JOHNSON HEALTH TECH: ADAPTIVE INDOOR ROWER FOR WHEELCHAIR USERS

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BACKGROUND & MOTIVATION

Benefits of Rowing Machines:

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

Importance of Adaptive Equipment:

- 5.5 million wheelchair users in the U.S. [2]
- Consistent upper body exercise can alleviate shoulder pain, which is common among wheelchair users [3]
- 81% of individuals with disabilities feel uncomfortable in fitness centers due to lack of adaptive exercise equipment [4]
- Existing devices permanently change functionality of the rower (AROW) [5]

Figure 1. AROW Rowing Machine [5]

PROBLEM STATEMENT

Individuals with injuries or disabilities have trouble utilizing typical workout machines due to a lack of accessible exercise equipment. Among these affected individuals are wheelchair users. Wheelchairs are used for a multitude of physical disabilities or injuries to the brain, spinal cord, or lower extremities. 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 were made to a standard Matrix Rower [6] to accommodate individuals in wheelchairs while maintaining safety and preserving the rowing motion. This unique design addresses the lack of exercise equipment available for wheelchair users and helps to improve their wellbeing.

DESIGN CRITERIA

Criteria:	Specification:
User Stability / Safety	Pulley mechanism and antlers withstand maximum 1050 N force [7]; zero tipping / displacement
Ease of Fabrication	Easy to fabricate; all materials available to order
Ease of Use / Ergonomics	Accessible to individuals in wheelchairs; no external assistance required
Adjustability	Fit wheelchairs 60-70 cm in width, 45-50 cm in seat height, 90-125 cm in depth [8]
Versatility	Easily convertible from standard to adaptive mode; adaptations extend a maximum 1.2 m from the rower
Durability	10 year lifespan / 8 million meters [9]
Budget	$500 for development

