

# MRI CARDIAC EXERCISE DEVICE

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# Outline

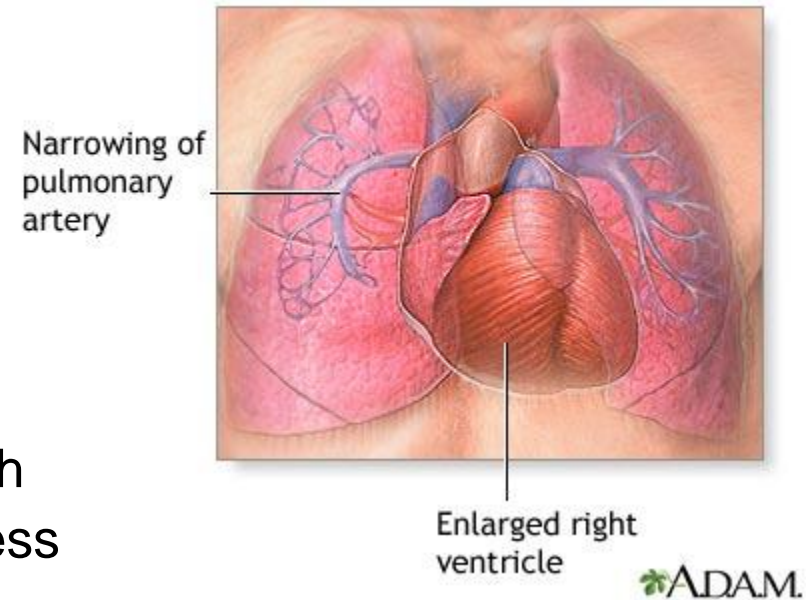
- Problem Statement
- Background Information
- Competition and Past BME Designs
- Preliminary Testing Results
- Design Options
  - Leg Extension
  - Leg Press
  - Stepper
- Design Matrix
- Final Design
- Future Work
- Acknowledgements / References

# Problem Statement

- Design an exercise device to be used in cardiac MRI scans in order to diagnose and assess pulmonary hypertension
- Client requirements
  - MRI compatible materials
  - Exercise within the bore
  - Comfortable supine exercise motion
  - Sufficient resistance to increase cardiac output
  - Adjustable workloads
  - Reasonable size and weight
  - Minimal upper-body movement

# Background Information

- Pulmonary Hypertension
  - Abnormally high blood pressure in pulmonary arteries
  - Decreased artery diameter
  - Enlarged right ventricle
  - Chronic decreased blood [O<sub>2</sub>]
- Symptoms
  - Chest pain or pressure
  - Fast heart rate, shortness of breath
  - Fatigue/weakness, light-headedness
  - Swelling of lower extremities
- Traditionally assessed with invasive procedure



<http://health.allrefer.com/health/primary-pulmonary-hypertension-primary-pulmonary-hypertension.html>

# Competition

- Lode B.V. MRI Ergometer
  - Expensive ( > \$28,000)
  - Cycling motion
- MRI-compatible Treadmill
  - Developed at Ohio State University
  - Exercise occurs outside of the MRI tube
  - Less accurate results



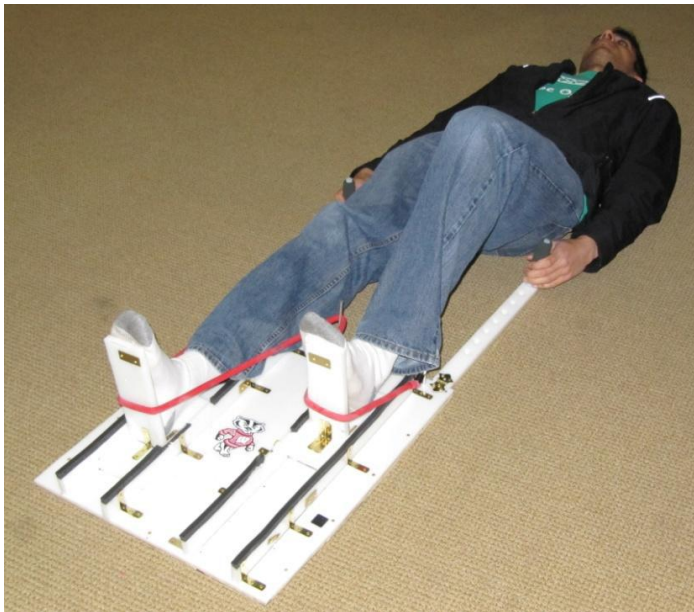
[http://www.lode.nl/en/products/mri\\_ergometer](http://www.lode.nl/en/products/mri_ergometer)



