BME 402

DEPARTMENT OF

Biomedical Engineering

UNIVERSITY OF WISCONSIN–MADISON

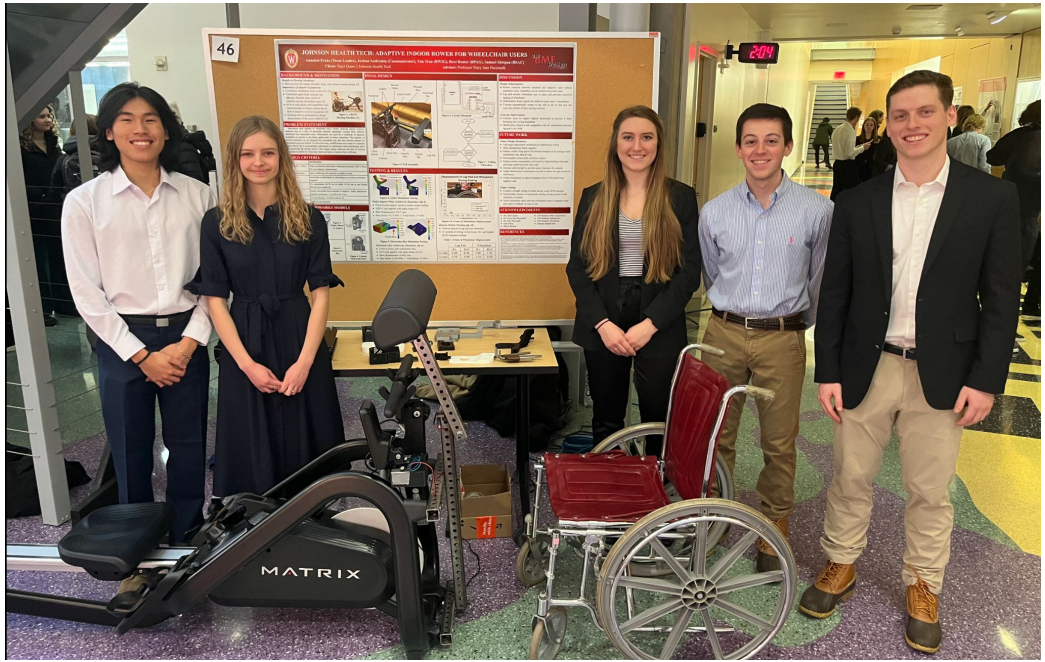
Continuing Project: Adaptive Rowing Machine

Preliminary Presentation February 10th, 2023

Client: Ms. Staci Quam

Advisor: Dr. TJ Puccinelli, Lab Section 307

Team Members



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Overview of Presentation

- Client Introduction
- Problem Statement
- PDS
- Background Knowledge
- Competing Designs
- BME 400 Accomplishments and Testing
- Future Fabrication and Testing Plans
- Device Documentation
- Budget

Client Introduction

- Ms. Staci Quam
- Mechanical Engineer and Biomech Lab Lead at Johnson Health Tech

[1][2]

Problem Statement

- Individuals in wheelchairs have trouble utilizing exercise equipment
- Rowing machines are not accessible to wheelchair users
- Implement ability to change resistance levels on both the standard and adaptive side of machine
- Ensure user safety

[3]

Motivation

Benefits of Rowing Machines:

- Rowing exercise targets shoulder, back, and oblique muscle groups [4]

Importance of Adaptive Equipment:

- 5.5 million wheelchair users in the U.S. [5]
- Consistent upper body exercise can alleviate shoulder pain common among people that use wheelchairs [6]
- 81% of individuals with disabilities feel uncomfortable in fitness centers due to lack of adaptive exercise equipment [7]
- Existing devices permanently change functionality of the rower (AROW) [8]

[8]

Product Design Specifications

- Zero outside assistance required
- Materials made out of metal and professionally fabricated
- Withstands at least 10 years of usage [9]
- Users will need to reach a max of 0.55 m to grab the handle [10]
- Normal rowing motion is preserved - 4 rowing phases
- Pulley Plates withstand 1050 N load (safety factor = 2) [11]
- Adjustable design to accommodate varying sized wheelchairs [12]
  - Width of Frame: 0.6 - 0.7 m
  - Height of Seat: 0.45 - 0.5 m
  - Length: 0.9 - 1.25 m

