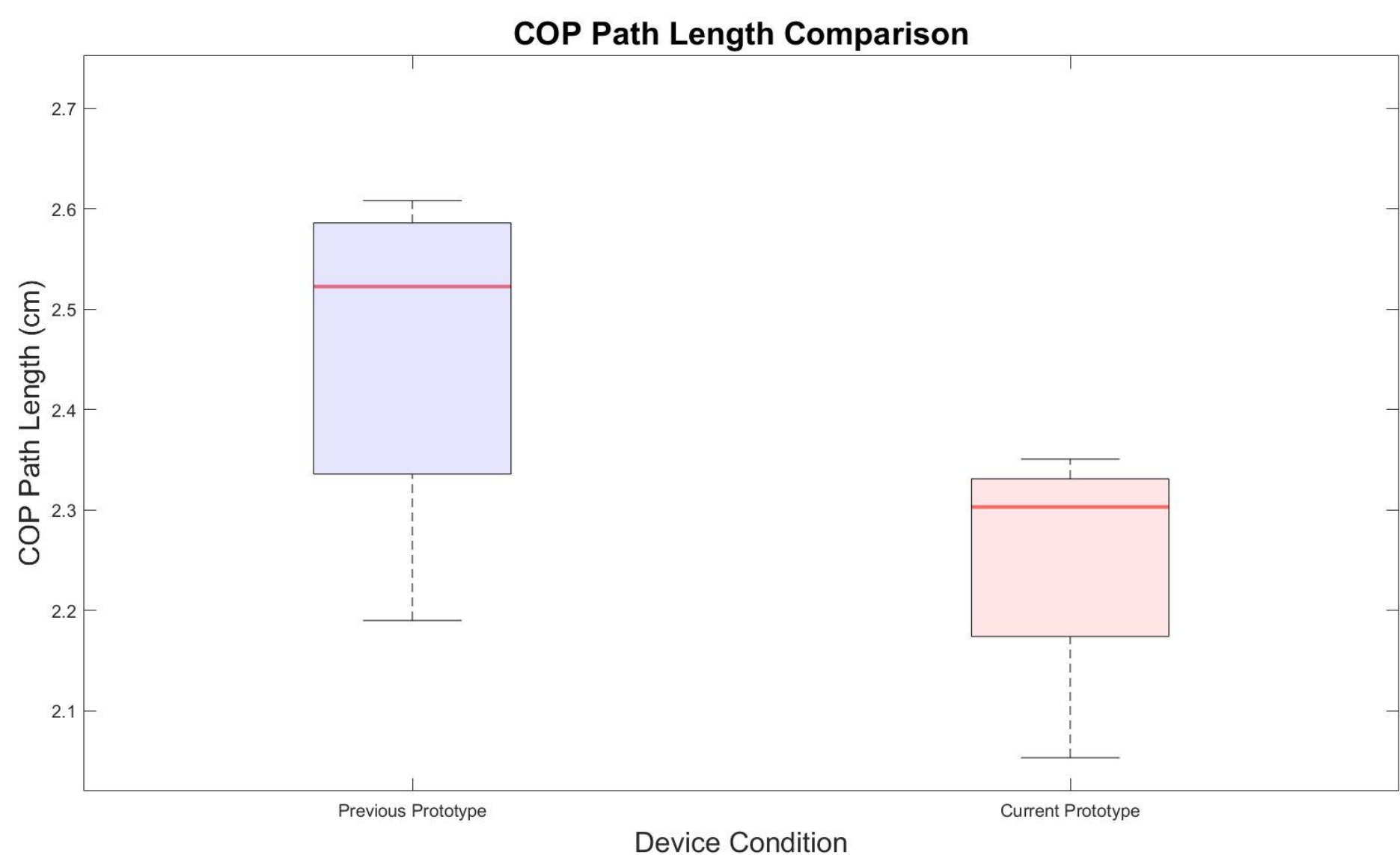


Fig 5. Comparison of path lengths for the current and previous knee crutch prototypes in a static stance

- Dynamic force plate testing:
 - Users stepped up onto a cinder block with previous and current knee crutch prototypes.
- Paired sample T-test:
 - $p = 0.0031 < 0.05$

