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

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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 incredible and 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 abandon their employment.

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 due to 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 [2]. 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.

This research will help us create the first inexpensive passive exoskeleton for sit-to-stand transition, resolving one of today's major aging issues.

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

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 the FURI project, the goal was to make improvements to the device and develop a more robust device with added comfort.

Improvements to Existing Device
- Review current prototype.
- Consider possible design improvements.
- Order materials for the final prototype.

Develop a New Robust Prototype
- Construct an improved prototype
- Design the model for scalability to allow for several of the same devices to be created for testing purposes.

Data Collection
- Conduct tests determining:
  - How comfort level can be improved and which device functions better.
  - Usability & Ease of Use
  - Opportunities When the Device Would Be Useful

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

Improve Current Device
- Utilize results and list of failure points to create a final prototype for the spring semester that functions as intended.

Acknowledgements

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Applications & Discussion

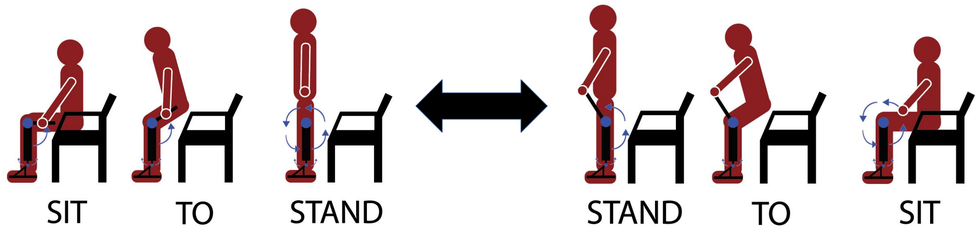

Figure 1: Use Cases For Sit to Stand & Stand to Sit Transfer Showing How The Device Operates.

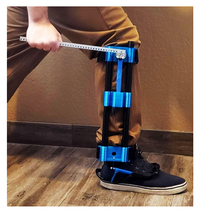

Figure 2: Original Prototype.

Original Prototype Materials:
- Lightweight Aluminum Piping
- Aluminum Extrusion Lever Arm
- One-Way Motion Device
- Aluminum Rotary Devices
- PLA Custom 3D Printed Parts

The device was functional, however, there were some concerns with the device strength depending on the force exerted by the user.

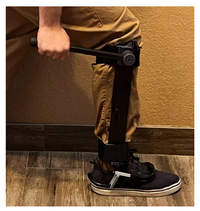

Figure 3: Current Device.

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.

The applications for this device are limitless. The device can be used by skilled workers who are constantly working on their hands and knees as well as bending down. An example of this type of worker is a plumber or construction worker. Additionally, the device can be used by anyone around the house to assist in getting out of bed, lowering themselves onto or getting off of a toilet, and giving adults the confidence to get up by themselves as they were able to when they had stronger knees.

Conclusion

- The device shows successes 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, it is clear that the device concept is valid and can help a large population of adults who have problems in their daily lives when doing simple tasks such as sitting, standing, and kneeling.
- By using light-weight affordable composites for the device construction, we believe that the product will have an affordable price tag allowing everyday consumers to purchase the device without having to worry about the large monetary contribution that other devices may require.

Future Work

- We intend to make modest design adjustments and allow for more testing and observation of the product.
- Work with test subjects to conduct a secondary data analysis to create a final device ready for sale.
- Make improvements with scalable device manufacturing in mind.
- Seek further opportunities for product licensing.

References

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