



JOHNSON HEALTH TECH: ADAPTIVE INDOOR ROWER FOR WHEELCHAIR USERS



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ABSTRACT

Exercise is essential to maintaining a healthy lifestyle. However, a majority of exercise machines at fitness centers are not accessible to individuals with disabilities or injuries that require a wheelchair. For example, standard rowers are not accessible to individuals in wheelchairs, and thus require external modifications to extend their functionality. In order to increase the accessibility of the standard rowing machine, an additional pulley was attached to the rower on the opposite side of the standard rowing side via mirroring support plates, and a cut was made in the rower neck to allow for the user to transition the rope and handle to the adaptive side. A wooden frame attached the wheelchair to the rower frame in order to stabilize the user and wheelchair during rowing. Testing of the pulley support plates and wooden frame revealed that all added components can withstand typical loads experienced during rowing while properly stabilizing the user, and showed that users can still achieve varying workout intensities from the adapted side.

BACKGROUND & MOTIVATION

Background:

- Rowing exercise targets shoulder, back, and oblique muscle groups [1]

Motivation:

- 5.5 million wheelchair users in the U.S [2]
- Consistent upper body exercise can alleviate shoulder pain, which is common amongst wheelchair users [3]
- Lack of adaptations for rowing machines on the market
- Existing devices permanently change functionality of the rower (AROW) [4]
- Increase exercise options for wheelchair users



Figure 1. AROW Rowing Machine [4]

PROBLEM STATEMENT

The majority of exercise machines are not designed for wheelchair use, and thus exercise options for wheelchair users are limited. To solve this issue, modifications will be made to a standard Matrix Rower [5] to accommodate wheelchair users. The Adaptive Rower design will secure the wheelchair to the rower to increase user stability / safety, and easily convert between standard and adaptive states to increase accessibility. This unique design will directly address the lack of exercise equipment available for wheelchair users and help to improve their wellbeing through exercise.

DESIGN CRITERIA

Criteria:	Specification:
User Stability / Safety	User is stabilized; pulley mechanism withstands maximum 1050 N force [6]; zero tipping / displacement
Ease of Fabrication	Easy to fabricate; all materials available to order / build
Ease of Use / Ergonomics	Easily accessible to individuals in wheelchairs; limited external assistance required
Versatility	Easily convertible from standard to adapted mode
Durability	10 year lifespan / 8 million meters [7]
Cost	Budget of \$200 for development

