MRI-Compatible Lower Leg Exerciser

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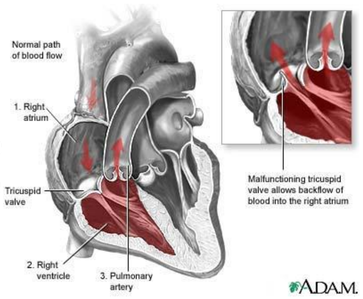
ABSTRACT

Our client plans to use magnetic resonance imaging (MRI) to study pulmonary blood flow before and during exercise in patients with pulmonary vascular disease. Our goal is to design an MRI-compatible exercise device that increases pulmonary artery blood flow during exercise. To do so, we performed exercise testing and motion capture analysis to determine the best motion. A leg-press type device was then manufactured to match that motion. Initial data show that use of the device to exercise in the MRI scanner raises heart rate and blood flow. In the future, our client hopes to use scan data such as these to determine whether exercise will benefit patients with pulmonary vascular disease.

PROBLEM DEFINITION

- Client is studying pulmonary blood flow in hypertensive patients
- A device is needed to exercise the patient while in an MRI Bore
- Imaging will be used to estimate pulmonary arterial pressure
  - MR and Doppler Ultrasound
  - Look at Tricuspid jet regurgitation



Tricuspid Regurgitant Jet

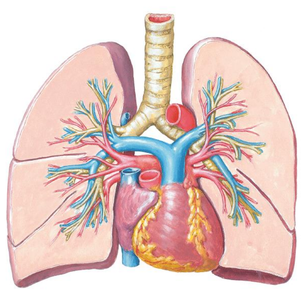
EXISTING DEVICES

- Northeastern Univ. Design Proj.
  - Used to image joint mechanics, not CV system
- Lode Ergometer
  - Very Expensive
  - Contains extra features

Lode Ergometer ($52,000)

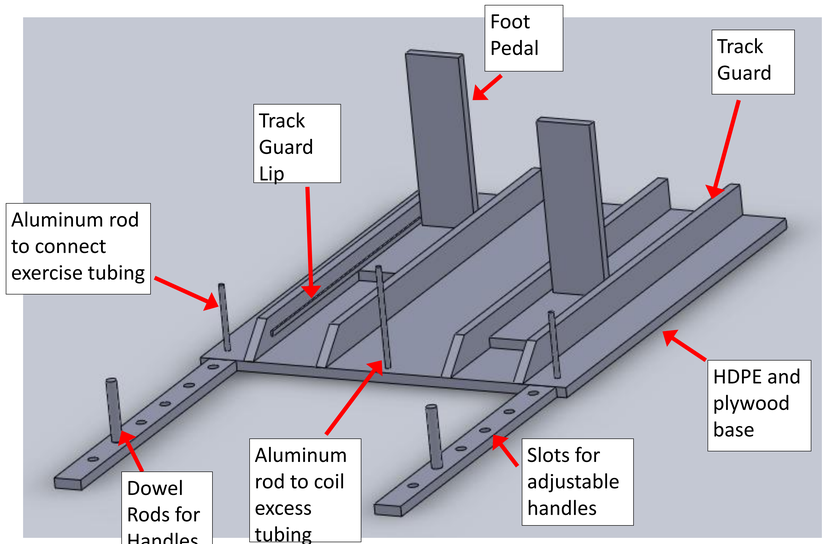
DESIGN CRITERIA

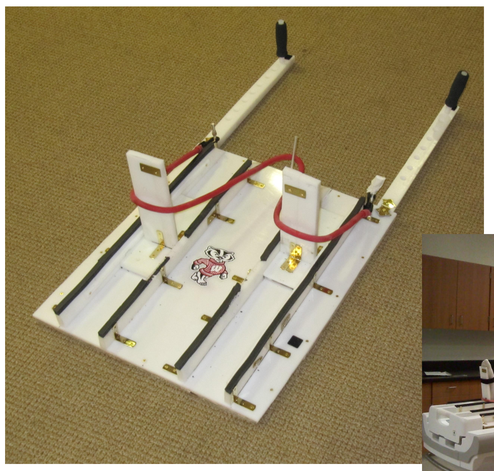
- MRI-compatible
- Adjustable for scanner bed
- Exercise patient at a rigorous workload
- Recruits multiple muscle groups
- Repeatable
- Ergonomic and comfortable
- Accurate biofeedback



Pulmonary Arteries (in blue)

FINAL DESIGN





Top: Schematic of device with labeled parts

Left: Final Device Prototype.

Bottom: Use of the device in a GE MRI Scanner

BUDGET

Approximate Cost: $162.00

Item	Cost
HDPE Rods and Sheet	75.00 (given free)
Brass Screws, Brackets and Plates	30.00
Varying Resistance Tubing	35.00
Plywood, Velcro , Mole Skin, Rubber Foam	22.00

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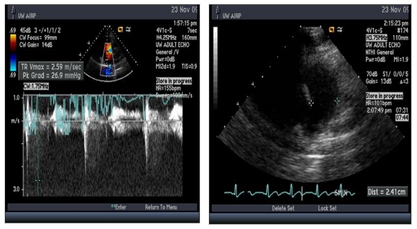
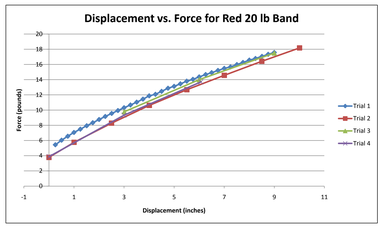
TESTING

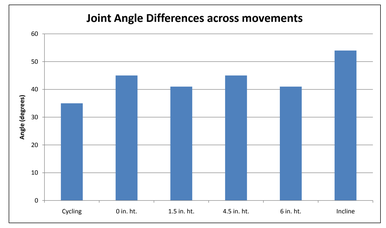
Images acquired from ultrasound test. Left shows Tricuspid Regurgitant (TR) velocity, and right shows the tricuspid valve.



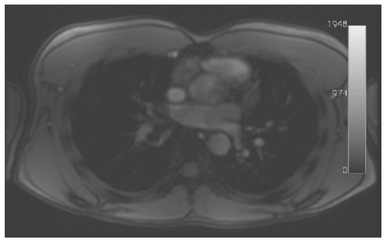
Motion Capture Testing

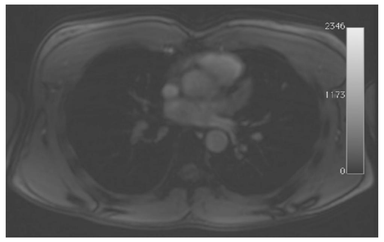
Below: Tensile testing performed on the 20 lb. exercise tubing (manufacturer's rating). Multiple trials were done to determine if hysteresis was present.





Above: Exercise movement comparison to determine optimal movement. Tibial femoral joint rotation angle was measured (only one trial per motion was done)





Images acquired during MRI scan. Left shows image quality while subject is at rest, and right shows image quality while subject is exercising in bore.

FUTURE WORK

- Resubmit IRB Protocol
- Submit IDR application to WARF

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