



Dynamic Balance Device

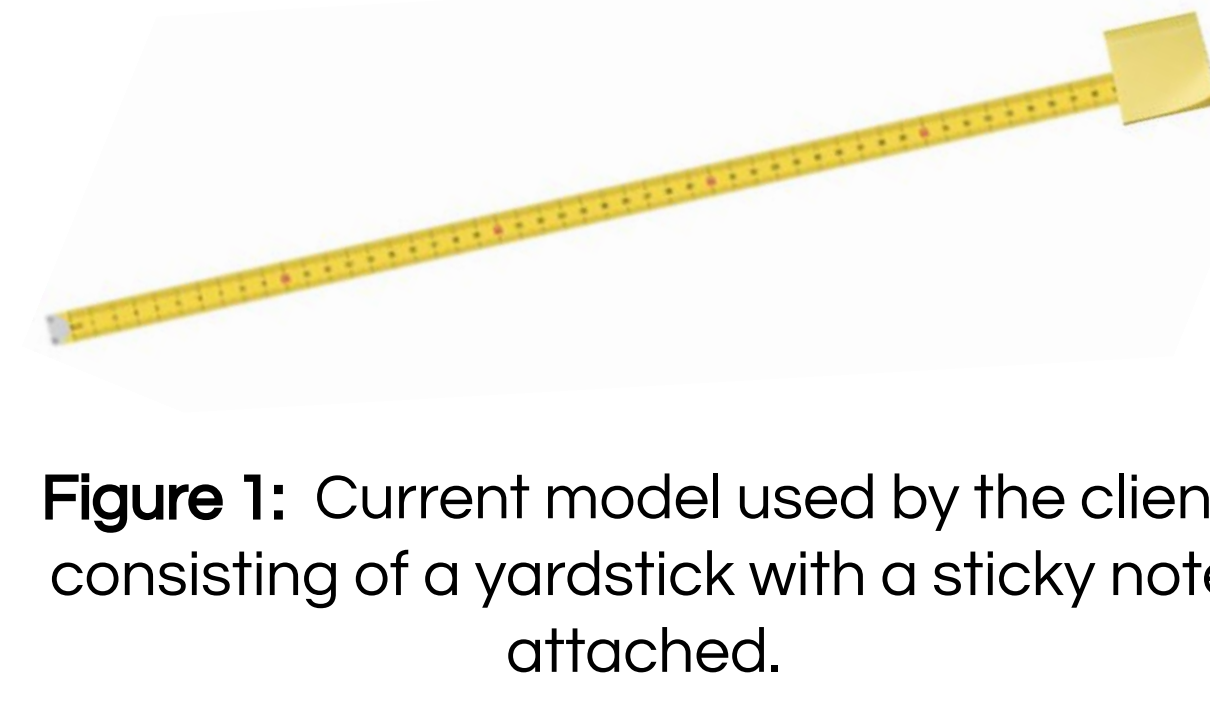
BME 301 Spring 2026

Katherine Sattel, Therese Kalt, Noor Awad, Freyja Heggeland
Client: Mr. Daniel Kutschera Advisor: Professor Monica Ohnsorg



Problem Statement

- Physical therapists rehabilitating stroke patients use devices to improve visual scanning and balance training [1]
- Current devices are either rudimentary, such as a yardstick with a sticky note at the end, bulky, or unaffordable



Motivation

- ~75% of physical therapists experience work-related musculoskeletal disorders during their career [2]
- Complex devices typically cost between \$12,000-\$22,000 [3]
- The length of physical therapy devices can make them feel heavier and cause fatigue more quickly, even when the actual weight of the device is relatively low
- Previous BME design teams have created lightweight devices, however, they often lack durability and are still perceived as heavy

