

Product Design Specifications – MRI-Compatible Exercise Device

September 13, 2011

Team : Nick Thate, Evan Flink, Tongkeun Lee, Andrew Hanske

Client: Prof. Naomi Chesler

Advisor: Prof. Willis Tompkins

Problem Statement

In order to better understand the effect of exercise on patients with pulmonary hypertension, Professor Naomi Chesler would like to use magnetic resonance imaging (MRI) to accurately measure changes in blood pressure and flow of the pulmonary arteries during exercise. Our task is to develop an improved MRI-compatible exercise device for patients undergoing cardiac MRI scans. It should allow the patient to exercise while lying within the MRI bore and have adjustable workloads so patients of varying fitness levels can generate a sufficient cardiac output and heart rate.

Client Requirements

- MRI-compatible, in both materials and dimensions
- Comfortable exercise motion in supine position
- Sufficient resistance to increase heart rate and cardiac output
- Adjustable workload

Design Requirements

1. Physical and Operational Characteristics
 - a. *Performance requirements:* The device should provide a natural exercise motion that can be performed while the patient is within the MRI bore. The workload provided must increase the patient's heart rate to >70-80% of their maximum predicted heart rate, which is equal to 220 beats/min minus the patient's age. It needs to be adjustable for various patient fitness levels and heights (155-195 cm). Additionally, only one assistant should be required during set up and testing.
 - b. *Safety:* All materials must be MRI-compatible (non-magnetic) for the safety of the patient, scanner, and medical staff. The exercise motion cannot put the patient at risk for injury during use.

- c. *Accuracy and reliability:* The design should provide consistent workload settings from patient-to-patient. All patients should be able to reach the target heart rate.
- d. *Life in service:* The device must be able to withstand clinical use for three years with minor maintenance.
- e. *Shelf life:* N/A
- f. *Operating environment:* The design will be used in clinical or research settings in the presence of an MRI scanner and ECG leads.
- g. *Ergonomics:* The motion should be natural, fluid, and controlled without any undesirable friction.
- h. *Size:* The device must allow for exercise within the bore of any MRI scanner. The standard measurements of the bore are 42 cm from the couch to the top and 60 cm in width.
- i. *Weight:* The weight on the couch cannot be greater than 150 kg, so the device will not exceed 25 kg. Individual components should not weigh more than 15 kg to ensure portability.
- j. *Materials:* All components must be durable and made of non-ferrous materials.
- k. *Aesthetics, appearance, and finish:* The device should be quiet and not intimidating to the user.

2. Product Characteristics

- a. *Quantity:* One working prototype
- b. *Target product cost:* \$200.00

3. Miscellaneous

- a. *Standards and specifications:* Must pass inspection for use in MRI and eventually be IRB approved for human trials
- b. *Customer:* Hospitals, clinics, and research labs
- c. *Patient-related concerns:* Comfortable, safe, and durable

Competition: Lode B.V. MRI Ergometer, prototypes from other universities, and past UW BME design projects