PURDUE UNIVERSITY

Vertically Integrated Project

Project Statement and Scope

Our team will focus on the problem of reducing the load on the lower backs of workers who can potentially overexert their back muscles to the point of injury, by building a passive exoskeleton that puts a supportive force on the chest of the user as they bend over. This exoskeleton may be used in various situations however, the target group for this specific model is those in manual labor professions.

We plan on creating a user testing protocol to test the reduction the exoskeleton provides by using electromyography (EMG) sensors on the erector spinae muscle while participants are bending to various positions. The positions that will be tested include standing up straight, bending to 25%, 50%, 75%, and all the way to the floor. These positions will be judged based on measurements for each participant individually.

HYUNDAI

laevo exoskeletons

ottobock.

hTRIUS

Background and Requirements

Our research is centered around a user assessment protocol performed on the Laevo exoskeleton to address the evaluate the effectiveness at reducing strenuous muscle activity during bending over tasks[1]. Industries that might value this technology include: the shipping, manufacturing, and healthcare sectors.

The requirements of this DIY exoskeleton are:

1) Reduce the force on the on the L5/S1 joint by at least 60%.

2) Reduced muscle activity (MVC) by 20%

3) Exoskeleton to cost less than $100 to build with the availability of conventional tools.

1. Koopman, A. S., Kingma, I., Faber, G. S., de Looze, M. P., & van Dieën, J. H. (2019). Effects of a passive exoskeleton on the mechanical loading of the low back in static holding tasks. *Journal of Biomechanics*, *83*, 97–103. https://doi.org/10.1016/j.jbiomech.2018.11.033

Final Design

Results

EMG Sensor Testing

The subject had Data Lite EMG sensors placed on the biceps femoris as well as the lumbar erector spinae muscles. The average root mean squared value was taken at each hand height during 3 trials of with the exoskeleton and without the exoskeleton. We expected that the load in the biceps femoris (hamstring muscles) would increase with the exo on as a result of posture correction however, it seemed to reduce the load on those muscles. The exo was also shown to have lower RMS values in the lumbar erector spinae muscles for all positions except for L1 for both right and left muscles and L5 on the left lumbar erector spinae muscle. For no values was the muscle activity reduced more than the goal of 60%.

Testing With The Exoskeleton On

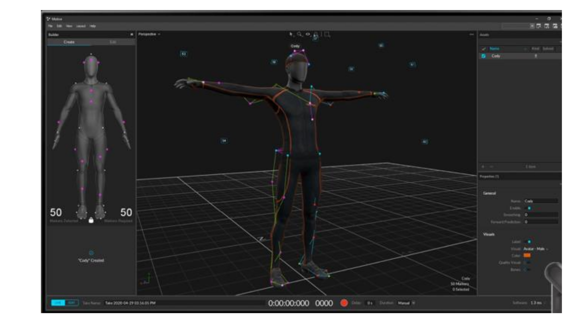
Level	Channel 1 RMS	Channel 2 RMS	Channel 4 RMS	Channel 5 RMS
L1	5.67	17	9	4.67
L2	20.67	12.67	17.67	3.67
L3	29.33	7.67	23	3.67
L4	20.33	7.67	13	4.67
L5	3.33	7.67	3.33	4.67