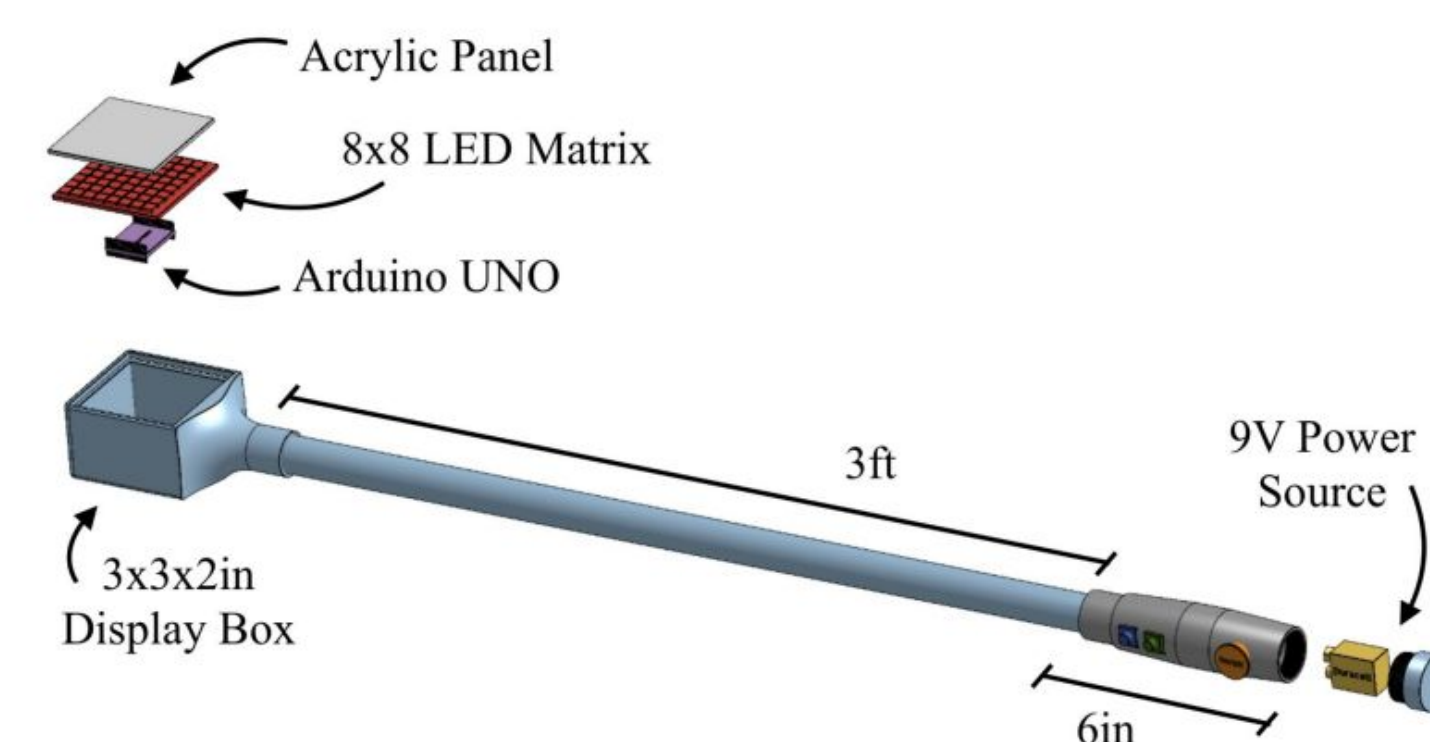


Figure 2: Previous design from Fall 2024 BME design team [4].

Background

- ~30% of patients who have suffered from stroke experience Spatial Neglect Syndrome or lose vestibular sense, leading to falls that set back their recoveries [5]
- Spatial neglect is most commonly caused from hemispheric stroke and results in impaired spatial attention [6]
- Visuomotor training involves asking the patient to reach toward an object to help their brain better interpret depth perception and spatial relationships [7]



Figure 3: Visuomotor training [8].

Design Criteria

- Lighter than previous model, which weighed 0.36 kg
- 7.5 cm x 7.5 cm display that displays red and blue
- 24 inch measurement system on the shaft of the device
- Multi-mode capabilities
- Sensor that provides feedback to the patient when they complete Functional Reach Test
- Budget: \$500