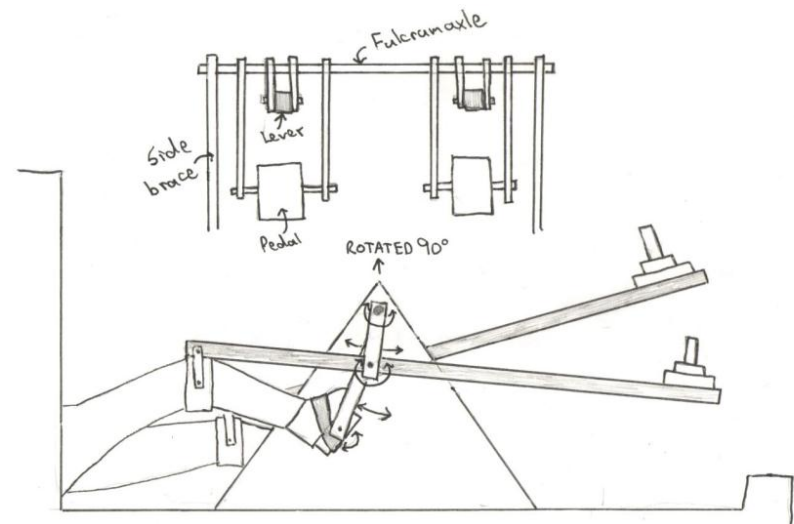
<http://www.medcitynews.com/2009/05/commercialization-ramps-up-on-ohio-state-university-treadmill-used-for-mri-heart-tests/>

# Past BME Designs

- MRI Lower Leg Exerciser
  - Spring 2010
  - Excess friction
  - Insufficient workload



- MRI Leg Exercise Device
  - Fall 2010
  - Unnatural loading
  - Bulky



# Preliminary Testing

- Constructed mock MRI bore
  - Tested exercise options
  - Excluded biking
- Desired Heart Rate: >70-80% of Max HR
- Exercise data:

	<b>Leg Extension</b>	<b>Leg Press</b>	<b>Stepper</b>	<b>Calf Machine</b>
<b>Time (min:sec)</b>	3:30	3:00	3:00	1:20
<b>Work Load</b>	90 lb (41 kg)	170 lb (77 kg)	68 rpm	160 lb (73 kg)
<b>Heart Rate (bpm)</b>	158	134	164	123

