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A MECHANICAL MODEL FOR HIP REDUCTION VIA PAVLIK HARNESS IN NEWBORNS

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https://sites.google.com/site/eraumebmssd1516hipdysplasiaexp/

INTRODUCTION

➢ Developmental dysplasia of the hip (DDH) is an abnormal condition in infants and commonly treated by the use of the Pavlik Harness.

➢ 1 out of every 20 babies has some hip instability.

➢ The effectiveness of the Pavlik Harness depends on physician's expertise, experience and trial- and error procedures.

➢ A multi-physics computational approach was used for a better understanding of how to use the Pavlik Harness in the most effective way possible.

➢ To prove the results of the computational approach, a mechanical model is needed to provide physicians with a better understanding of the mechanics of DDH when using the Pavlik Harness.
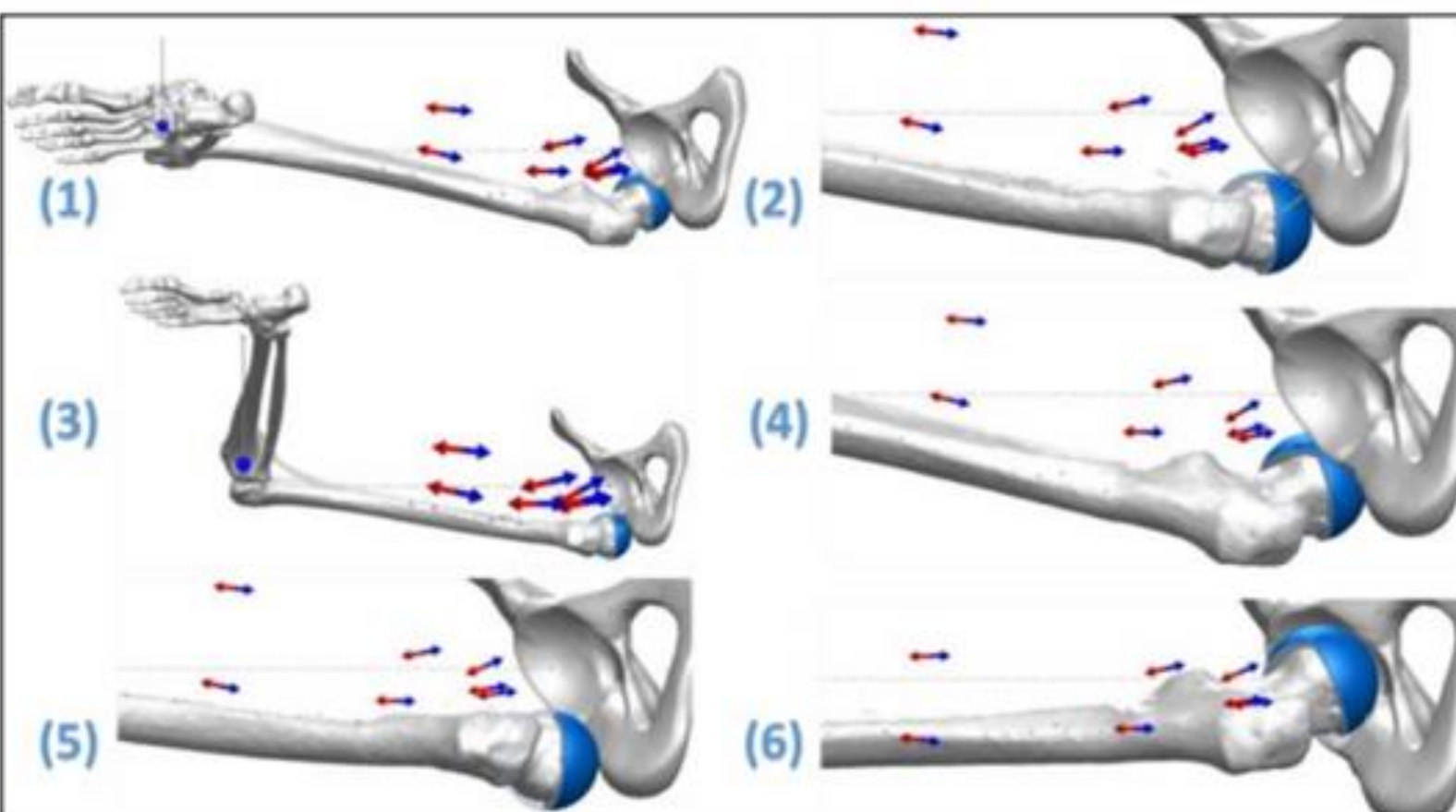