Final Design

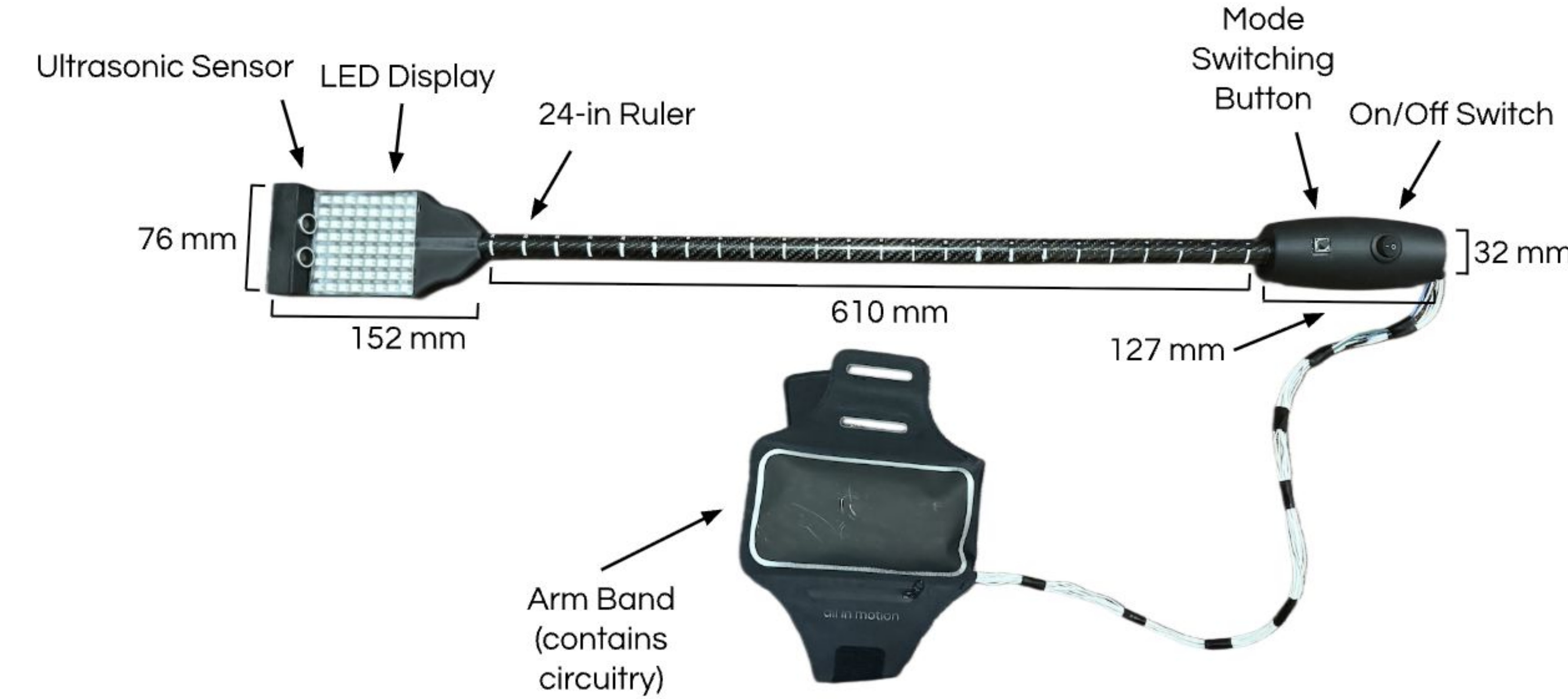


Figure 4: Picture of entire final design with arrows pointing to and describing key components

Design Explanation:

- Final weight: **0.294 kg**
- Lightweight carbon fiber
- Permanent circuitry housed in arm band
- 3 functional modes controlled by 1 button
 - Red/Blue
 - Random
 - Functional Reach

MTS Testing and Results

MTS Testing:

- 3-point bending set-up
- Ensures that the design does not bend under its weight
- Proof of durability and strength improvements when compared to previous aluminum design



Figure 11: Carbon fiber rod during 3-point bending MTS testing

Key Values:

- Average elastic modulus: 105.667 MPa
- Maximum stress before plastic deformation: 15.776 MPa
- Maximum deflection before plastic deformation: 2.88 mm