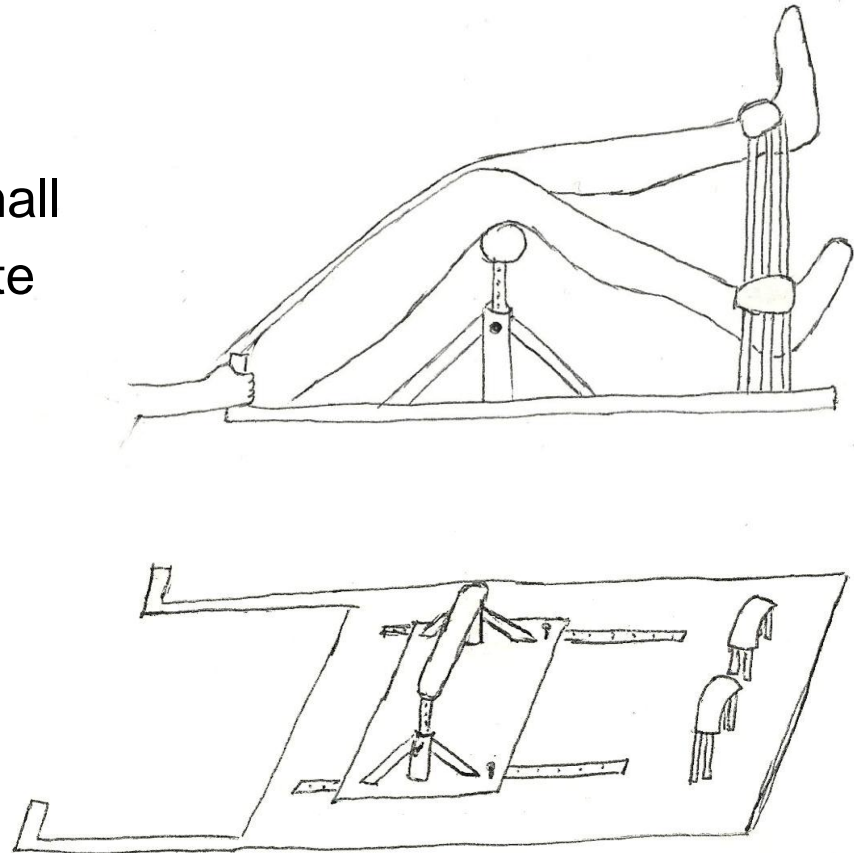
# Leg Extension Motion





# Leg Extension Design

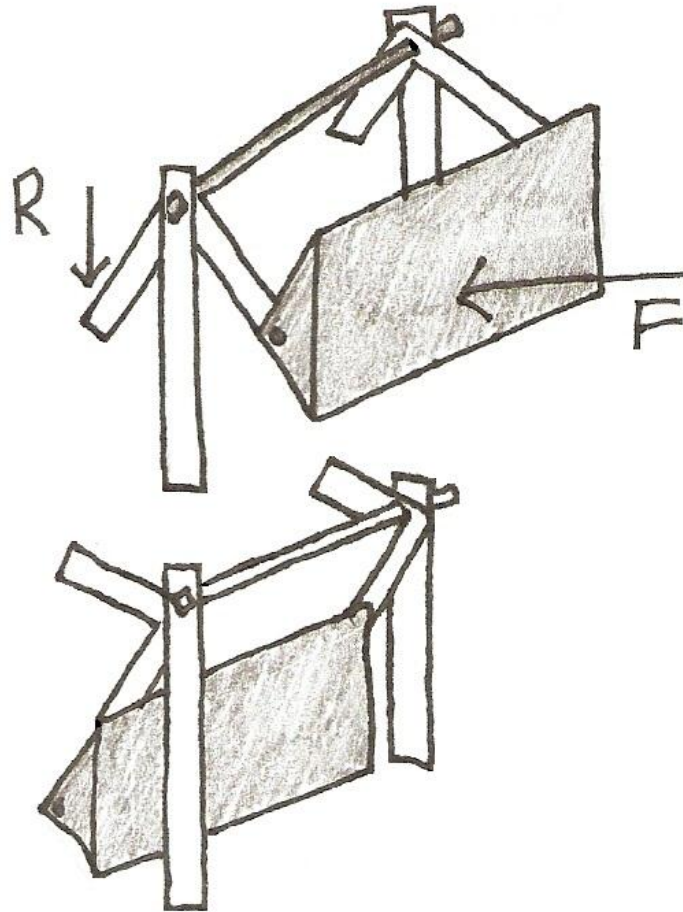
- Pros
  - Natural motion
  - Light-weight & relatively small
  - Effective at raising heart rate
- Cons
  - Some muscle fatigue
  - Durability concerns