Figure 1. An infant wearing a Pavlik Harness

OBJECTIVES

Figure 2. Computational model with grade IV dislocation and its path of reduction will be validated with a mechanical model

➢ Replicate an infant's hip with DDH and the 7 muscles that play a role in the hip reduction.

➢ The mechanical model will be scaled proportionally to the size of an infant and passive muscle forces will be simulated.
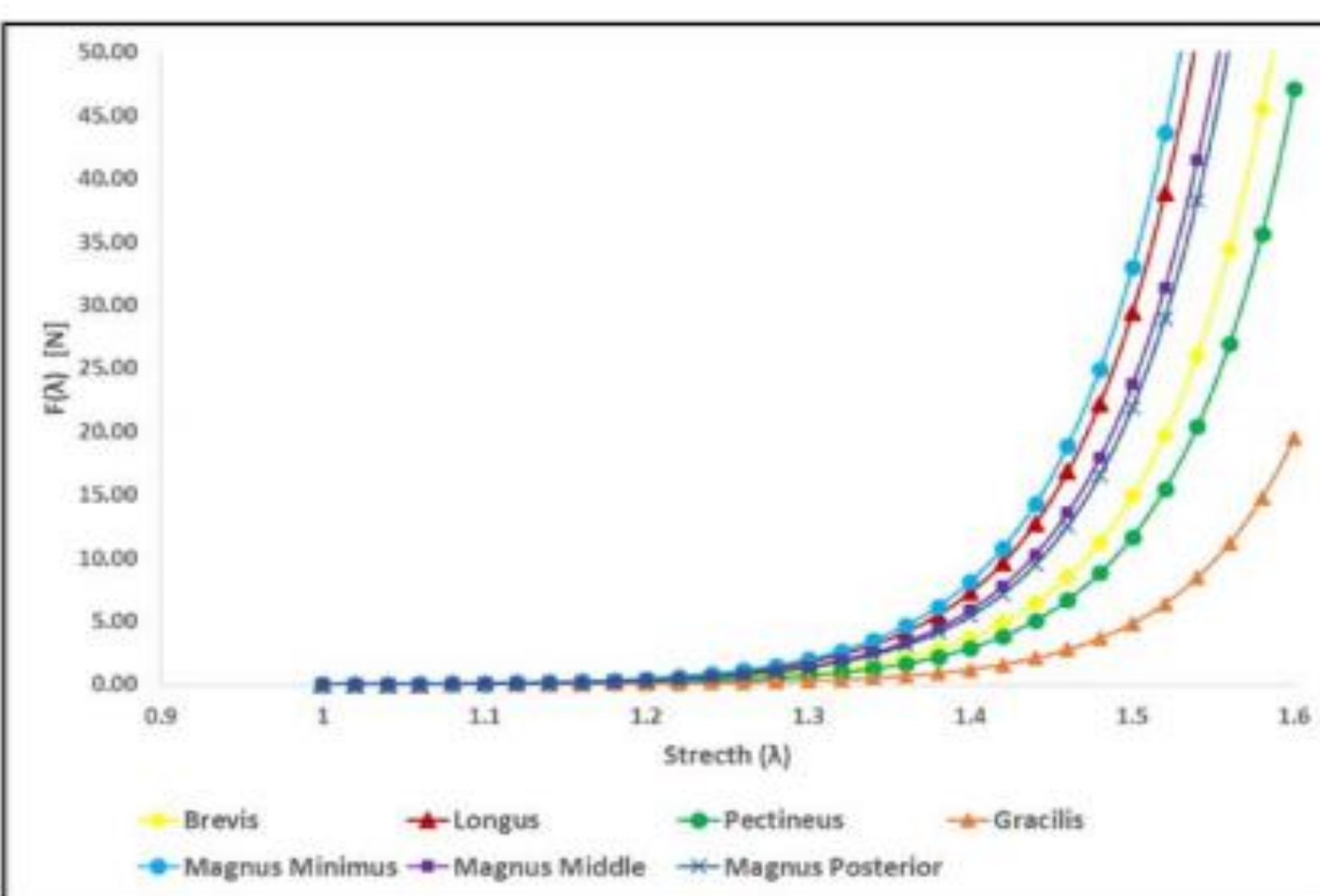
METHOD

