PASSIVE EXOSKELETON FOR SIT-TO-STAND AND STAND-TO-SIT TRANSFER

Jake Okun, Manufacturing Engineering B.S.
Mentor: **Dr. Thomas Sugar**, Barrett, The Honors College Associate Dean & FSE Professor
ASU Ira A. Fulton Schools of Engineering, School of Manufacturing Systems and Networks

Research question

Can the usage of a custom passive exoskeleton assist people who have difficulty rising and lowering from surfaces due to diminished lower body strength as a result of aging?

Introduction

Wearable exoskeleton systems can aid injured individuals and help to reduce injuries in the home and/or in the workplace. We are learning that the possibilities for exoskeletons are life changing as they can provide ordinary people with assistance in completing everyday tasks.

According to AARP, about 37.3% of the United States workforce are above the age of 50 and almost 15% are over the age of 60 years or older. Furthermore, nearly 30% of of these workers are designated as essential and complete strenuous activities daily [1]. This number could be higher, but due to physical limitations, many people are forced to retire early or leave their job.

Professions like assembly line workers, welders, plumbers, and field laborers must continuously lower themselves to the ground and quickly raise up again.
Many individuals have trouble getting out of bed or chairs attributed to weak knees. This problem can be caused by age, obesity, minor injuries, or just doing repetitive chores with their legs. When getting up from a chair, there are four major steps to successfully move from a sit to a stand position. To do this, one must lift themselves up using their legs, specifically, the quadriceps, hamstrings, and glutes [2]. A surface is necessary for a person with weak or injured muscles to lift up or push against. This is a common condition among the elderly and professionals who are frequently on their knees.

We were able to improve our prototype in this ongoing endeavor in order to bring the device to market. This research enabled us to develop the first low-cost passive exoskeleton for sit-to-stand transfer, addressing one of today's significant aging challenges.

Our hypothesis is that a passive exoskeleton will provide an inexpensive and straightforward solution for those with mobility issues to move from kneeling or sitting to standing with less effort.

Background

Conventional passive support for sit-to-stand transfer is a cane, but the average walking cane does not support the appropriate method of rising or sitting oneself down softly. Other current sit-to-stand assistive technologies are not portable or passive and require another person to assist with the operation. Our solution will let people get up from a kneeling or sitting position without the usage of hefty external equipment. The most similar device is a hybrid exoskeleton designed in France which is powered and limits normal movement as it is extremely large and cumbersome to wear [3]. The objective is to help individuals who have difficulties getting up from the ground, a chair, or similar surfaces who have not been diagnosed with major knee or leg muscle injuries. Many people experience this problem because of age, obesity, minor injuries, or just doing repetitive chores with their legs. When getting up from a chair, there are four major steps to successfully move from a sitting to a standing position. In order to do this, one must lift themselves up using their legs, specifically, the quadriceps, hamstrings, and glutes. A surface is necessary for a person with weak or injured muscles to lift up or push against. This is a common condition amongst elderly people and professionals who are often on their knees.

Research Methods

Prior to beginning research with FURI, we had created a prototype of this device and began the patent process and successfully secured a provisional patent.
During the duration of this 2 semester long FURI project, the goal was to make improvements to the device and develop a more robust device with added comfort which eventually would be ready to license, produce, and bring to market. During the second semester of the FURI project, we followed the process below.

Improvements to Existing Device
- Review device results from last semester to determine improvements and testing procedure.
- Consider functional improvements.
- Order materials for the final device to ensure it is ready for industry exposure.

Data Collection
- Conduct tests determining:
  - How to make the device more robust for daily use and harsh working conditions.
  - Usability & Ease of Use
  - How to improve comfort.

Data Analysis
- Analyze Results
- Determine Failure Points
- Determine Possible Improvements

Improve Current Device
- Utilize results and list of failure points to create the device from the prototype model so the device will function as intended.

Research Additional Use Cases For Components of the iRISExo™
- Break up device into subassemblies and determine use cases for future exoskeleton devices based on the iRISExo™.