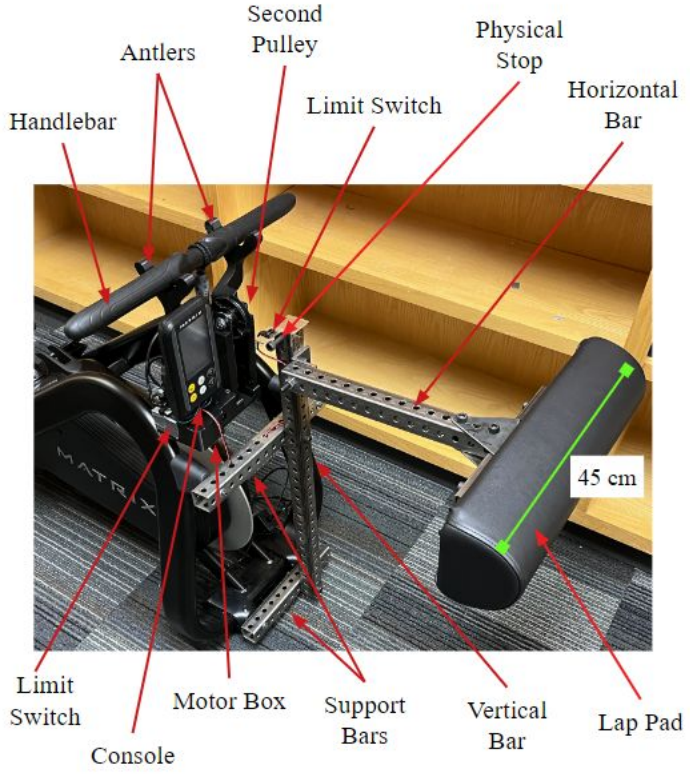
Competing Design: Adaptive Rowing Machine (AROW)

[8]

- Designed by researchers at British Columbia Institute of Technology
- Made specifically for the Concept 2 rowing machine
- Voids warranty and prohibits standard use

BME 400 Rower Accomplishments

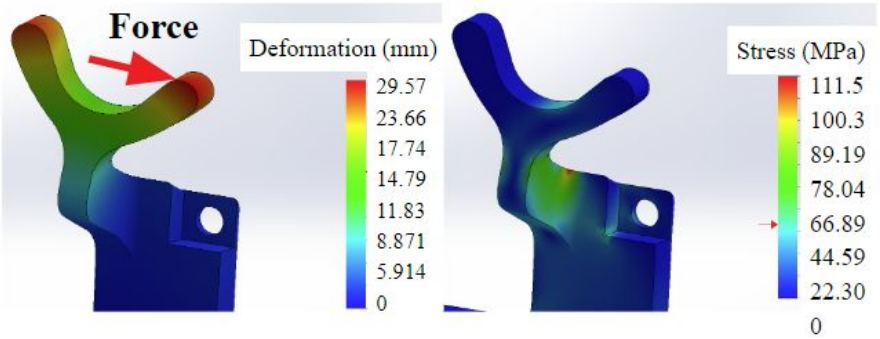
1. Successful transition between sides without outside assistance
2. Adjustable and sturdy stabilization frame
3. Automatic rotation of the console



BME 400 Testing - Simulation

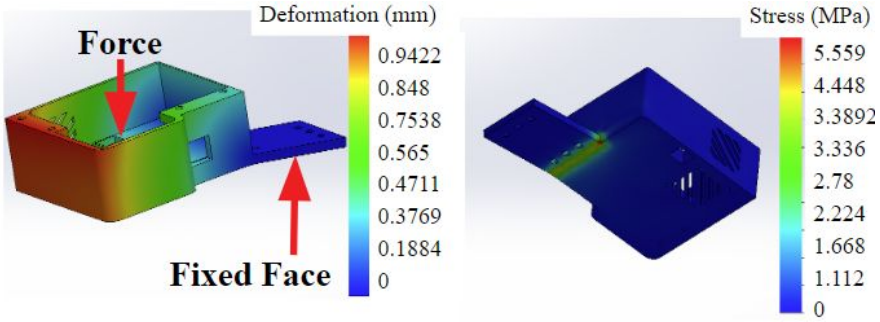
Pulley Support Plates Solidworks Simulation