Figure 3. Each muscle has an individual force vs. stretch curve representing the passive muscle force; these curves have to be replicated.
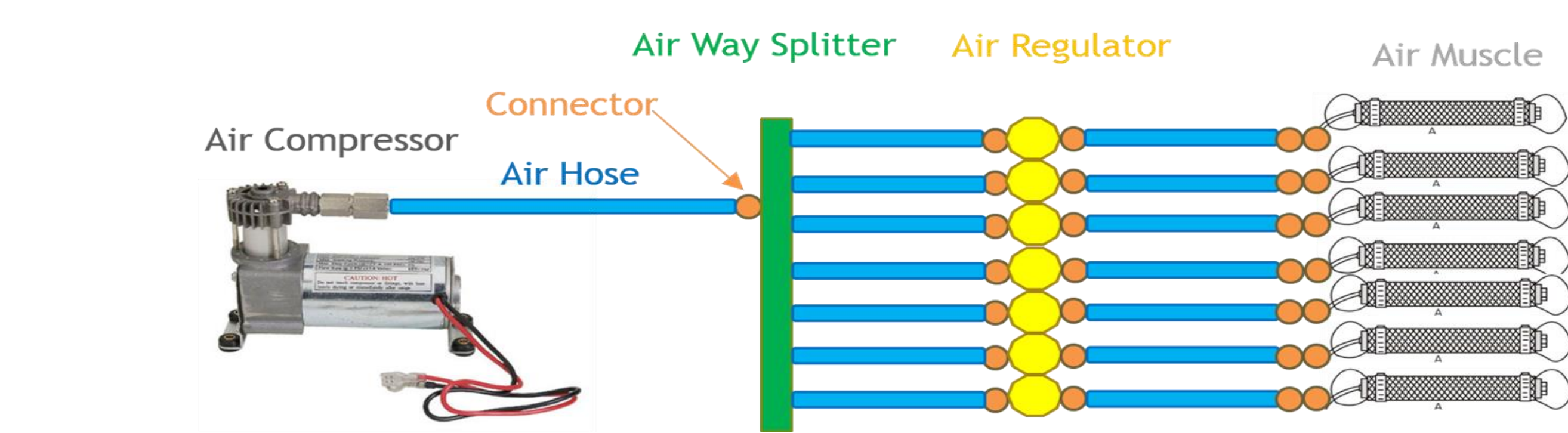
➢ Trial and error experiments will calibrate the pneumatic muscles to obtain the desired pressure for replicating each individual curve.

➢ The data for the path of reduction of the femoral head will be acquired by IMUs, and processed using MATLAB.

Figure 4. Set up of the 7 pneumatic muscles attached to an air compressor

ABSTRACT

Developmental Dysplasia of the Hip (DDH) refers to an abnormal hip condition in infants characterized by anomalous development of the hip joint, in which hip joint dislocation, misalignment, and musculoskeletal instability are present.