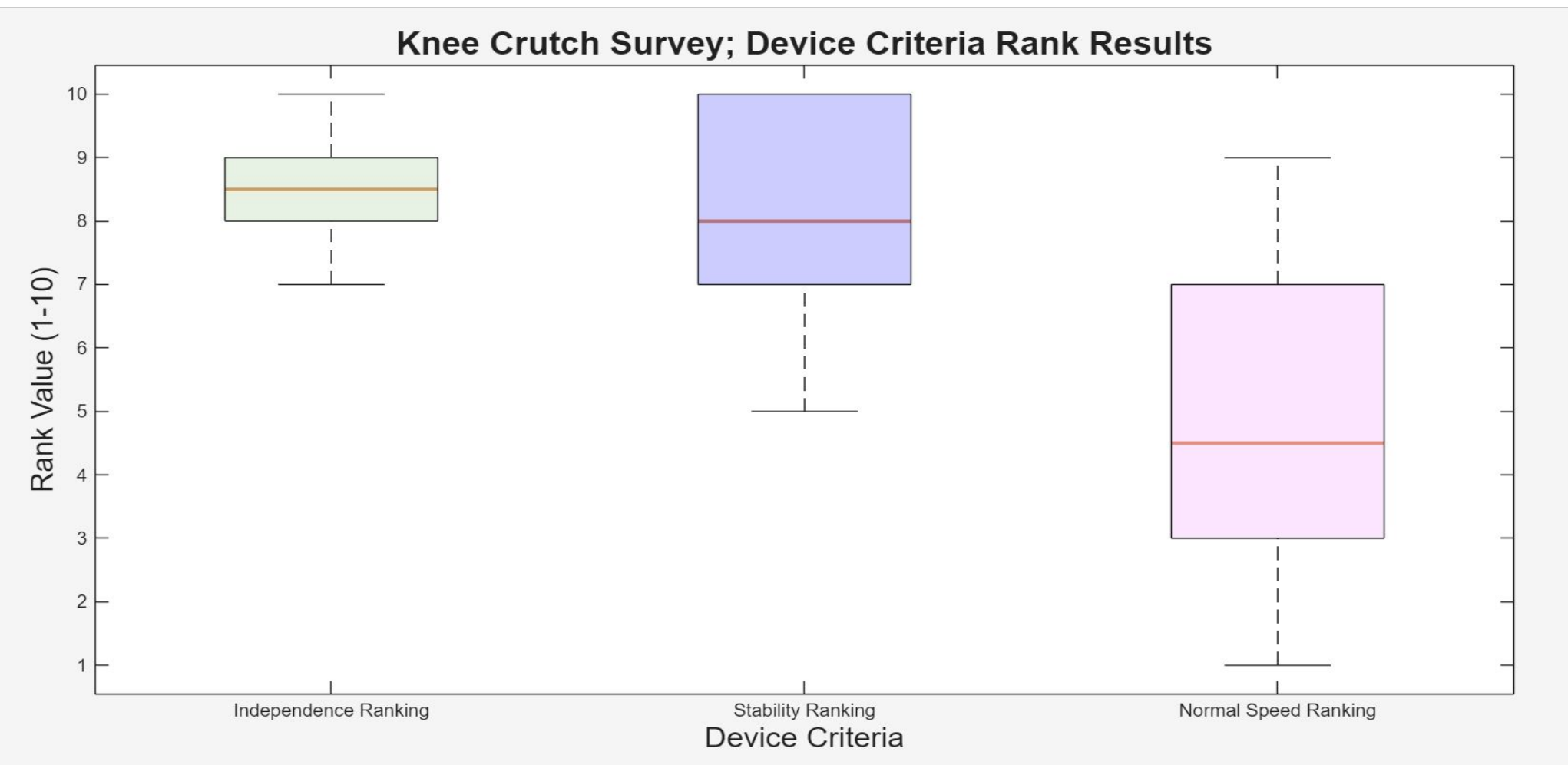


Fig 7. Box Plots comparing the ranks of the following device criteria; independence, stability, and normal speed.

- Static force plate testing:
 - Users balanced on current and previous knee crutch prototype for 20 seconds.
 - Paired sample T-test:
 - $p = 0.0188 < 0.05$
 - $t = 4.65$