FINAL DESIGN

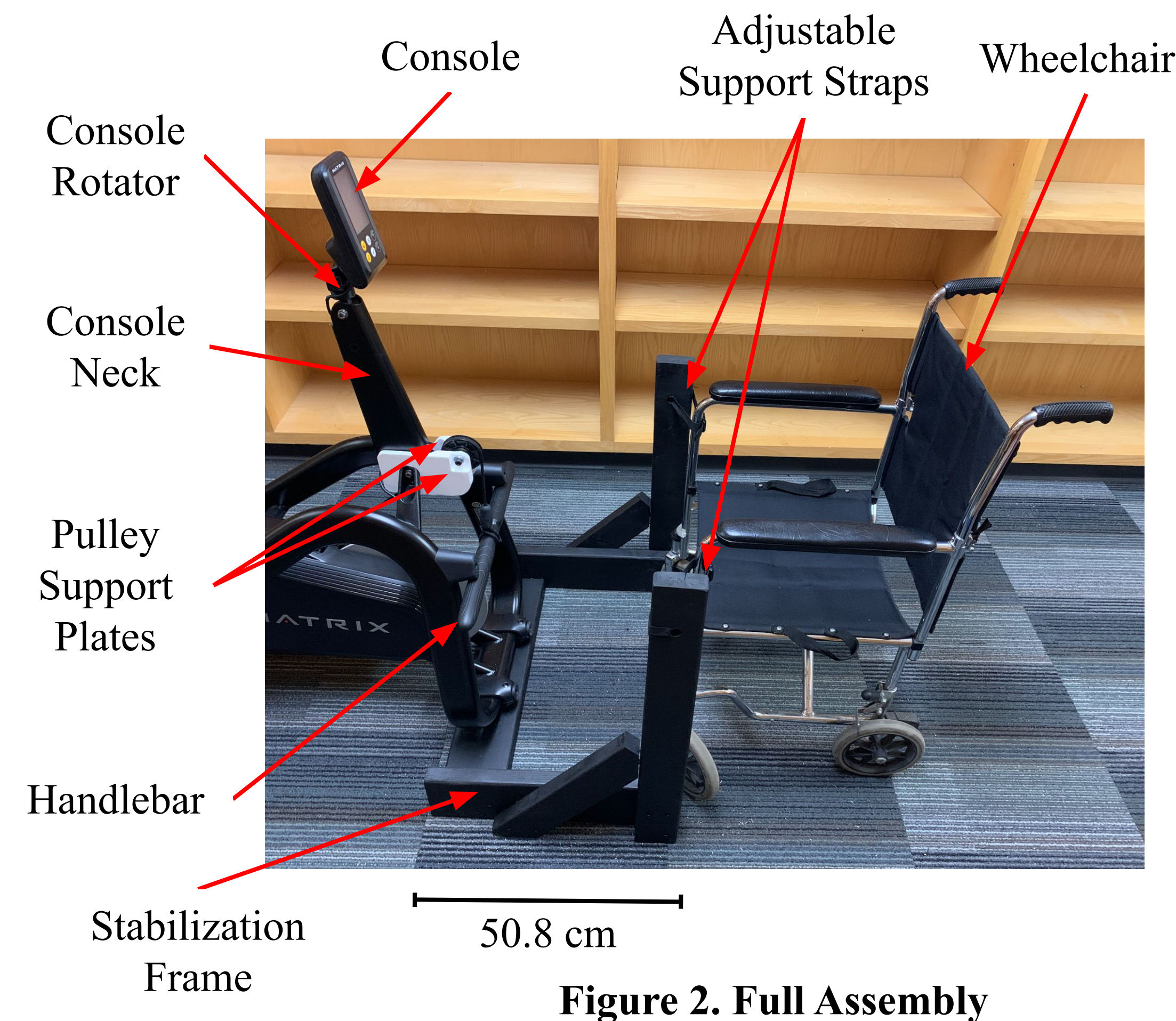


Figure 2. Full Assembly



Figure 3. Pulley Support Plates and Slit Cut

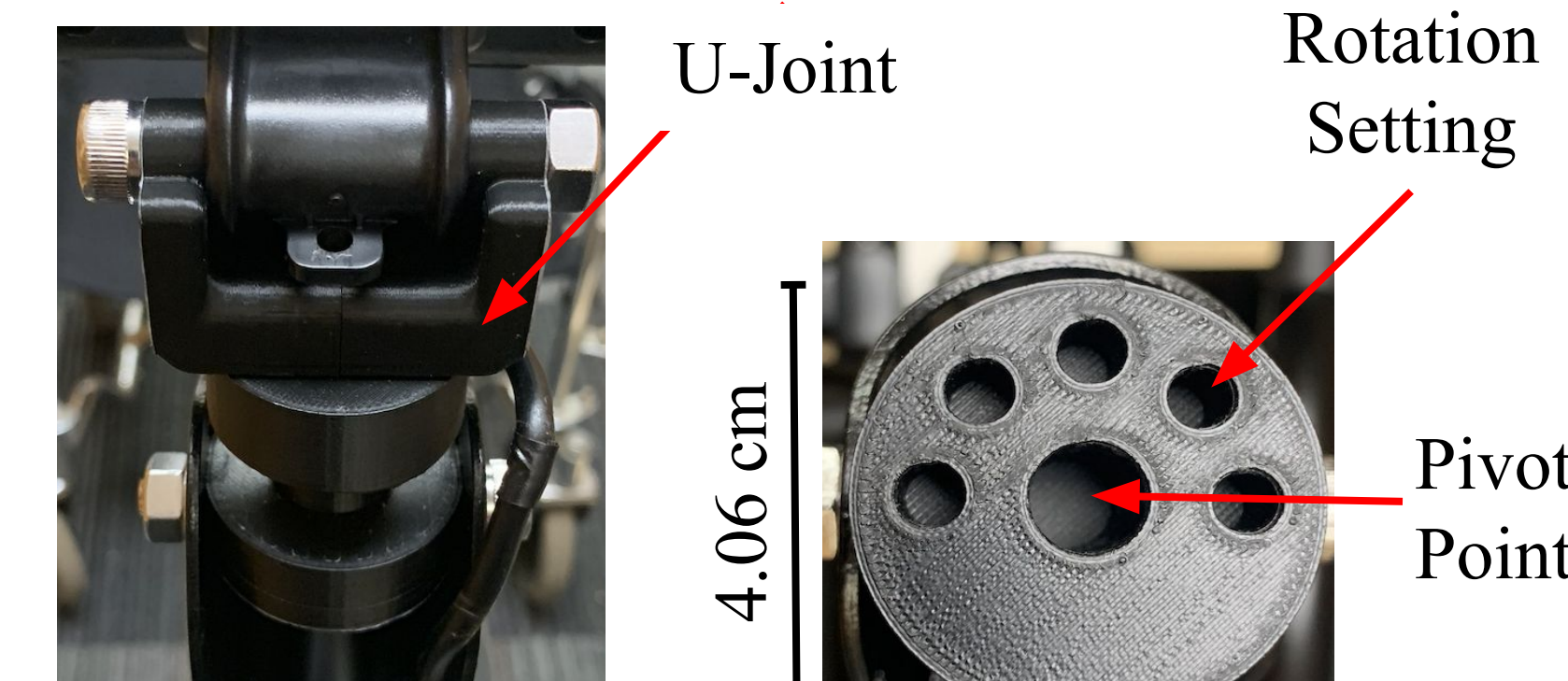


Figure 4. Console Rotation U-Joint

Figure 5. Console Rotation Base

TESTING & RESULTS

Pulley Support Plates Solidworks Simulation (fig 6):

- Held fixed at large cavity to mimic actual loading
- 1050 N load applied with safety factor of 2
- Max Displacement: 1.076 mm
- Max Stress: 18.84 MPa < Yield Stress: 37 MPa