Clinical reports and previous research show very low success rates for the Pavlik Harness for severe grades of hip dislocation. Statistically, it has been shown that for reduction rate for the International Hip Dysplasia Institute (IHDI) Grades I-III is 92% while only 2% for grade IV.
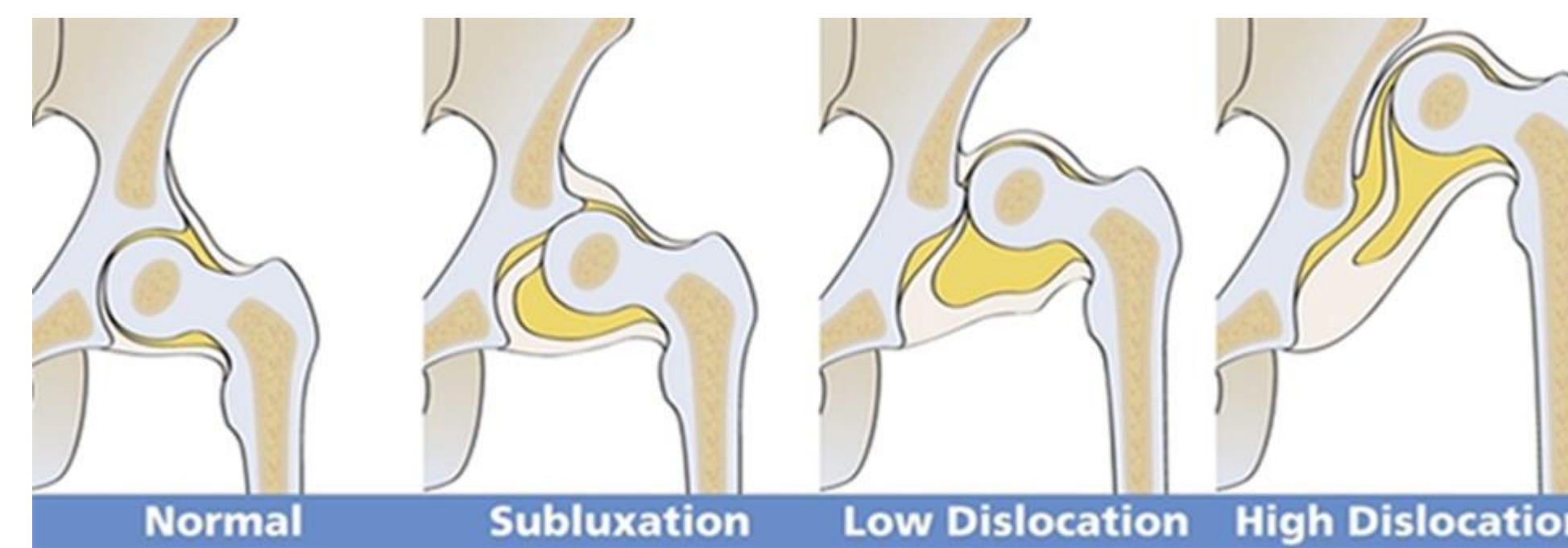

Figure 5. From Left to Right, IHDI Grades I-IV

DDH is found responsible for 29% of primary hip replacements in people up to 60 years of age. The primary goal of this project is to assist in the improvement of the success rate on non-surgical interventions for patients with DDH, as well as the ensuing consequences in adulthood.

In order to experimentally verify the computational model of the hip reduction and abduction in severe cases of DDH, a mechanical bench-top model is to be designed, built and tested for the four grades of dislocation.

This approach will be repeated for three patient-specific infant's musculoskeletal models, as to corroborate the use of this experimental bench-top design in the validation of the patient-specific computational model.

