Biomechatronic Hip Exoskeleton Team (BHET)

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Project Description

Background

- The NAU Biomechatronics Lab develops and tests robotic exoskeletons that provide powered assistance to the wearer during the walking gait cycle
- Research is focused on improving mobility for individuals with diminished motor function
- Created an exoskeleton for ankle assist

Project Description

Project Goal

- Design an exoskeleton device that applies torque assistance at the hips and measure the torque being delivered. The device will be used to test joint torque assistance needed to reduce the metabolic cost of walking.

Client

- Leah Liebelt
- NAU Biomechatronics Lab

Sponsor

- W.L. Gore & Associates

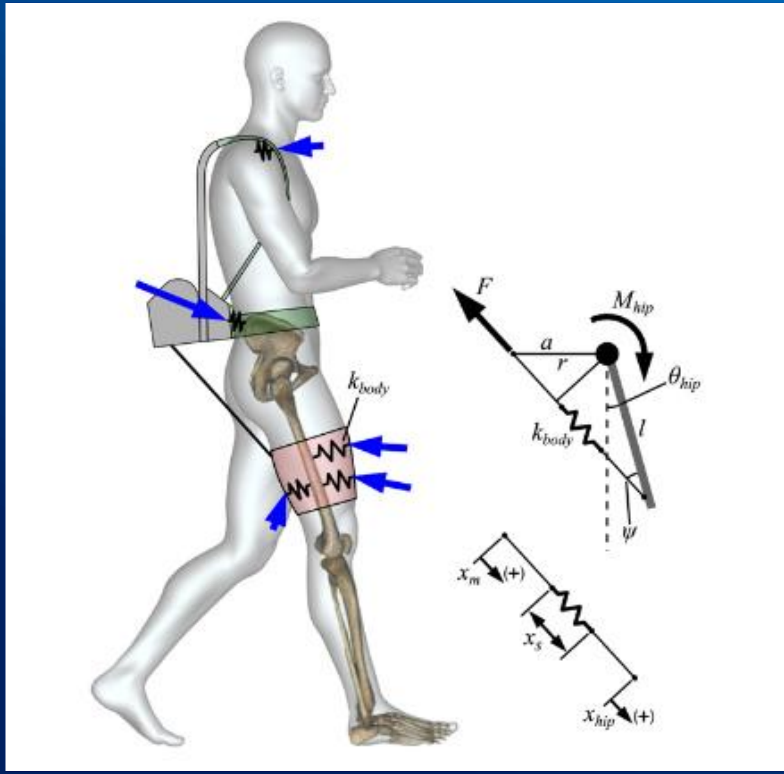
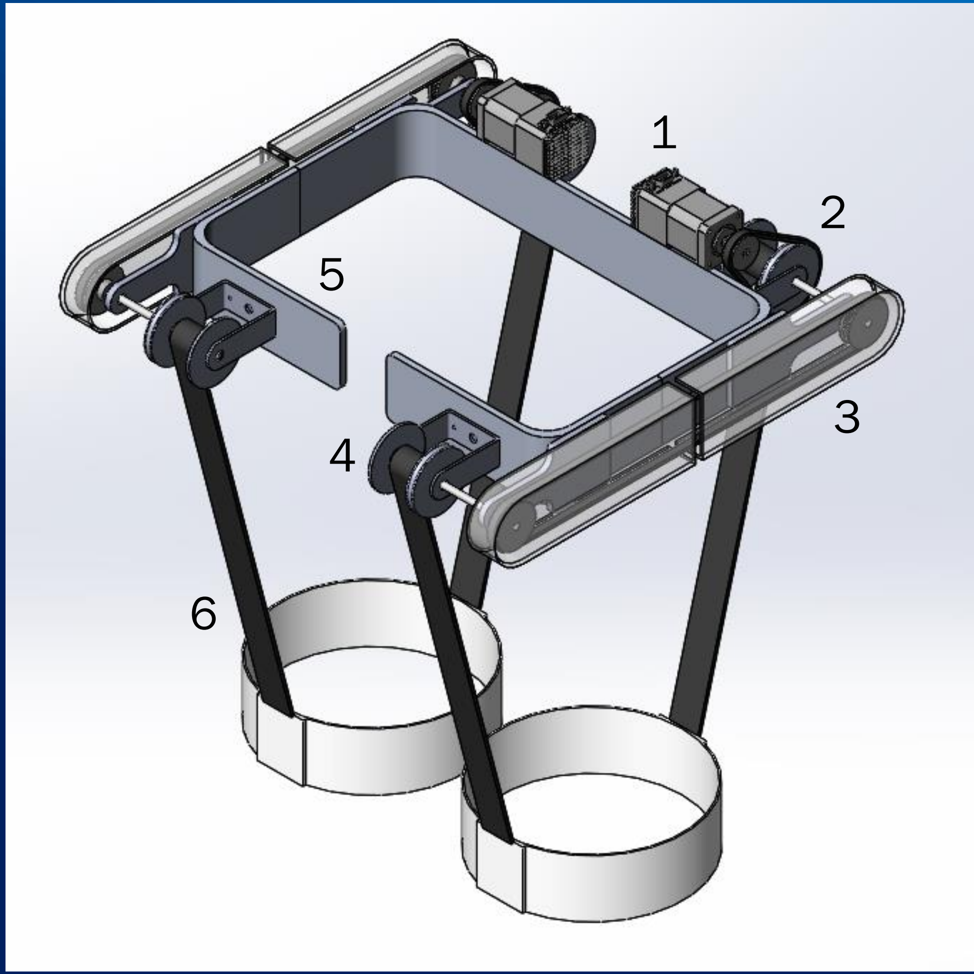