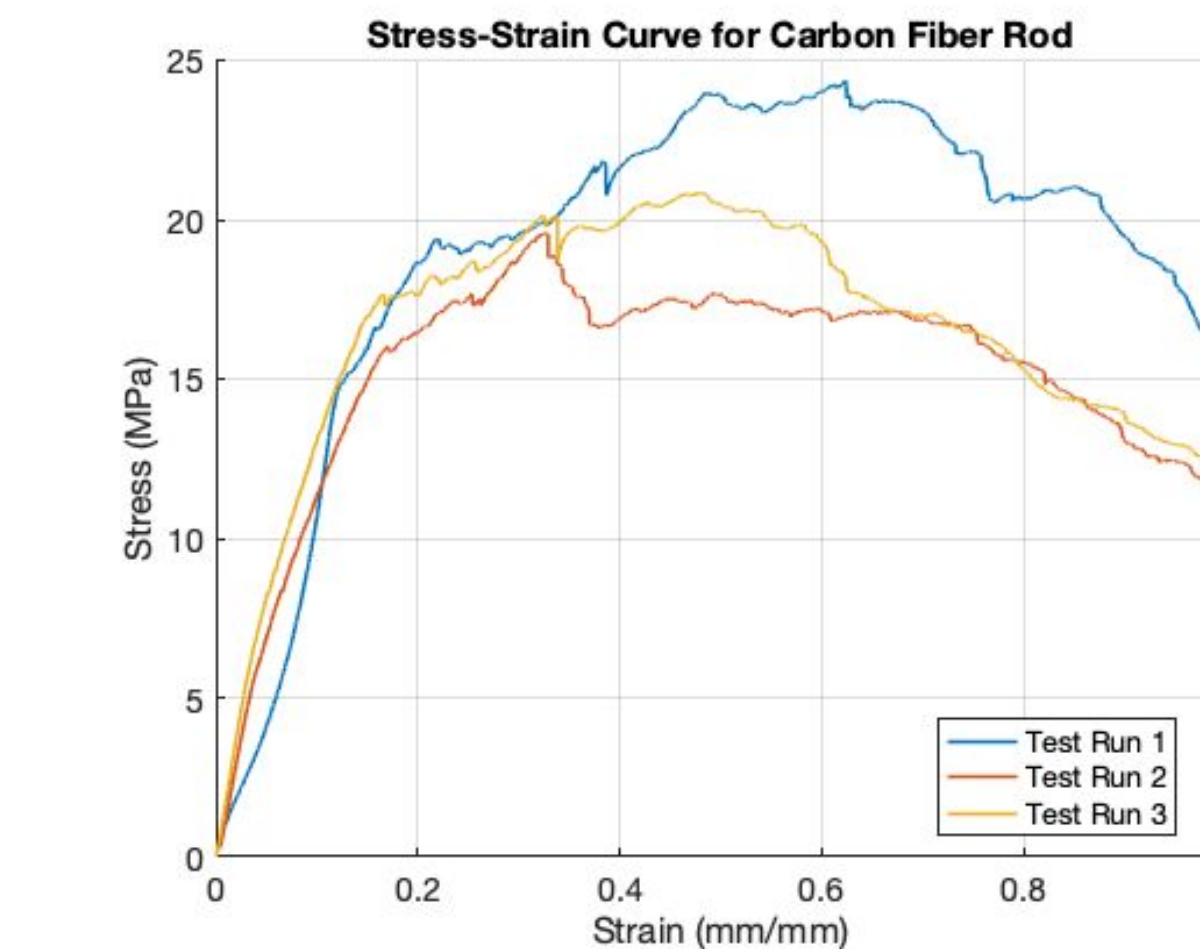


Figure 12: Experimental Stress-Strain Curve of Carbon Fiber

Fatigue Testing and Results

Fatigue Testing:

- Survey to collect qualitative data compared to control prototype
- Quantified data based on difficulty (5-point scale)
- Tested prototype during two typical modes of operation, static and dynamic