Testing Without The Exoskeleton On

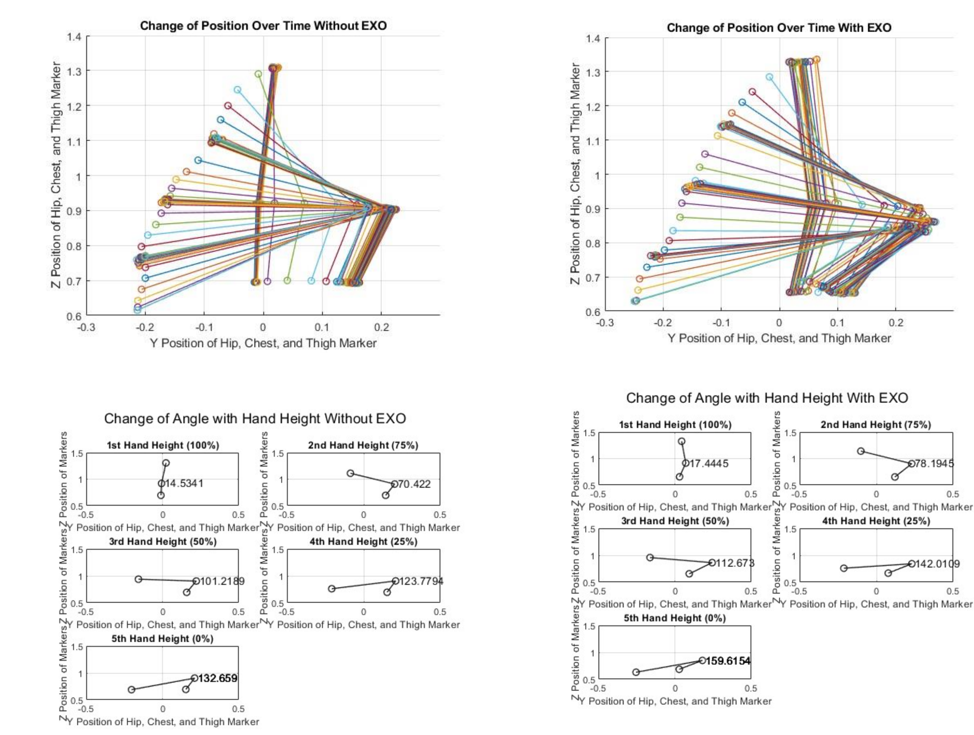
Level	Channel 1 RMS	Channel 2 RMS	Channel 4 RMS	Channel 5 RMS
L1	3.33	10.33	4.67	9.33
L2	29.67	9.33	26.67	5.67
L3	34.33	10	32	4
L4	27.67	10.67	22.33	6
L5	2.33	11	4	5.67

Motion Capture

Purdue's Envision Center was used for motion capture to analyze the exoskeleton's effectiveness. Subjects performed bending tasks both with and without the exoskeleton and we measured the change in angles between the tests at each bending height.



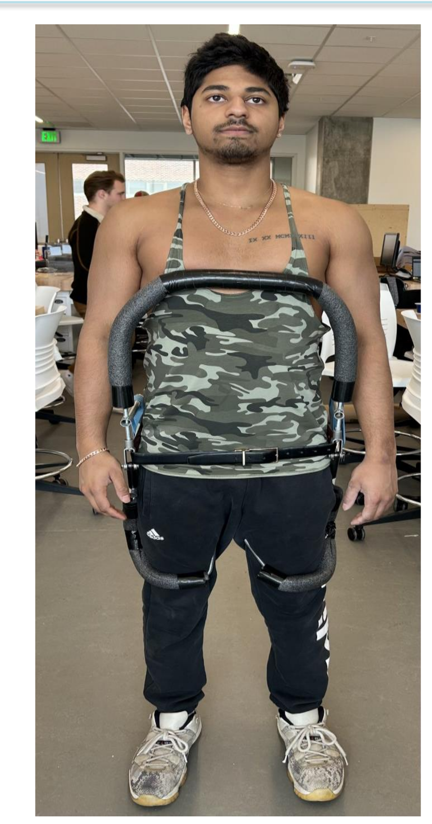
OptiTrack Motive Software



Experimentation and Concepts

The subject will have sensors attached at the lower back and hamstrings. Participants will start by standing upright with their arms and fingers extended downwards. Then, they will bend forward until their fingertips reach a location marker, shown in pink on a vertical ruler. The participant will pause for 5 seconds, then bend forward to the next pink marker.

The building process involved three prototypes. The first prototype had too many moving parts, introducing many points of failure. For the second prototype we simplified the design, but there still existed a point of failure in the hinge that we used at the bending point. For the third prototype, we replaced the hinge with a clevis rod, removing the previous point of failure.



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