Acknowledgements

This research was made possible with the support and guidance from my mentor Dr. Sugar. Without his support, this project would not be at the level in which it is today! Thank you, Dr. Sugar, for all of your innovative ideas, time, and assistance. Furthermore, I would like to extend my gratitude to the FURI program for making this project a reality!

Applications & Discussion

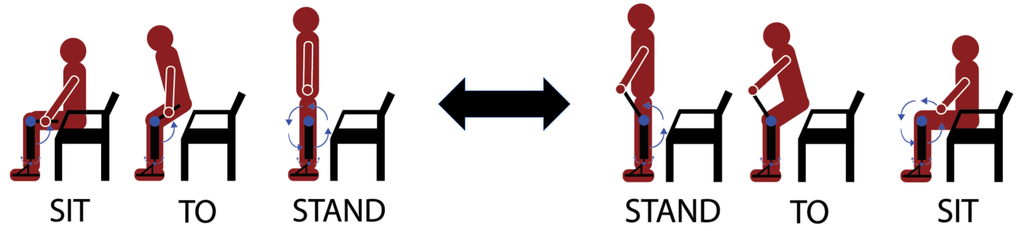

Figure 1: Use Cases For Sit to Stand & Stand to Sit Transfer Showing How The Device Operates.

Figure 2: Original Prototype.

Current Device Materials:
- Lightweight Carbon Fiber Body
- Carbon Fiber Tube Lever Arm
- Improved Custom Rotation Mechanism
- Carbon Fiber 3D-Printed Parts
- Custom Machined Components

The device is much stronger than the original prototype and also provides added levels of comfort due to the low-profile design.

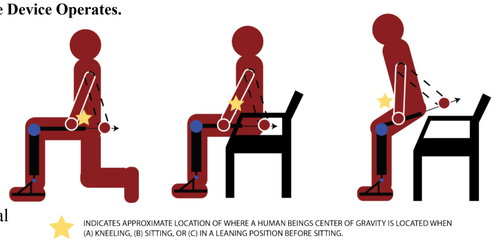

Figure 3: Improvements with extendable lever arm.

The possibilities for this device are endless. Skilled employees who are frequently on their hands and knees and bending down can utilize the device. These types of workers include plumbers and construction personnel. Furthermore, anyone can use the device around the house to help them get out of bed, lower themselves onto or off of a toilet, and give people the confidence to get up on their own as they once could when their knees were stronger. We improved the device this semester by using fewer components, stronger materials, an extended lever arm to allow for center of gravity adjustments, extra padding, and other features.

Conclusion

- The device shows success in accomplishing its goals. The device is able to successfully help someone get up from a chair or surface as well as aid in sitting down gently. Based on results found after testing, the revisions made to the device have helped in certain aspects making tasks such as sitting, standing, and kneeling easier, more comfortable and attainable.
- The utilization of robust, light-weight, and cost-effective composites in the device's design has resulted in a solid device that will not buckle under the strain of variable human strength and weight. The enhancements made this semester have helped make the device stronger in all types of operating settings. This semester, a patent for the device was also filed in order to help bring it to market in the near future.

Future Work

- Work on fatigue testing and analyze data to create a final device ready for sale.
- Make improvements with scalable device manufacturing in mind.
- Seek further opportunities for product licensing.
- Use the knowledge gained from iRISExo™ research to develop a series of exoskeleton devices based on similar passive components.

References

[1] Schramm, J. and Figueiredo, C., "The US Essential Workforce Ages 50 and Older," Sep. 2020.
[2] D. M. Scarborough, C. A. McGibbon, and D. E. Krebs, "Chair rise strategies in older adults with functional limitations," Nov. 2007.
[3] M. A. Alouane, W. Huo, H. Rifai, Y. Amirat, and S. Mohammed, "Hybrid FES-Exoskeleton Controller to Assist Sit-To-Stand movement," Feb. 2019.

FURI

iRISExo™
iRaise Instantly Sit Effortlessly

Ira A. Fulton Schools of Engineering
Arizona State University