Figure 1: Force diagram of a hip exoskeleton design [1]

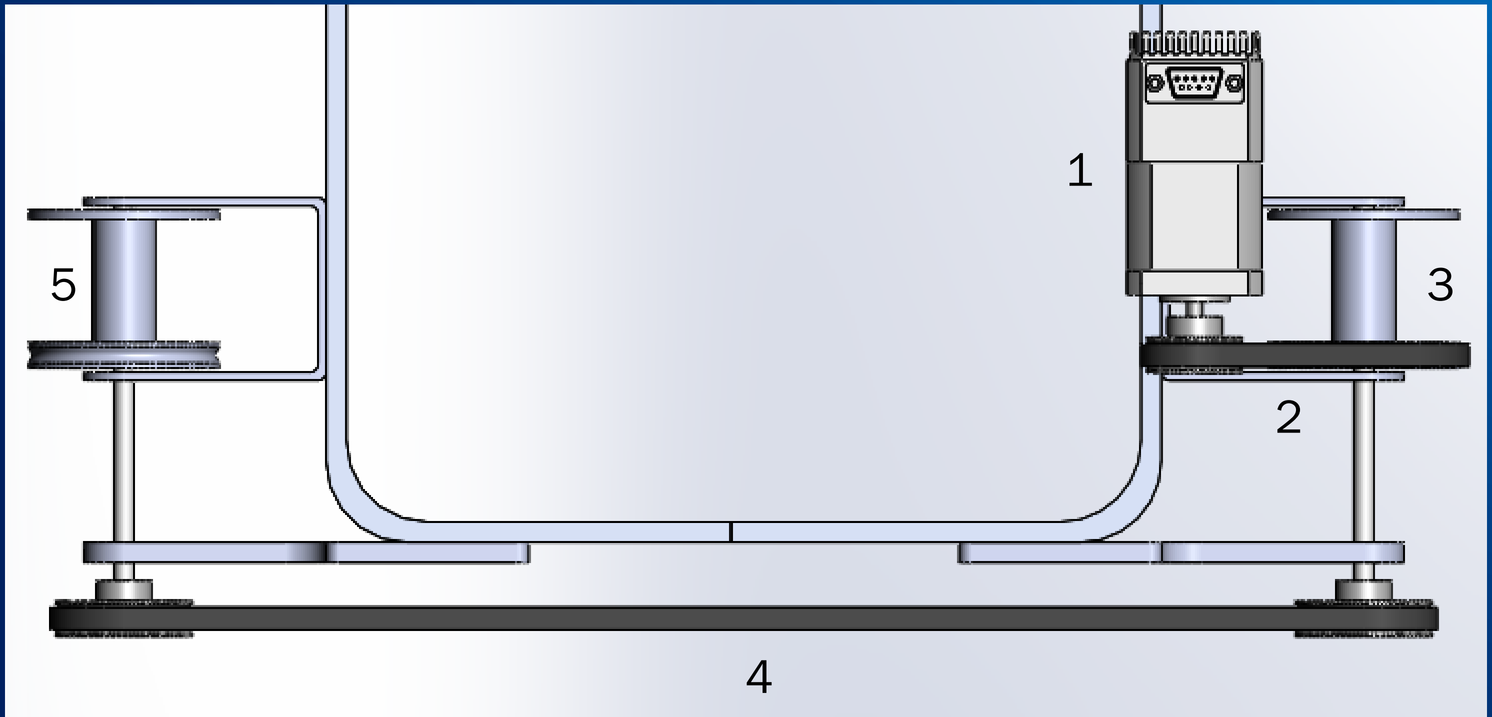
Design Description – CAD Model

1. Electric Motor
2. Rear Spool
3. Drive Belt with Cover
4. Front Spool
5. Rigid Frame
6. Belts with Leg Loops



Design Description – Drive System

1. Electric Motor
2. Drive Belt I
3. Rear Pulley
4. Drive Belt II
5. Front Pulley



Design Requirements

List of customer requirements:

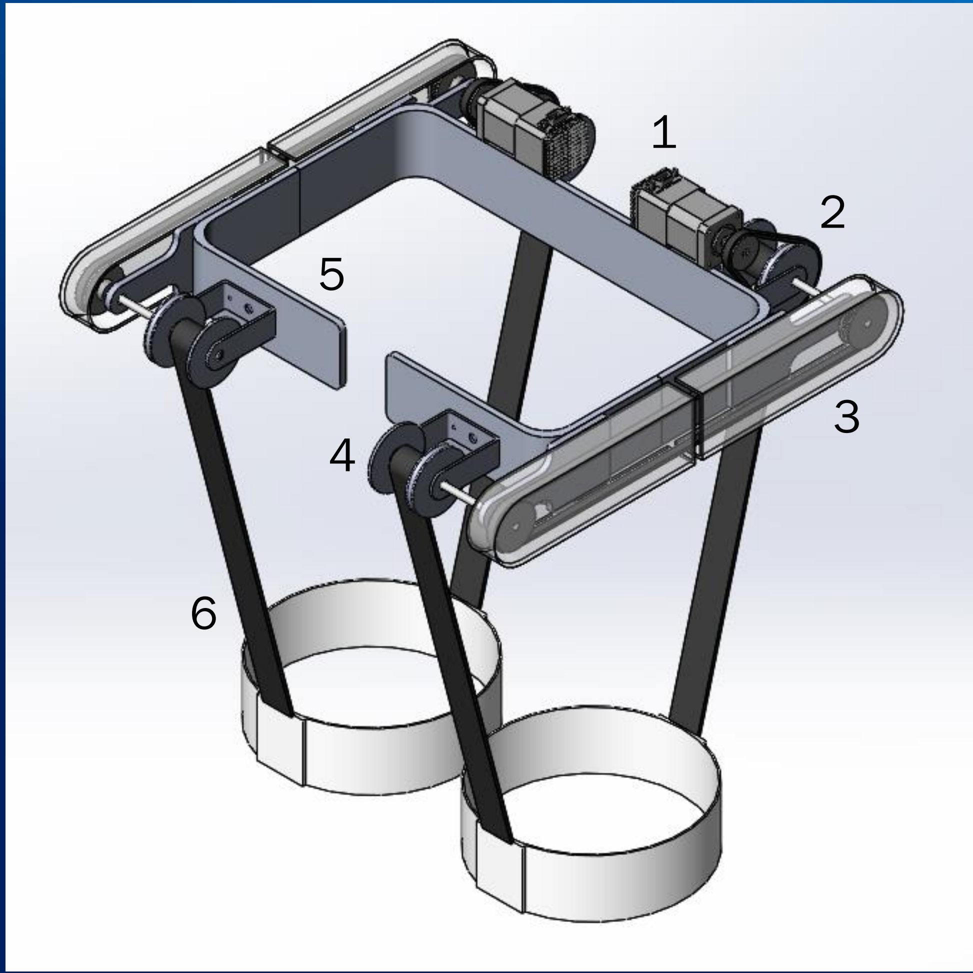
- Hip Actuation
- Full Range of motion
- Sense Torque
- Minimize metabolic cost
- Safe to operate
- Untethered
- Durable
- Easy to don and doff
- Comfortable
- Reliable
- Within Budget
- Fit small to medium build

Design Requirements – ER's

- Torque Applied (^)
- Metabolic cost of walking (v)
- Time to don/doff
- User comfort rating (0-10)
- Weight (v)
- Operation time/cycle (time per test) (^)
- Power required
- Cycles to failure
- Cost to manufacture (v)
- Extension/Flexion (^)
- Abduction/Adduction
- Rotation
- Noise (v)
- Compliance/comfortability.

