MRI-Compatible Lower Leg Exerciser

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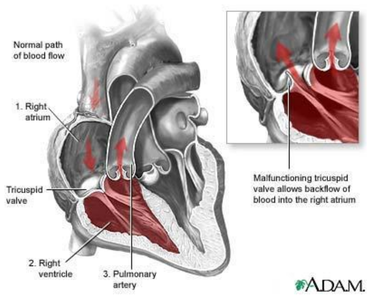
ABSTRACT

MR imaging is used to study pulmonary blood flow in hypertensive patients before and after exercise. The goal of this project is to create a device which will exercise the lower extremities to 40% of a predetermined maximal workload in both healthy subjects and patients with hypertension. A prototype was made and tested using ultrasound imaging. Using Bernoulli's equation, initial results show an increase in pulmonary systolic pressure of 5.54 mmHg. Future work will involve making the cycle completely MR compatible, increasing resistance, and developing a proper biofeedback mechanism to maintain constant workload.

PROBLEM DEFINITION

- Studying pulmonary blood flow in hypertensive patients
- Using imaging to estimate pulmonary arterial pressure
  - MR and Doppler Ultrasound
  - Look at Tricuspid jet regurgitation
- Imaging patient before and after exercise



Tricuspid Regurgitant Jet

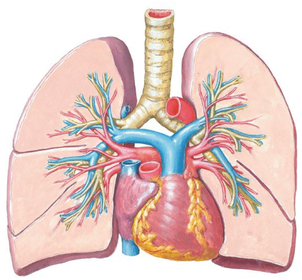
EXISTING DEVICES

- Northeastern Univ. Design Proj.
- Lode Ergometer
- Problems
  - Very Expensive
  - Contains extra features
  - Used to image joint mechanics

Lode Ergometer ($52,000)

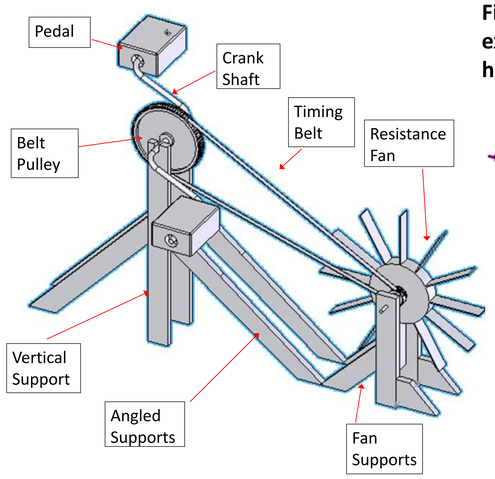
DESIGN CRITERIA

- MRI-compatible
- Adjustable for scanner bed
- Exercise patient at maximal workload and at 40%
- Recruits multiple muscle groups
- Repeatable
- Ergonomic and comfortable
- Accurate biofeedback



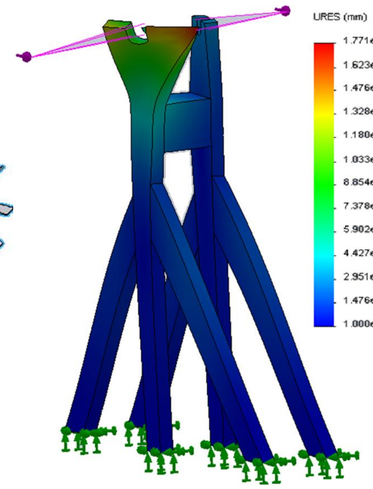
Pulmonary Arteries (in blue)

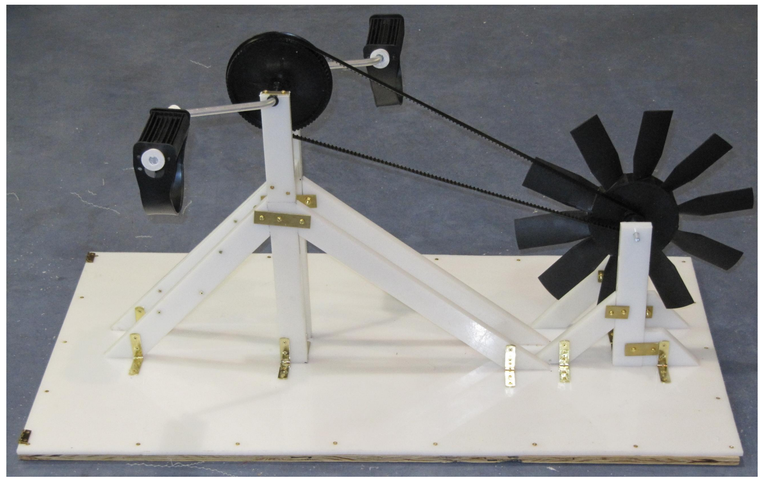
FINAL DESIGN



Schematic of our design from an isometric view. (Base not shown)

Finite Element Analysis. Figure is exaggerated to show regions where highest strain (in mm) is located.





Our final prototype design

BUDGET

Approximate Cost: $170.00

Item	Cost
HDPE Rods and Sheet	43.00 (given free)
Brass Screws, Brackets and Plates	30.00
Timing Pulleys/Belt	26.95
Pedals/Toe Clips	20.00
Resistance Fan	21.95
Crank Axle and Fan Axle	7.00
Axel Spacers, Plywood, Glue, Velcro	22.00

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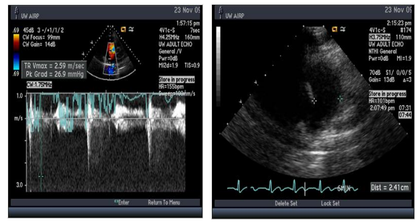
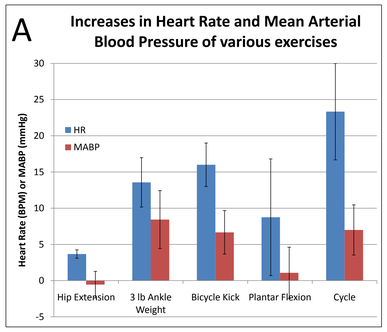
TESTING

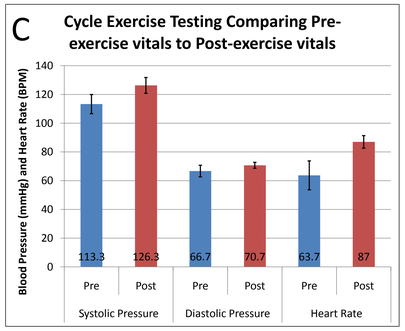
Images acquired from ultrasound test. Left shows Tricuspid Regurgitant (TR) velocity, and right shows the tricuspid valve.

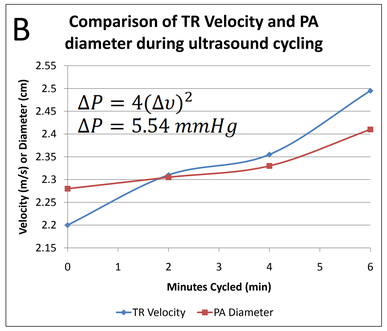


Exercise testing with ultrasound imaging

Exercise and ultrasound testing data:
A: Exercise comparison to determine optimal method
B: TR Velocity and PA diameter increases during exercise via ultrasound test. Shown is modified Bernoulli equation and calculated value.
C: Comparison of vitals before and after exercise







FUTURE WORK

- Increase resistance with braking or additional fans
- Reconstruct device using custom made supports
- Secure device to scanner bed
- Fabricate ergonomically designed pedals
- Add wheels and handle for easy transportation

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