Physical Function Testing Apparatus for Monkeys

Team: Ben Horman, Ben Myers, Ben Ratliff, David Luzzio, Heather Barnwell

Client: Dr. Ricki Colman **Advisor:** Dr. Aaron Suminski

Abstract

Rhesus monkeys have long been used in research as a model for humans due to their similar anatomy. It has been proven that caloric restriction without malnutrition can delay sarcopenia and its accompanying health problems. Current methods for testing the threshold for muscle loss do not provide quantitative data on physical function; however, a device to measure the maximum strength of the monkeys will offer more versatile records for Dr. Colman's research on aging. A prototype that has the capability of testing the maximum strength of the subject's entire lower body has been fabricated, but improvements are necessary before the device can be used on any animal participants.

Background

- Humans and monkeys share similar anatomical structures, which makes rhesus monkeys good candidates for comparing human and non-human primate health [1]
- Rhesus macaques are quadrupedal with opposable toes, which allows for an increased range of motion and strength [1]
- To obtain muscle mass data, biopsies are taken from the quadriceps but quantitative muscle strength data is required to show the decay over time of physical function with limited caloric diets
- Sarcopenia: the natural loss of muscle tissue with aging [2]

Figure 1. The image above shows a rhesus monkey found in the cages used by our client. [3]

Motivation

There is currently no product on the market that accurately tests muscular function and strength in rhesus monkeys.

Product Design Specifications

- Measures the entire force range generated by the monkeys
- Safe for use with the monkeys and easily sanitized
- Durable enough to withstand long term stresses
- Able to be set up, then function without human assistance
- Isolates leg strength as much as possible

Final Design

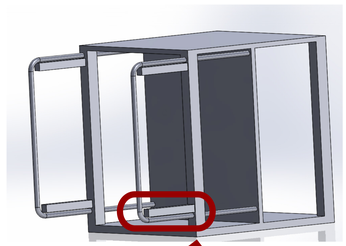

Figure 2: SolidWorks design of a cage. Included is a squeeze plate with bars that extend out front. Highlighted is the device which is around the extended bar of the squeeze plate.

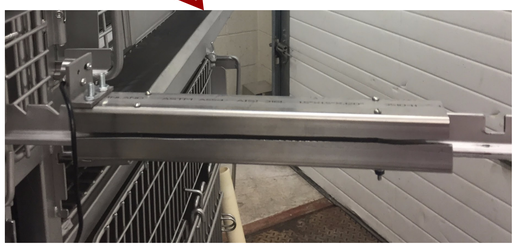

Figure 3: The device attached to one of the bottom bars of the cage

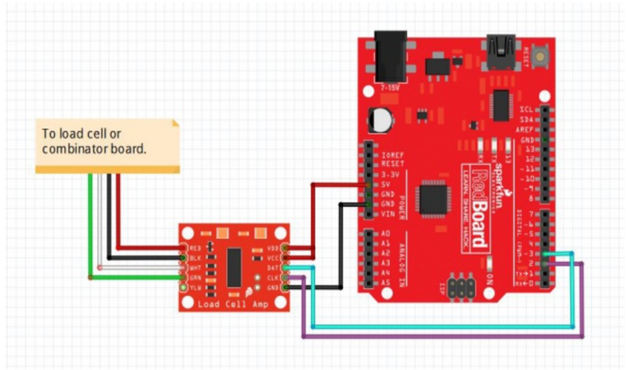

Figure 4: The image above shows the overall layout of our circuitry. The load cell was connected to the HX711 op amp which was further connected to our Red Board [4].

Circuit:

- 50 kg Load Cell
- Wheatstone Bridge Op Amp
- 5V Arduino Red Board

Code:

- Provided by SparkFun

Testing

- Load cell was calibrated using series of weights
- Device was connected to each unique corner of the cage
- Device tested over range of forces while attached to the cage

Figure 5: Setup of device at the Wisconsin National Primate Center.

Results

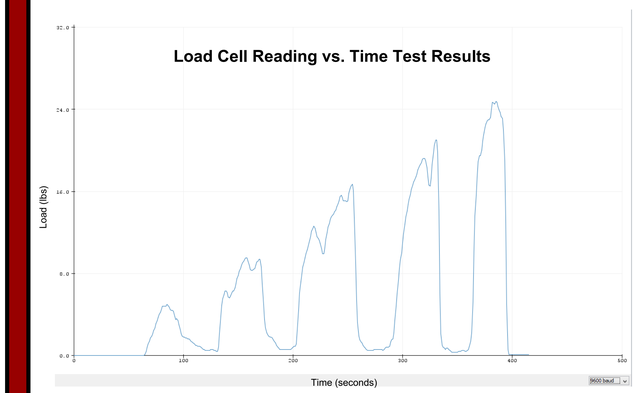

Figure 6: The image above shows the load cell's response to various forces over time. The forces were continually increased starting at 5 pounds and ending at 25 pounds.

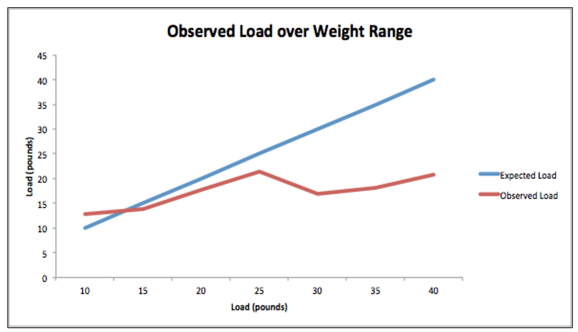

Figure 7: The image above shows the load cell's response over a force range when attached to the rhesus monkey cage. The observed load generally followed the trend up until 20 pounds before flattening out. This is likely due to moments generated about the other three corners of the cage at high loads.

Discussion

- Device was able to be attached with relative ease to the cage
- Device could only be attached to two out of four bars due to geometry of bars
- Testing assumed that all forces were transferred to the load cell
- Load cell was accurate at lower forces
- At higher forces, accuracy decreased
- Error could be due to moments inducing frictional forces on other bars
- If devices were placed on each bar, error from cage would be decreased
- Incorporation of automatic feeder still required
- Code that enables a threshold of force still required

Future Work

- Integrate automatic food reward system
- Build four of the devices so that one can be placed in each corner of the cage
- Improve the ease of use and adjustability
- Code increasing threshold force levels

Acknowledgements

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- Dr. Aaron Suminski, Advisor
- Scott Baum, Research Assistant
- Wisconsin National Primate Research Center

References

[1] K. C. Lang, 'Primate Factsheets: Rhesus macaque (Macaca mulatta) Taxonomy, Morphology, & Ecology', National Primate Research Center Library, 2005. [Online] [Accessed: 16- Oct- 2016].

[2] R. J. Colman *et al.*, "Muscle mass loss in Rhesus monkeys: Age of onset," *Exp. Gerontol.*, vol. 40, no. 7, pp. 573–581, 2005.

[3] Bennett, Allyson J. "Wisconsin National Primate Research Center." *Speaking of Research*. Word Press, 31 Mar. 2016. Web. 05 Dec. 2016.

[4] Al-Mutlaq, Sarah. "Load Cell - 200kg, Disc (TAS606)." *Learn at SparkFun Electronics*. N.p., n.d. Web. 07 Dec. 2016.