- 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



Electronics Box Solidworks Simulation

- 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



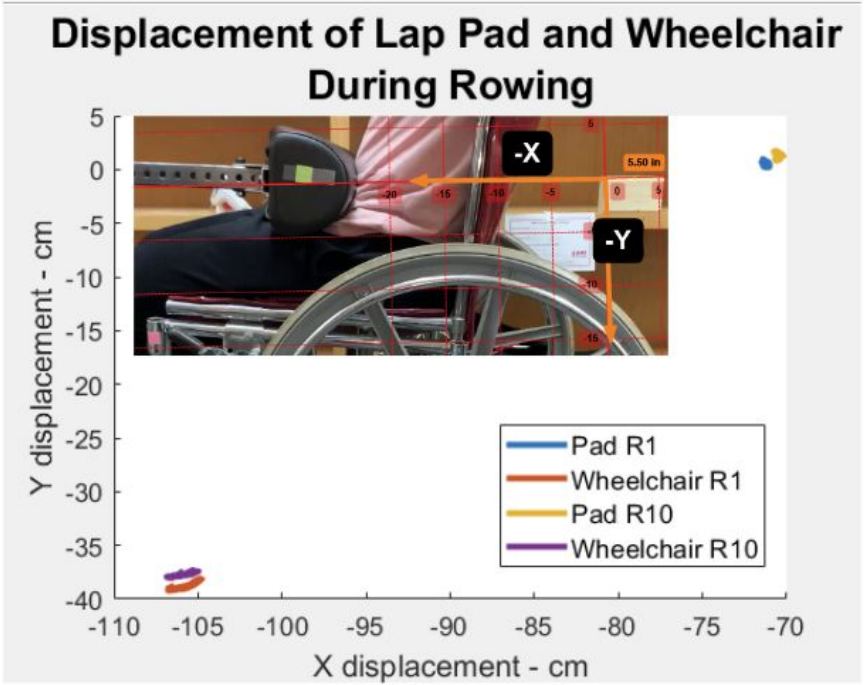
BME 400 Testing - Wheelchair Stability

Kinovea Motion Tracking

- Trackers placed on lap pad and wheelchair
- 25 seconds of rowing on the lowest (R1) and highest (R10) resistance settings
- Reduced frame & wheelchair displacement as compared to BME 301 prototype

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



Fabrication Plan

Pulley Plates & Antlers

- Modified as two-part assemblies and fabricated at JHT

Electronics Box

- Confirm screw hole placements and fabricate at JHT

Stabilization Frame

- Use a lesser width lap pad, non-perforated hollow bars, and weld at JHT

Resistance Dial Mechanism

- Develop & 3D print initial prototype for stepper motor and LCD placement within flywheel plastic housing

Testing Plan

Overall Analysis Goal: Verify the ability of the adaptive rower to keep the user safe, provide a sufficient workout, and allow for the user to easily interact with the device

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Test 1: Standard vs Adaptive Side Comparison

- Subjects: Team and other users not requiring wheelchair
- Purpose: Determine muscle activation differences and experience of user
- Data collected: EMG data and survey including ratings (1-5) on safety/comfort/ease of use of various device components

Test 2: Adaptive Side Experience

- Subjects: Users that require a wheelchair
- Purpose: Determine experience of users that require a wheelchair
- Data collected: Survey including ratings (1-5) on safety/comfort/ease of use of various device components

February Timeline

Task Category	Task Title	2/6-2/10	2/13-2/17	2/20-2/24	2/27-3/3
Design and Fabrication	Update SolidWorks model of antlers, pulley plates, and electronics box				
	Update SolidWorks model of stabilization frame				
	Brainstorm session for resistance mechanism				
	JHT fabricates antlers and pulley plates				
	JHT fabricates stabilization frame				
	Formulate coding and interface for resistance mechanism				
	Create SolidWorks model of resistance mechanism				
Testing	Submit IRB application				
	IRB application review				

March Timeline

Task Category	Task Title	2/27-3/3	3/6-3/10	3/13-3/17	3/20-3/24	3/27-3/31
Design and Fabrication	JHT fabricates antlers and pulley plates			SPRING BREAK		
	JHT fabricates stabilization frame					
	Formulate coding and interface for resistance mechanism					
	Create SolidWorks model of resistance mechanism					
	Pickup fabricated materials at JHT					
	Purchase materials for resistance mechanism					
	Assemble resistance mechanism on rowing machine					
Testing	Submit IRB application					
	IRB application review					
	Receive IRB approval/exemption					
	Recruit test subjects					
	Complete testing					

April Timeline

Task Category	Task Title	4/3-4/7	4/10-4/14	4/17-4/21	4/24-4/28
Testing	Complete testing				
Final Deliverable Work	Analyze results of testing data				
	Poster Presentation				

Device Documentation

Current device documentation

- JHT Matrix Rower User Instruction Manual
- JHT Matrix Rower Service Manual
- Protocols for IRB Application:
  - Adaptive Side Testing
  - Standard Side Testing
- IRB Device Description and Documentation

Future Documentation Work

- Create Adaptive Rower Manual or Update Current User Instruction Manual
- Update Service Manual
  - Adaptive side
- Update Device Caution and Warning Labels
  - Instructions on transition for standard side

Budget: $500 (flexible)

Previous Expenses (Fall 2022)

- **Motor components and circuitry: $117.51**
  - Stepper motors, power supply, motor controller, motor driver, relay, heat shrink, wire, Arduino
- **3D Prints: $180.32**
  - Test and final prints of pulley plates, antlers, electronics box, console components

Total: $297.83

Future Expenses (Spring 2023)

- **Resistance dial improvements: ~$65**
  - Stepper motor (~$25)
  - Arduino Mega (~$20)
  - Wire, LCDs, and other small circuit components (~$20)
- **Fabrication Improvements: ~$0**
  - JHT is providing materials and services for all current design improvements (stabilization frame, pulley plates, and antlers)

Total: ~$65

Overall Estimated Expenses: ~$362.83 of $500 budget

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Thank you to past contributors - Dhruv Biswas, Cate Flynn, and Dr. John Puccinelli

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QUESTIONS