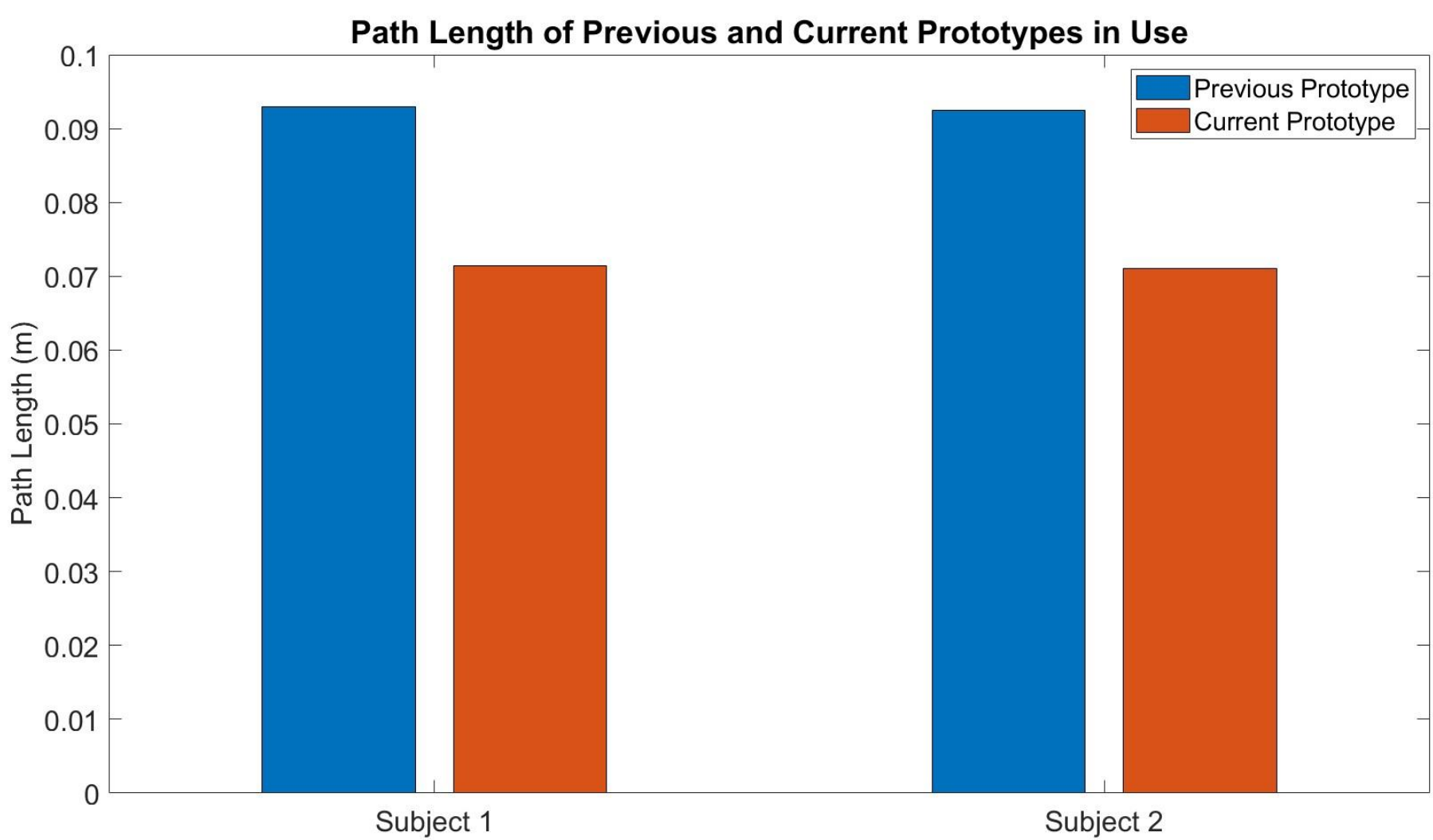


Fig 6. Path lengths with current and previous prototypes in use

- Survey Testing:
 - Random participants were asked to use knee crutch and complete survey.
 - The highest mean rank was 8.64, for being able to navigate the device independently.

Discussion

- The prototype utilizes an extruded aluminum base, an adjustable knee rest, and a removable cushion to create an assistive device for climbing stairs for patients with a lower limb injury.
- The initial three-sided armrest design increased the difficulty of use. To accommodate left and right limb injuries the design now only includes two arm rests.
- Preliminary feedback received on the prototype highlighted the instability of a four peg base. In response, the base was changed to a square base.
- During testing, users commented on the increased stability and recommended implementing a label system to make the device more intuitive.

Future Work

- Conduct additional testing with larger sample size and more accurate target age demographic.
- Conduct weight bearing capacity testing to provide users with a determined weight limit.
- Improve cushion casing for cleaner look.
- Source more flat head screws that are compatible with each height block.
- Optimize weight of knee crutch with materials/design changes.
 - Current prototype weighs 2.72 kg

Acknowledgements

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References

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