Design Requirements

- **How design meets requirements:**
  - Design can actuate movement in extension/flexion (2, 4)
  - Able to move freely in other degrees of motion (6)
  - Untethered, run by a motor and battery (1)
  - Able to place sensors on the rigid frame (5)
  - It's easy to don and doff since it is attached to a soft belt



Design Requirements

Why we picked the prototype design:

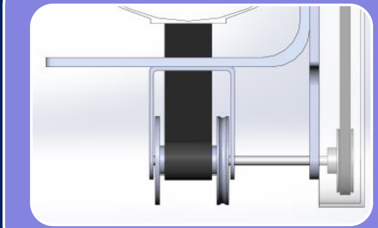
Mass

- Hamstring = 14.53 lbs.
- Belt = 5.89 lbs.
- Prototype = 4.41 lbs.
- The team wants to minimize the mass.

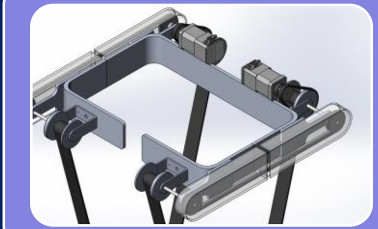
Motors

- Original belt system had four motors
  - Wanted to reduce this
- Prototype has a belt drive which reduces this amount to two motors
- Affects budget and power