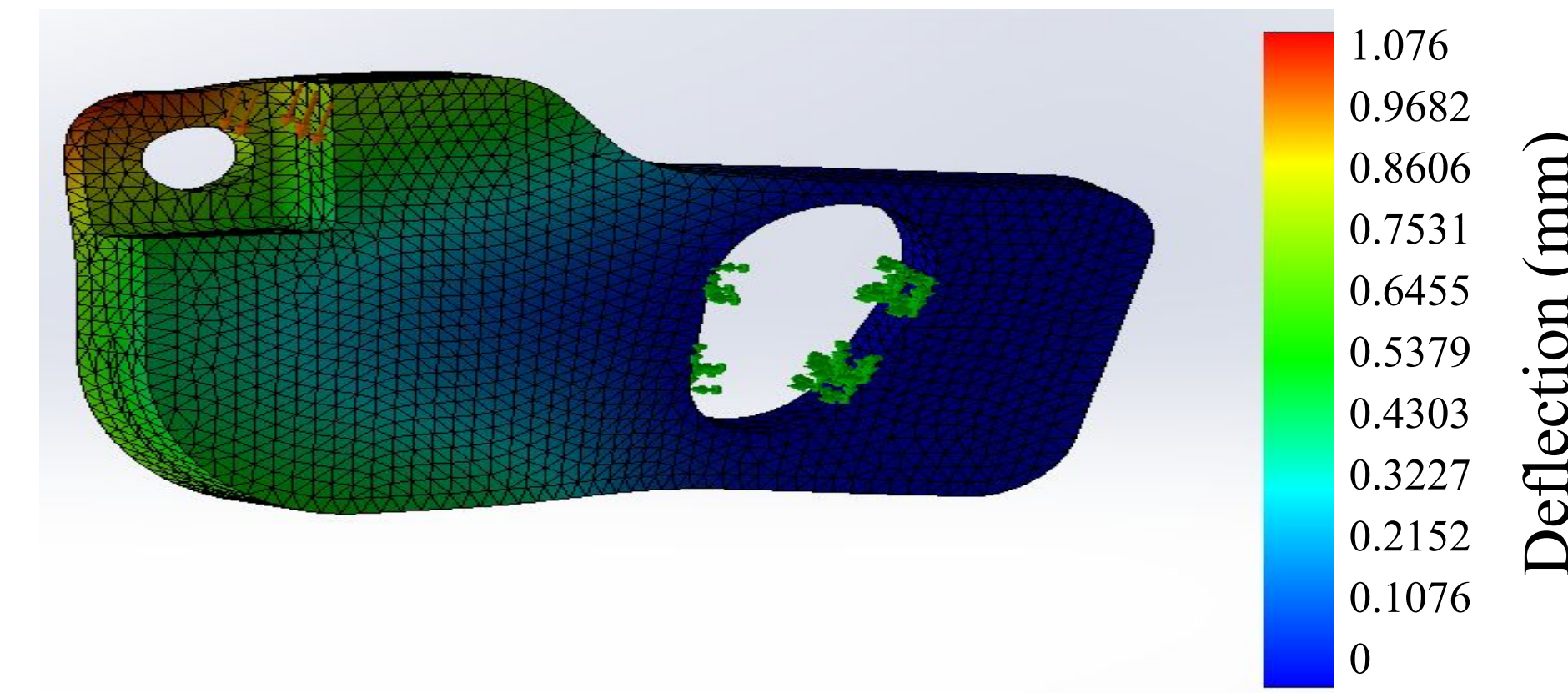


Figure 6. Solidworks Simulation Testing

Force Generated During Rowing

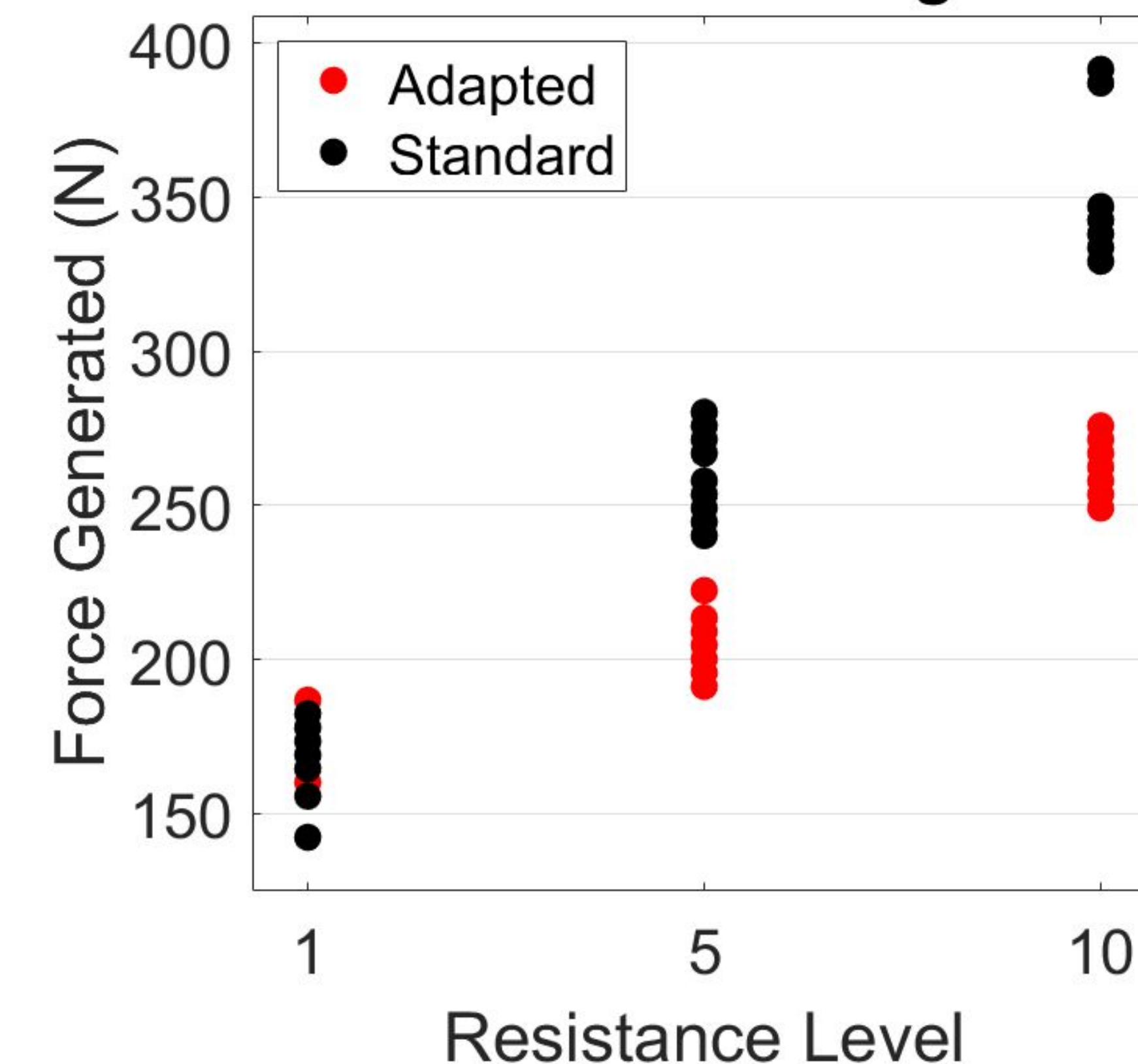


Figure 7. Rope Tension vs. Resistance

Rope Tension (fig 7):

- 45 kg (100 lb) spring gauge used to measure tension between adapted and standard side
- 10 rowing trials for 3 resistance levels: 1, 5, 10
- Paired Sample T-Test showed significant difference in force for resistances 5 and 10