BUDGET

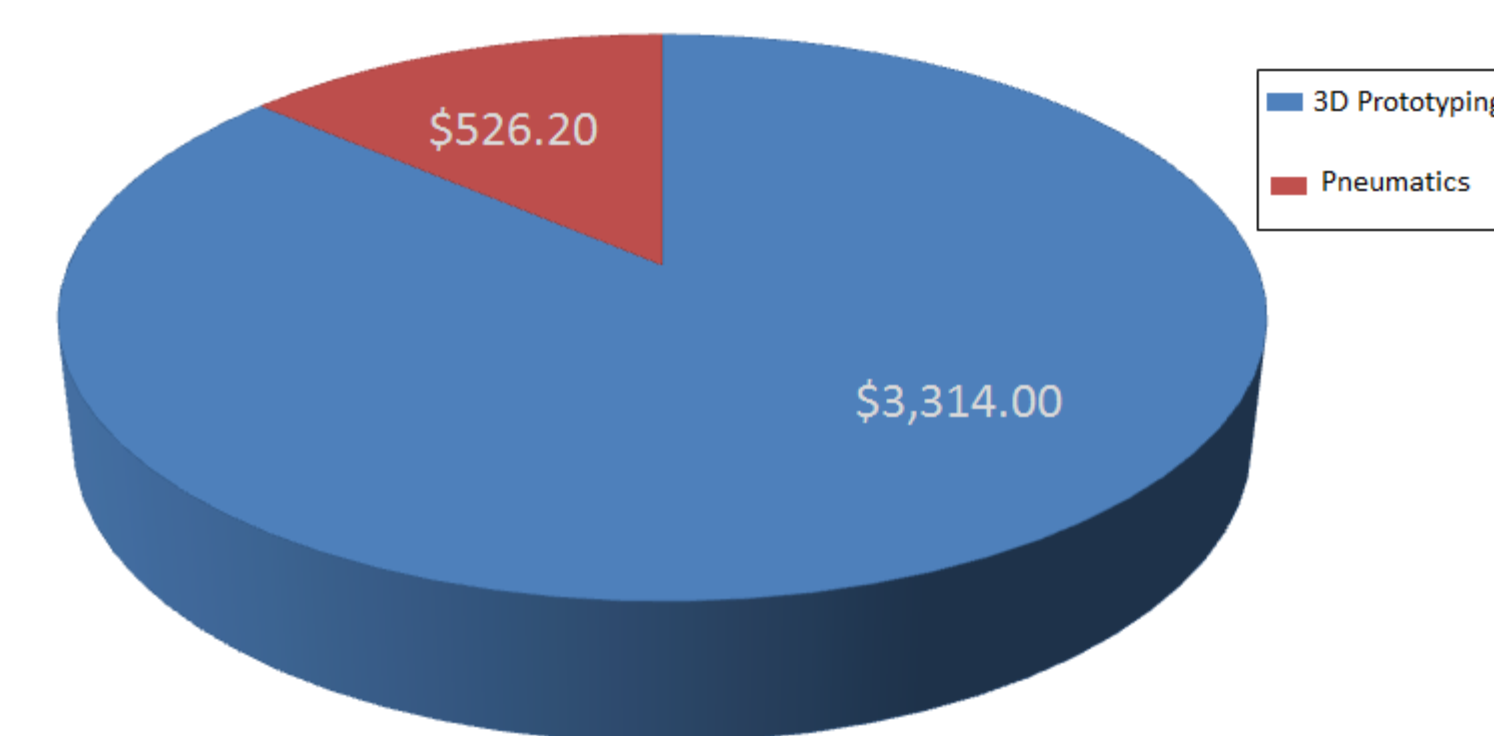**Figure 6. The 3D printer, MakerBot 5th Generation has been the most expensive purchase**

Figure 7. Visual representation of budget divided in 3D prototyping and air muscle pneumatics. Total Budget is $3840.20

RESULTS

➢ A scale of 4:1 was selected for the model to ensure an adequate size and weight practical for teaching and testing purposes.

Figure 8. The lower extremities were generated from 3D scans imported to SolidWorks and converted to STL files for 3D printing.

Figure 9. McKibben air muscles have been chosen to replicate the individual force vs. stretch curves. By varying the pressure, the passive muscle force can be adjusted

Figure 10. Foot and tibia have been 3D printed with a scaling factor of 4

➢ The team successfully created a 3D printed model of the right half of the lower extremities that will be used to visualize the desired points of origin and insertion.