# Leg Press Motion



# Leg Press Design

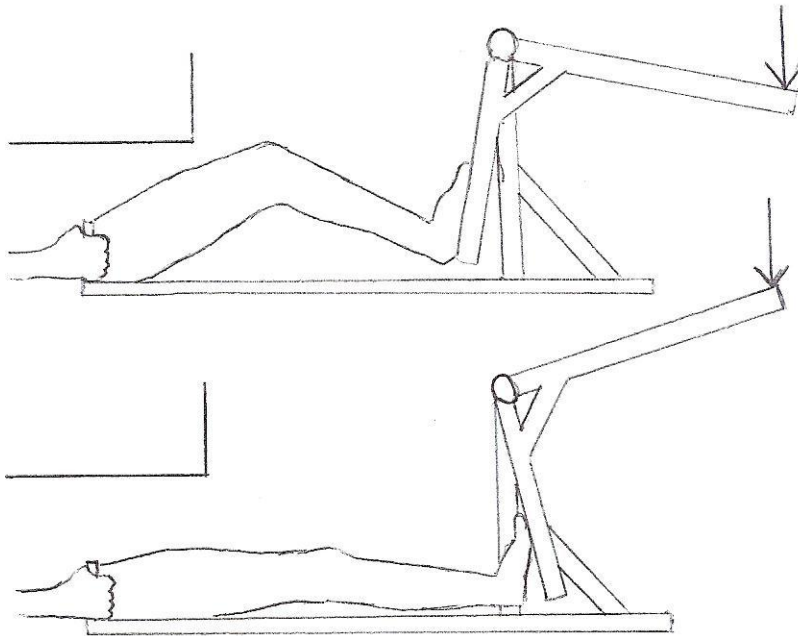


- Pros
  - Effective at raising heart rate
  - Most durable design
- Cons
  - Largest design
  - Unnatural aerobic motion
  - Some muscle fatigue
  - Most upper-body movement

# Stepper Motion



# Stepper Design



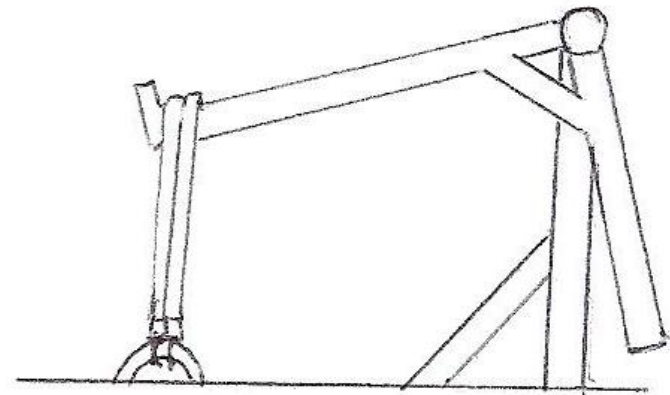
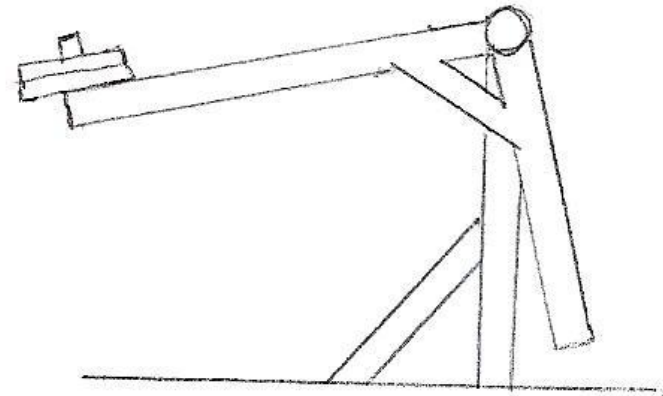
- Pros
  - Natural, comfortable motion
  - Most effective at raising heart rate
  - Reduced friction
- Cons
  - More moving parts
  - May not disassemble easily

# Design Matrix

Weight	Criteria	Leg Extension	Leg Press	Stepper
0.2	Patient Comfort	6	7	9
0.2	Motion Mechanics	9	7	8
0.2	Effectiveness	8	7	9
0.15	Durability	6	8	7
0.1	Ease of Assembly	8	7	6
0.1	Size/Weight	9	6	8
0.05	Cost	9	7	7
	<b>Weighted Average</b>	<b>7.65</b>	<b>7.05</b>	<b>8</b>

# Final Design

- Primary materials:
  - HDPE, Delrin
  - Brass fasteners
  - Glass bearings
- Elastic resistance:
  - Light-weight, resistance can vary, subject to fatigue
- Weight resistance:
  - Heavy/bulky, consistent, durable



# Future Work

- Order materials and components
- Construct and assemble prototype components
- Test effectiveness of prototype
- Test compatibility of prototype with MRI
- Successfully acquire pulmonary blood pressure data through MRI scans before, during, and after exercise



# Acknowledgements

- Prof. Naomi Chesler
- Prof. John Webster
- Prof. Darryl Thelen
- Alejandro Roldan
- Previous BME Design Teams

# References

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