Displacement of Side Handle Bar and Wheelchair During Rowing Motion

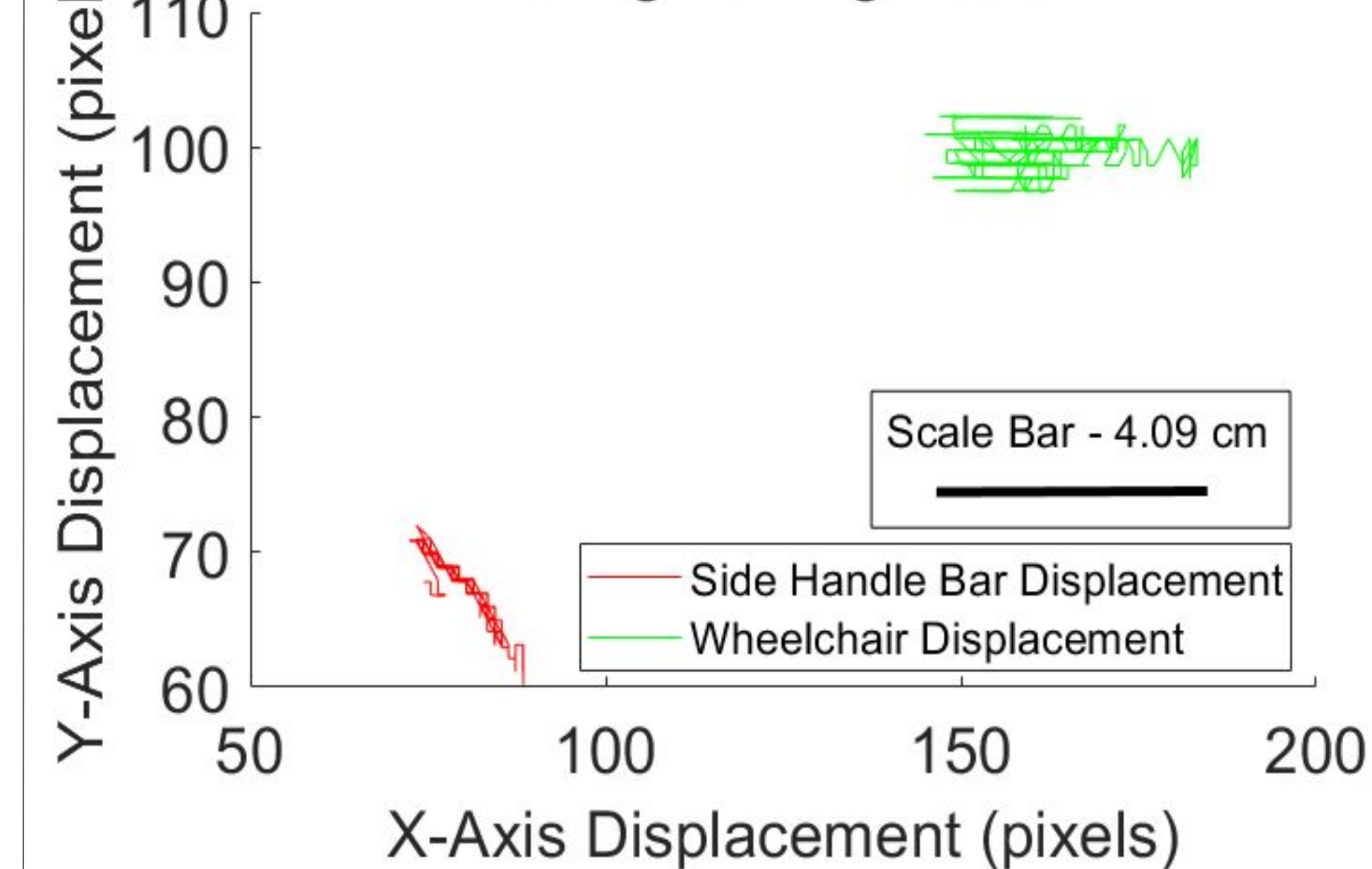


Figure 8. Maximum Displacements

Kinovea Wheelchair Displacement (fig 8):

- Trackers placed on side handlebars and wheelchair
- 30 seconds of rowing on highest resistance setting
- Maximum displacement measured:
 - Side handlebars: 1.86 cm
 - Wheelchair: 4.09 cm

DISCUSSION

Design Achievements:

- Rower is convertible between standard and adapted sides
- Wheelchair users can roll into the wooden frame and lock themselves in with only minimal movement during rowing
- Users can adjust resistance levels and get workouts of varying intensity on adapted side

Design Shortcomings:

- Stabilization frame lifts both up and forward during strong rowing effort by user
- Stabilization frame is not adjustable for varying sized wheelchairs
- Additional help is required to release tension in the rope prior to transitioning it to the opposite side through the neck

FUTURE WORK

Prototype Improvements:

- Fabricate the pulley support plates, console rotational mechanism, and arm rest support base out of steel
- Create a chest / abdomen support mechanism to prevent the user from sliding out of the wheelchair during use
- Fabricate a device that takes tension off of the rope and allows for easier transition of the handlebar from one side to the other
- Make the arm rest support base adjustable to allow for different sized users to use the rowing machine both safely and comfortably
- Adapted side needs a component to hold the handle bar during rest

Testing Improvements:

- Find wheelchair users to participate in testing
- For non-wheelchair users, use an EMG to monitor and limit the use of leg muscles by test subjects during rowing
- Attach the handlebar to the spring gauge to more accurately replicate the standard rowing motion during testing

User Survey:

- Received feedback on the user stability, intuitiveness of the design, workout mechanics, and ease of use
- Difficult to not use legs; transitioning the rope was feasible, but not from wheelchair; rowing mechanics felt similar to normal rowing

ACKNOWLEDGMENTS

- Ms. Staci Quam
- Dr. John Puccinelli
- UW-Madison MakerSpace
- UW-Madison TEAMLab
- UW-Madison BME Department
- Johnson Health Tech

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