UPDATED SOLIDWORKS MODELS

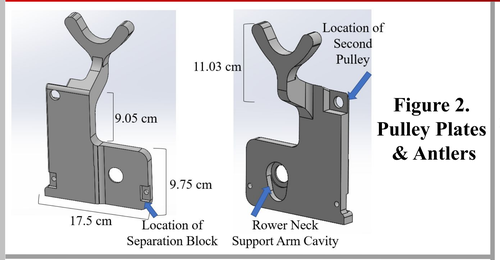

Figure 2. Pulley Plates & Antlers

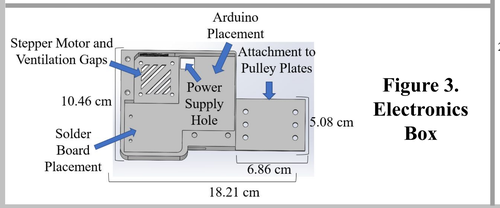

Figure 3. Electronics Box

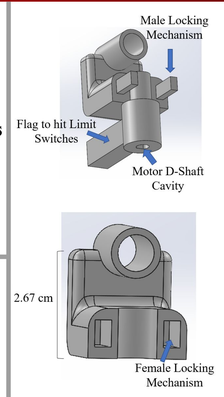

Figure 4. Console Field Goal Posts

FINAL DESIGN

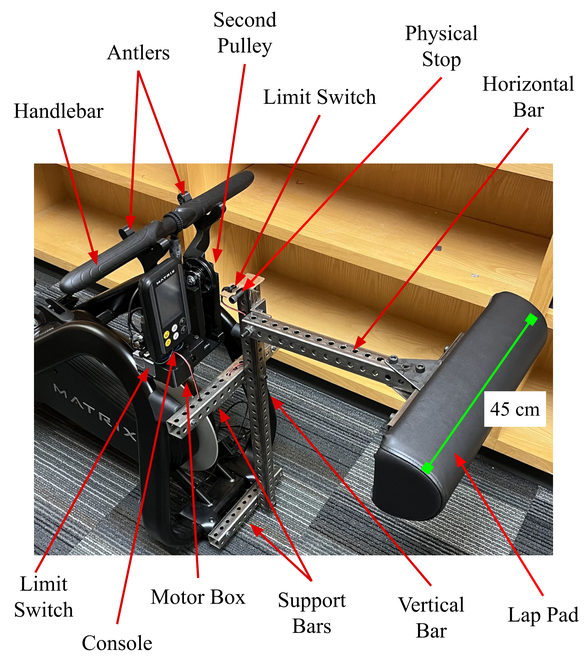

Figure 5. Full Assembly

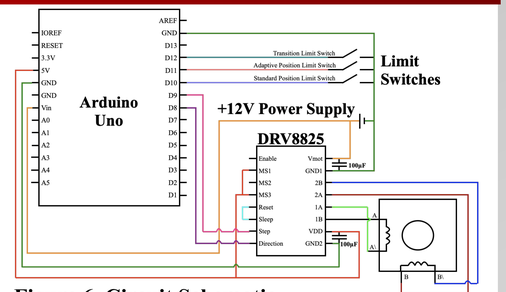

Figure 6. Circuit Schematic

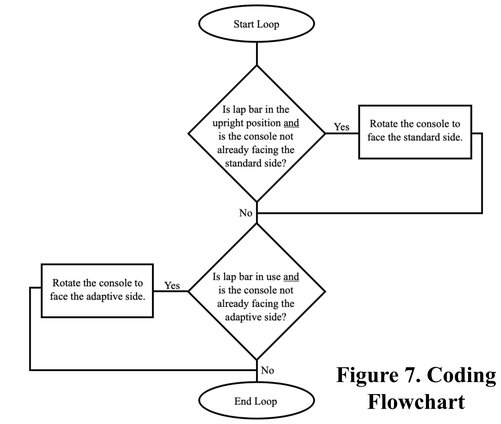

Figure 7. Coding Flowchart

TESTING & RESULTS

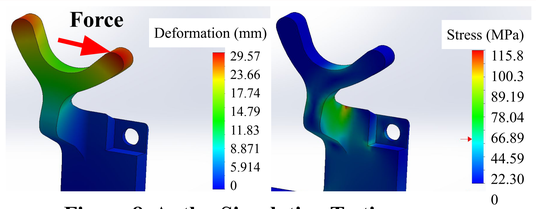

Figure 8. Antler Simulation Testing

Pulley Support Plates Solidworks Simulation (fig 8):

- Fixed at neck support cavity to mimic actual loading
- 1050 N load applied with safety factor of 2
- Max Displacement: 29.57 mm
- Max Stress: 111.5 MPa > Yield Stress: 37 MPa

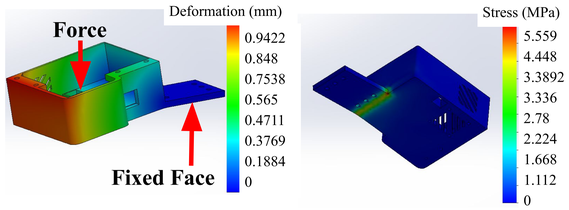

Figure 9. Electronics Box Simulation Testing

Electronics Box Solidworks Simulation (fig 9):

- Fixed at pulley plate attachment face
- 50 N load applied with safety factor of 2.25
- Max Displacement: 0.9422 mm
- Max Stress: 5.559 MPa < Yield Stress: 37 MPa

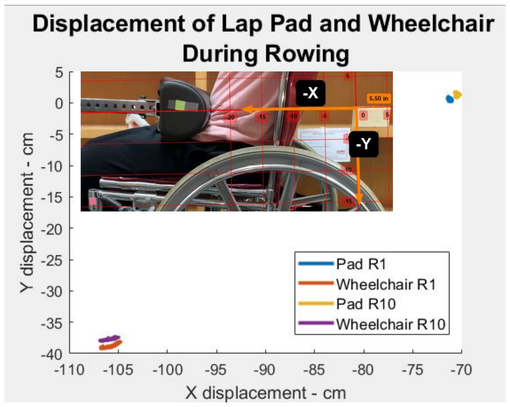

Figure 10. Frame & Wheelchair Displacements

Kinovea Motion Tracking (fig 10):

- Trackers placed on lap pad and wheelchair
- 25 seconds of rowing on the lowest (R1) and highest (R10) resistance settings

Table 1. Frame & Wheelchair Displacements

	Lap Pad		Wheelchair	
	R1	R10	R1	R10
x (cm)	0.48	0.58	2.06	1.93
y (cm)	0.79	0.99	1.19	0.69

DISCUSSION

Design Achievements:

- Rower converts between standard and adaptive sides without assistance since handlebar can be reached from both sides
- Lap pad secures wheelchair user in place and prevents excessive tipping of wheelchair
- Stabilization frame adjusts for different sized users / wheelchairs
- Console automatically rotates to the side in use so that user can view the metrics of their rowing workout

Areas for Improvement:

- Console must be angled slightly downward to prevent it from bumping into rowing handlebar
- Stabilization frame is not compatible with all wheelchairs because lap pad is too wide

FUTURE WORK

Future Design Iterations:

- Add angle adjustment mechanism to stabilization frame
- Weld stabilization frame together
- Reduce width of lap pad to fit between handles of an average-sized wheelchair (less than 40 cm)
- Permanently secure limit switches in place
- Reduce power consumption of circuit by implementing interrupts and sleep mode functions into code
- Increase antler height to provide more clearance for console
- Adjust dimensions of electronics box/lid to allow for easy access to electronics
- Create mechanism to adjust resistance level of flywheel from adaptive side

Future Testing:

- Conduct strength testing of antler design using MTS machine
- Intentionally release rowing handle during rowing motion to test durability of antlers
- Invite wheelchair users and non-wheelchair users to operate rower and collect feedback on ease of use

ACKNOWLEDGMENTS

- Ms. Staci Quam
- Dr. Tracy Jane Puccinelli
- Dr. John Puccinelli
- Cate Flynn
- Dhruv Biswas
- UW-Madison BME Department
- UW-Madison MakerSpace
- UW-Madison TEAMLab
- Johnson Health Tech

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