➢ The 3D model will also help to visually understand what is happening during the hip reduction process in order to implement this procedure on a patient-specific case.
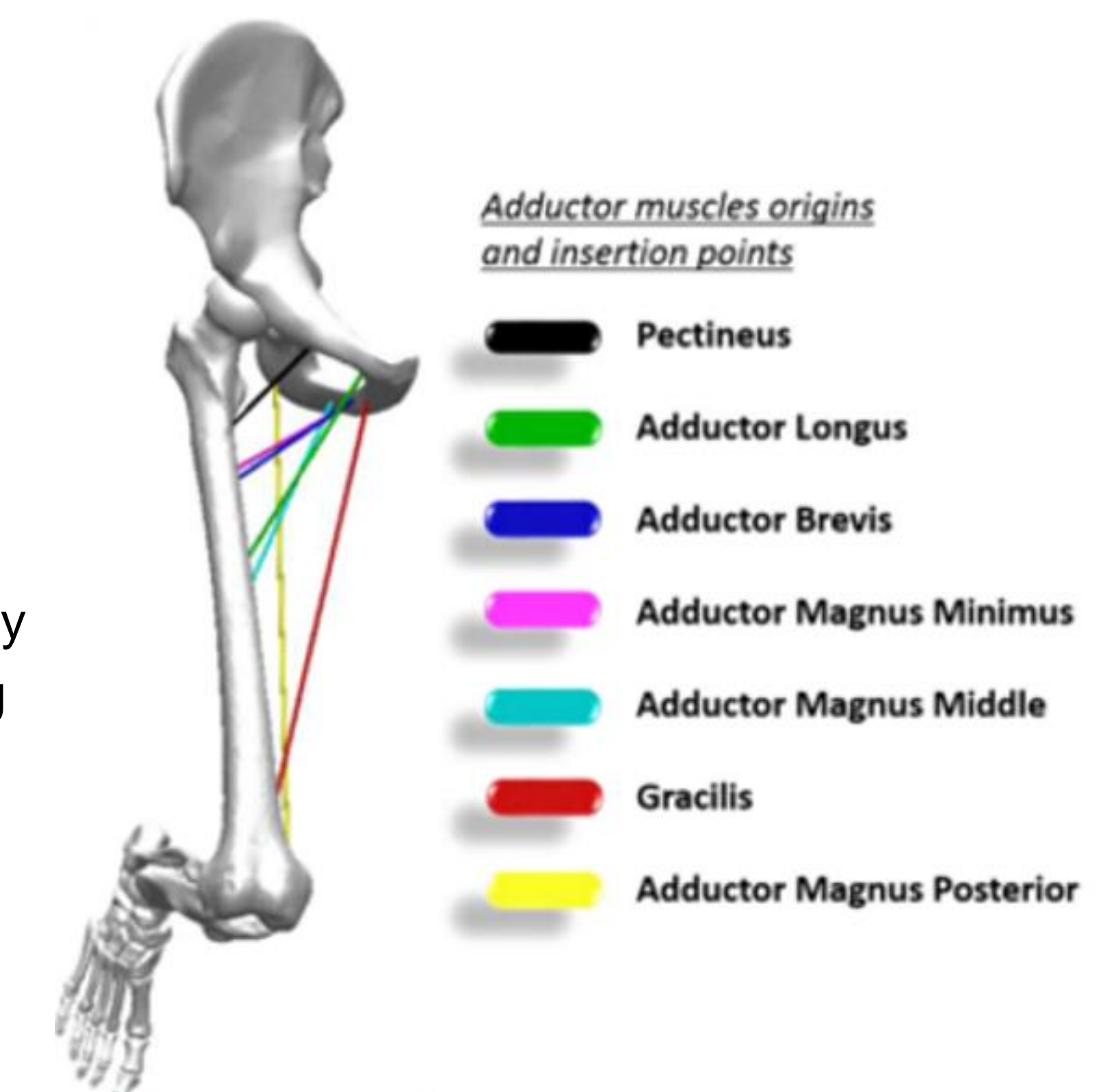

Figure 11. Right half of the lower extremities with muscle location

REFERENCES

1. Huayamave, Victor A. "Biomechanics of Developmental Dysplasia of the Hip - an Engineering Study of Closed Reduction Utilizing the Pavlik Harness for a Range of Subtle to Severe Dislocations in Infants." Diss. College of Engineering and Computer Science at the Univeristy of Central Florida, 2015. Print.

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