Figures 5, 6: Experimental set-up for fatigue testing

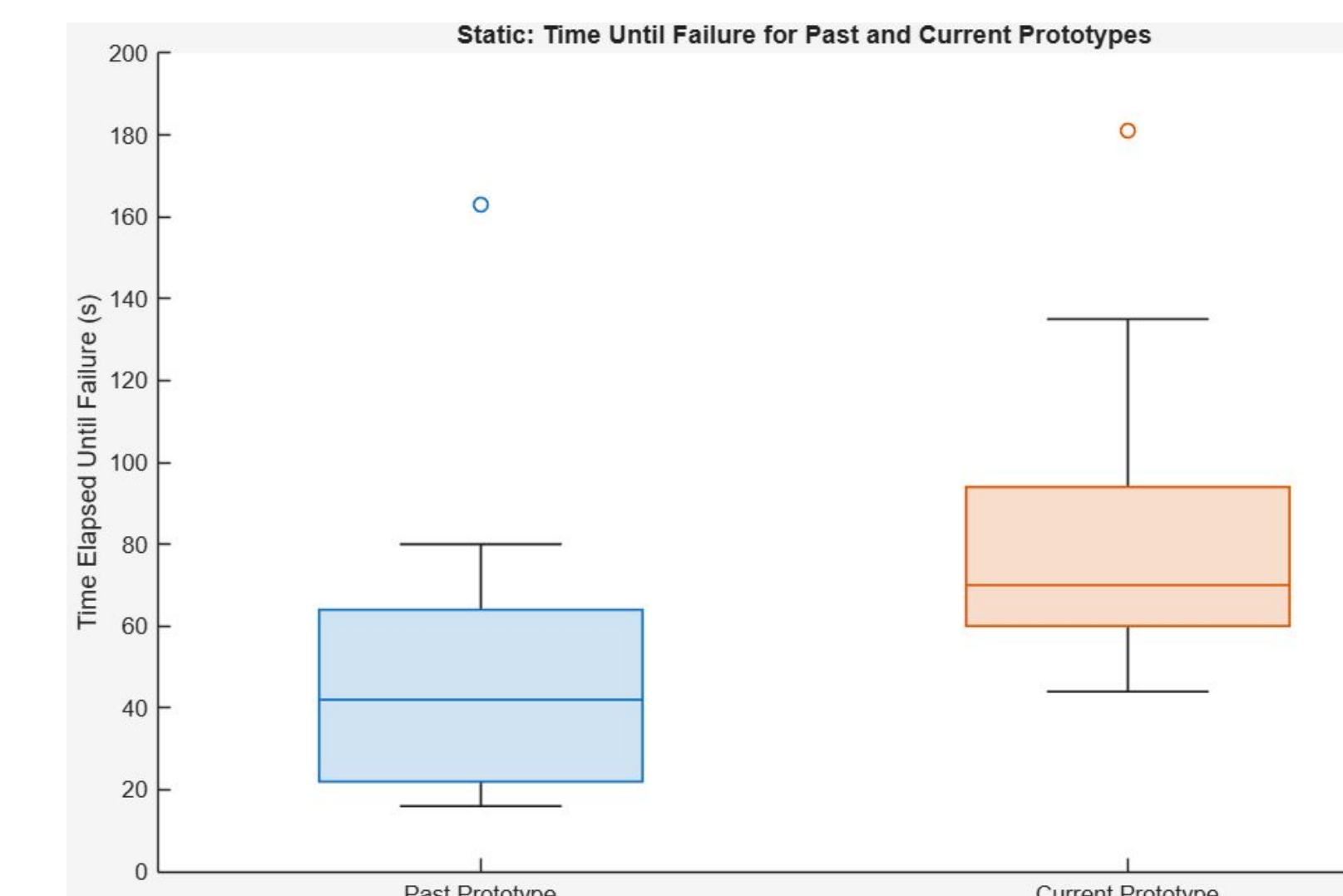


Figure 7: Box and whisker plot of static time until failure

Key Values:

- n = 14
- Static P-Value: $8.25e^{-6}$
- Dynamic P-Value: $4.69e^{-6}$

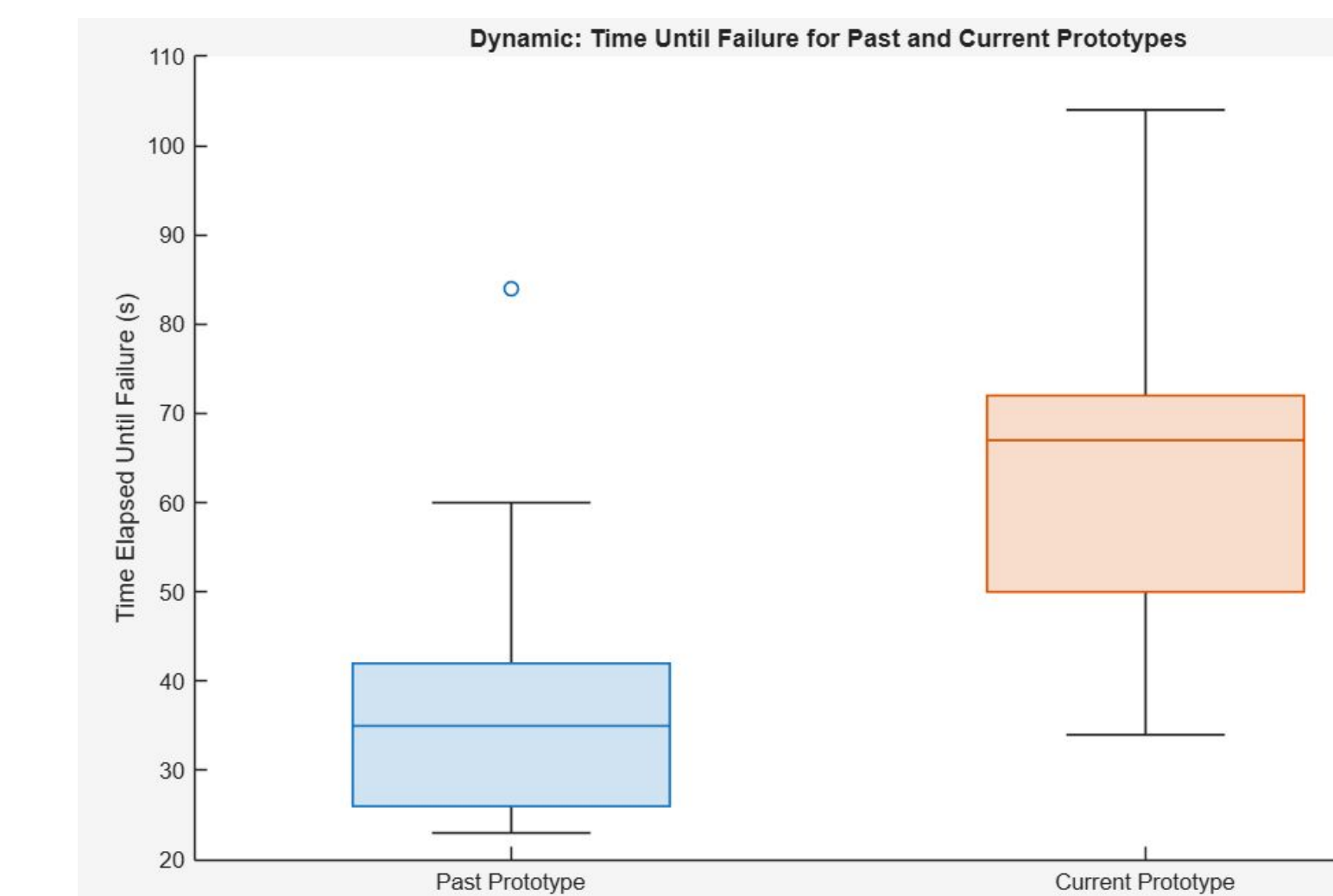


Figure 8: Box and whisker plot of