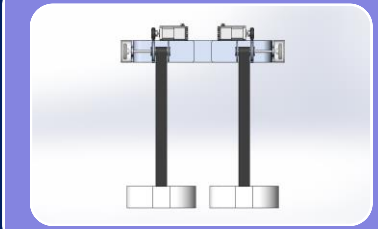
Design Validation – Potential Failures



Connection between Rigid Belt and Spools

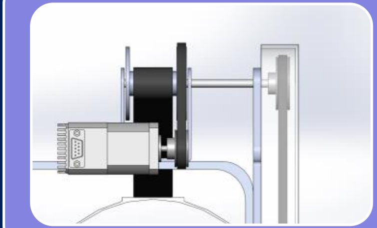


Frame Deflection during Torque Delivery



Belts Fraying or Failing

Design Validation – Test Procedures

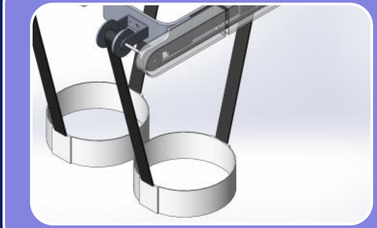


Materials Testing

- Frame Components and Spools

Frame Deflection Testing

- FEA Analysis, Test Rig

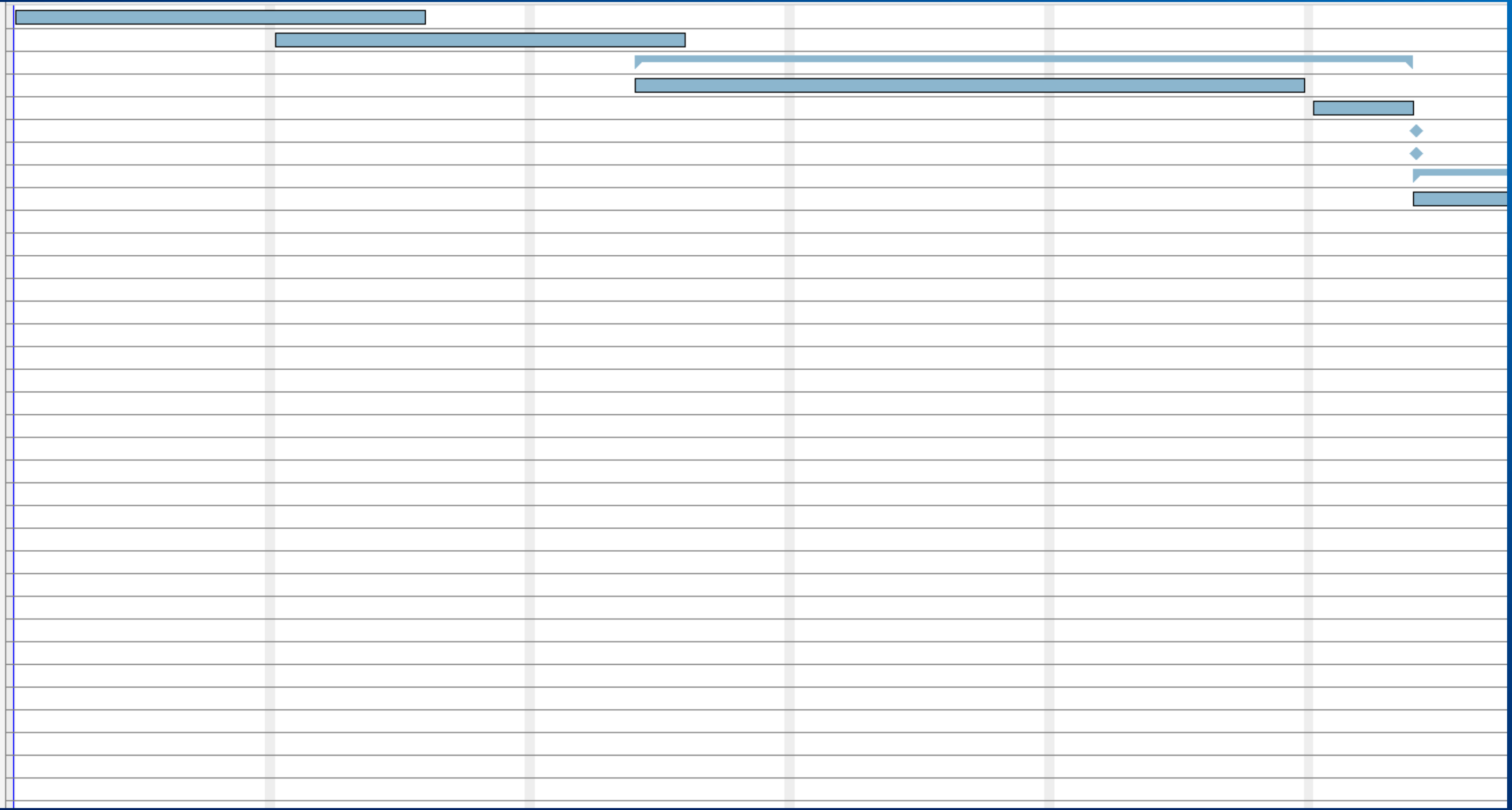


Tensile Testing on Belts

- Lightest weight possible

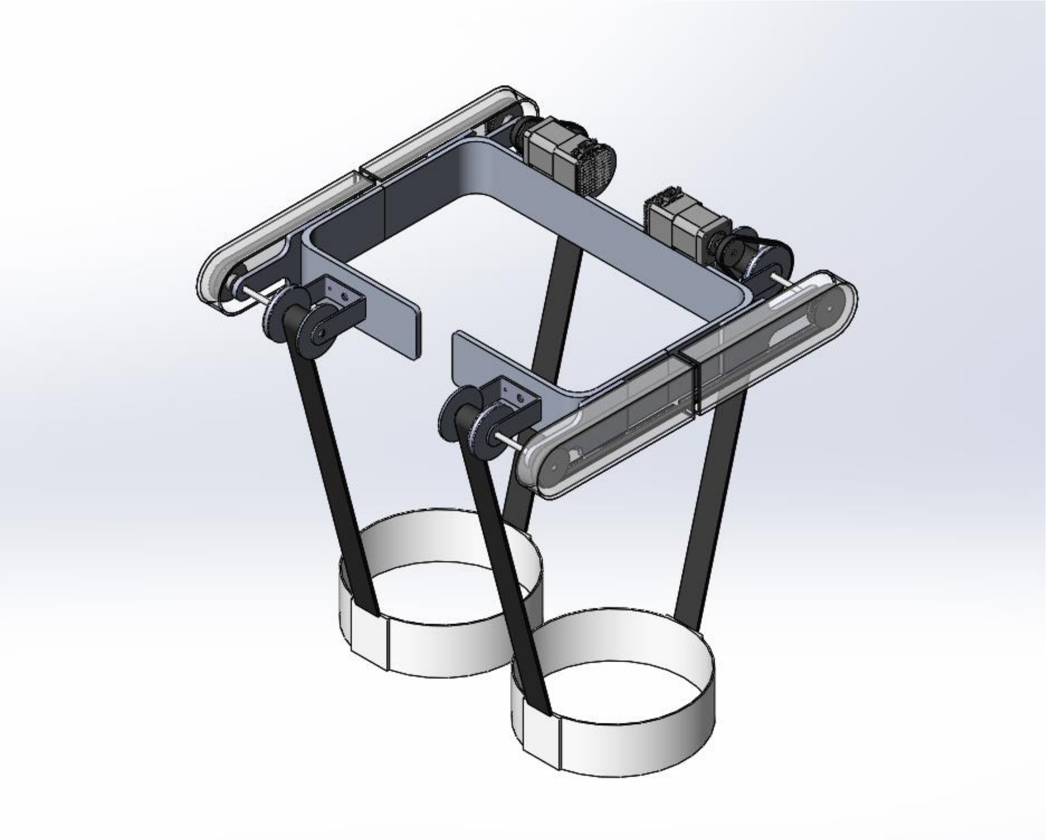
Schedule

Post Mortum Due	1/6/20	1/15/20	All
Self-Learning	1/13/20	1/22/20	All
Hardware Summary 1 Due	1/22/20	2/11/20	
Start Hardware Summary	1/22/20	2/7/20	All
Edit Hardware Summary	2/10/20	2/11/20	All
Hardware Summary Due	2/12/20	2/12/20	
Peer Eval 1	2/12/20	2/12/20	All
Website Check 1	2/12/20	2/18/20	
Edit Website	2/12/20	2/18/20	Mohanad Fakkeh,Inna Quiambao
Website Check Due	2/19/20	2/19/20	
Midpoint Report	2/24/20	3/3/20	
Start Midpoint Report	2/24/20	2/28/20	All
Edit Midpoint Report	2/28/20	3/3/20	Inna Quiambao
Midpoint Report Due	3/4/20	3/4/20	All
Individual Analysis II	2/24/20	3/10/20	
Choose Topics	2/24/20	2/28/20	All
Compile Research	2/28/20	3/6/20	All
Analysis II Due	3/11/20	3/11/20	
Device Summary	3/11/20	3/25/20	All
Peer Eval 2	3/25/20	3/25/20	All
Postar Drafts	3/25/20	4/1/20	All
Testing Proof	4/1/20	4/8/20	All
Final Poster	4/8/20	4/15/20	All
Operation Manual	4/15/20	4/15/20	Sean Oviedo
Final Presentation	4/13/20	4/22/20	
Compile Information	4/13/20	4/17/20	All
Edit Presentation	4/17/20	4/21/20	All
Presentation Due	4/22/20	4/22/20	
Final Report	4/13/20	4/28/20	
Compile Information	4/13/20	4/22/20	All
Edit Report	4/22/20	4/27/20	Keegan Ragan
Report Due	4/29/20	4/29/20	
CAD Package	4/15/20	4/29/20	Keegan Ragan,Sean Oviedo
Website	5/6/20	5/6/20	Mohanad Fakkeh
Peer Eval 3	5/6/20	5/6/20	All



Budget

Dual-Belt Design	
Component	**Price (Total)**
Aluminum Stock (Frame)	$75.00
Bearings and Gearing	$100.00
Harness	$50.00
Power Supply	$50.00
Battery	$50.00
Wiring	$30.00
1 inch webbing	$12.63
Electric Motor x 2	$1,200.00
Spools	$100.00
Knee Brace 2	$35.76
Buckles	$5.00
Sensors	$100.00
Total	**$1,808.39**



Thank you

Questions?

References

[1] A. T. Asbeck, K. Schmidt and C. J. Walsh, "Soft exosuit for hip assistance," Elsevier - Robotics and Autonomous Systems, vol. 73, pp. 102-110, 2015.

[2] M. O. Bair, "The Design and Testing of a Powered Exoskeleton to Reduce Metabolic Cost Of Walking in Individuals with Cerebral Palsy," Northern Arizona University, Flagstaff, 2018.