dynamic time until failure

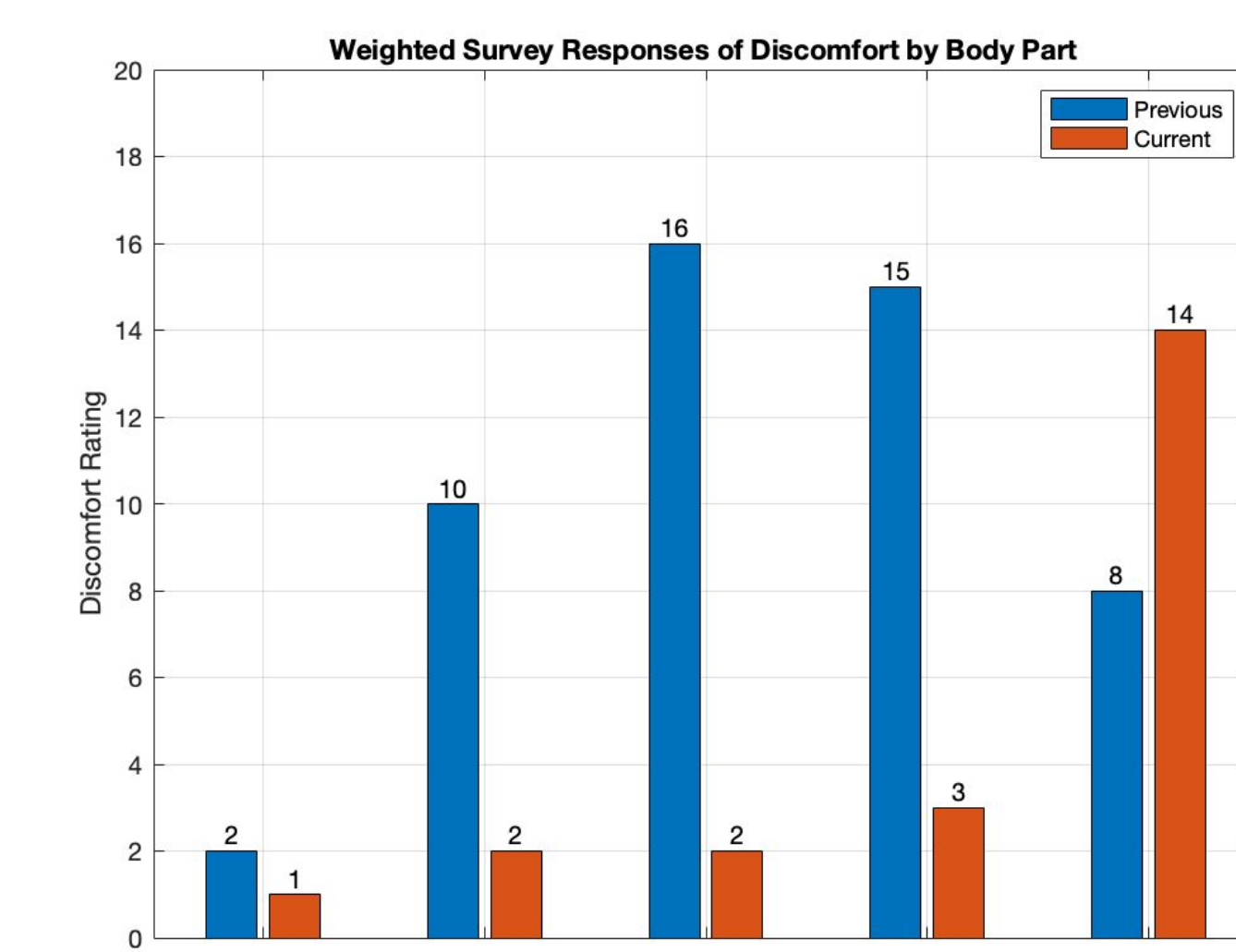


Figure 9: Bar graph showing weighted sums of discomfort ratings

Key Values:

- Discomfort P-values:
 - Static: 0.0010
 - Dynamic: 0.0031

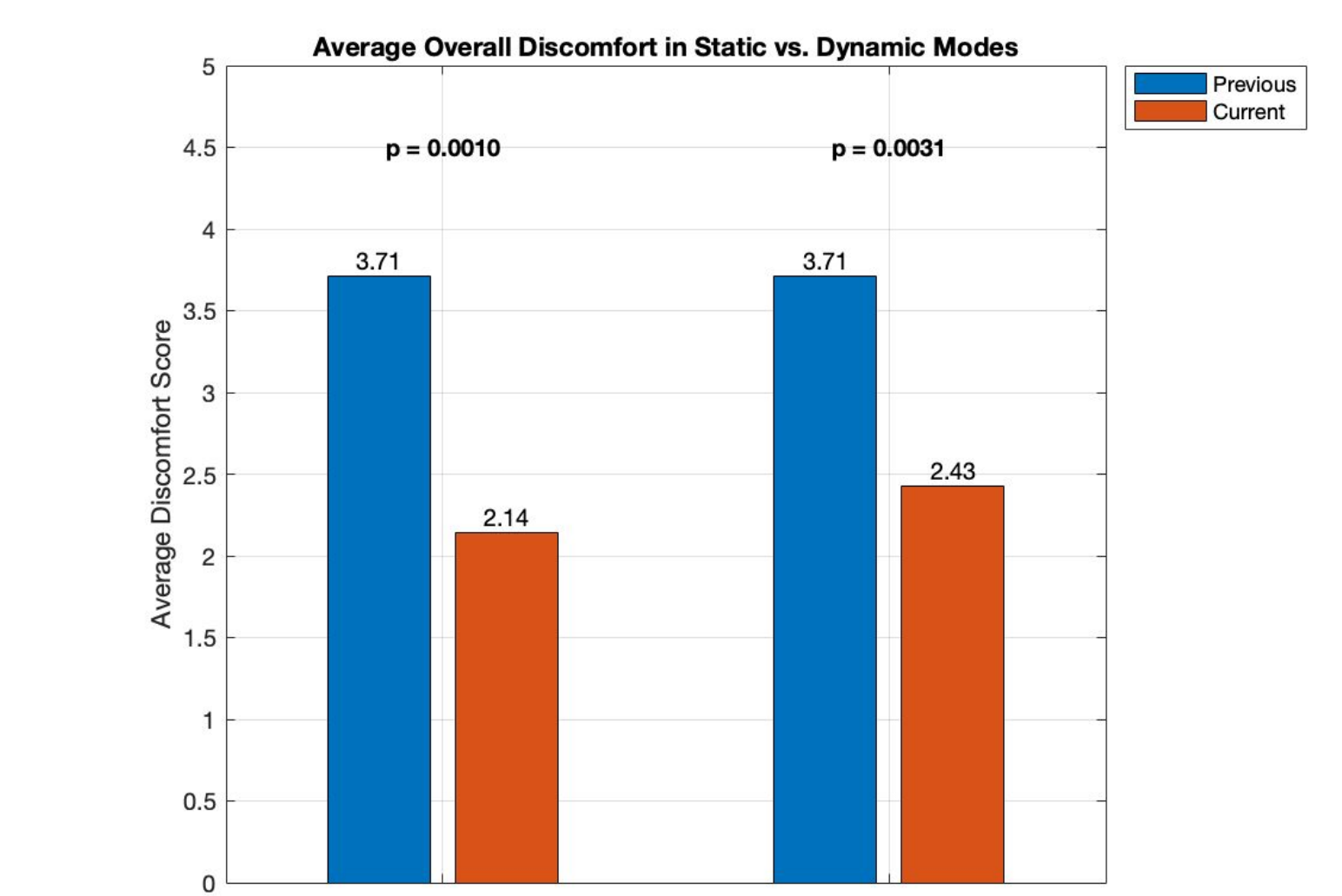


Figure 10: Bar graph comparing average overall discomfort across prototypes

Discussion

- Test subjects used prototypes sequentially
- Significant decrease in wrist discomfort with current prototype
- Carbon fiber significantly stronger than expected force during clinical use
- Compatibility of passive speaker with high power LED display
- Capacitive vs. Ultrasonic sensor

Future Work

- Add audio feedback using digital speaker to customize noise
- Redesign handle to be more ergonomic
- Create housing for circuitry within arm band
- Add another counterweight system behind the handle
- Rechargeable battery integration
- Implementation of a remote control to add more functional modes

Acknowledgments

- Mr. Dan Kutschera
- Professor Monica Ohnsorg
- Sam Kahr
- Dr. John Puccinelli
- Dr. Tracy Puccinelli
- Biomedical Engineering Department
- UW Design and Innovation Labs + Staff

References

[1] Y. Wang, L. Huang, Z. Weng, and T. Liu, "Visuomotor Training to Enhance Proprioception of Contralateral Wrist Based on the Cross-Transfer Effect," *CNS Neuroscience & Therapeutics*, vol. 31, no. 9, Sep. 2025, doi: <https://doi.org/10.1111/ctns.70504>.

[2] T. Mahmood, W. Afzal, W. Mahmood, U. Moqsood, and A. Sumiya, "Frequency of work-related musculoskeletal disorders among physical therapists: a systematic review," *Revista Brasileira de Medicina do Trabalho*, vol. 23, no. 03, pp. 01-10, 2025, doi: <https://doi.org/10.47826/1679-4435-2025-1481>.

[3] "Biomechanical Therapy System Cost - Cost Digest," *CostDigest.org*, Dec. 22, 2025, <https://costdigest.org/biomechanical-therapy-system-cost/> (accessed Feb. 22, 2026).

[4] G. Ceccon, G. Haeffler, J. Zembick, K. Komra, "Dynamic Balance Device," *BME Design Fall 2024*, https://bmedesign.engr.wisc.edu/projects/f24/dynamic_balance.

[5] K. Li and P. A. Mathiassen, "Spatial Neglect," *Practical Neurology*, vol. 15, no. 5, pp. 333-339, May 2015, doi: <https://doi.org/10.1136/practneurol-2015-001115>.

[6] Y. Wang, L. Huang, Z. Weng, and T. Liu, "Visuomotor Training to Enhance Proprioception of Contralateral Wrist Based on the Cross-Transfer Effect," *CNS Neuroscience & Therapeutics*, vol. 31, no. 9, Sep. 2025, doi: <https://doi.org/10.1111/ctns.70504>.

[7] "Motion Works Physiotherapy & Sports Injury Centre," *Mwphysiotherapy.com*, 2025, <https://www.mwphysiotherapy.com/site/blog/2025/01/14/dizziness-vs-vertigo-treatment-for-vestibular-disorders> (accessed Feb. 20, 2026).