**Restoration of Arm Mobility with Power-Assist Exoskeletons for Young Men with Duchenne Muscular Dystrophy**

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**Opportunity and Significance**
Duchenne Muscular Dystrophy (DMD) is the most common form of muscular dystrophy, affecting over one in 5,000 boys [1]. Typically, by twelve years of age, muscle mass is reduced to a point where the individuals require power wheelchairs for mobility, and participation in activities of daily living (ADL) such as self feeding and grooming, become significantly more challenging [2]. In this phase of a larger study, we demonstrate the initial impact of an admittance-controlled, hybrid, power-assisted robotic exoskeleton on upper limb mobility.

**Technical Objectives**
1. Integrate admittance-controlled, power-assist technology into an existing passive mechanical exoskeleton
2. Characterize and refine the performance and behavior of the fundamental admittance control variables when applied to a hybrid exoskeleton system
3. Evaluate the impact of the enhanced hybrid system, by comparing passive mechanical-assisted to power-assisted range of motion (ROM)

**Related Work and State of Practice**
This study is based on previous research conducted at New Jersey Institute of Technology by Dr. Corrigan and Dr. Foulds, in which they demonstrated the admittance control system, developed by RUR, was evaluated and thoroughly field tested and is anticipated to be a commercially viable design. A full demonstration video, filmed and edited by Zachary and Raegan Smith may be viewed from the PPMD Conference On-Demand Library under the Resources & Tools category, title: Restoration Of Arm Mobility With Power-Assist Exoskeletons (Figure 1).

**Technical Approach and Accomplishments – Prototype Deployment**
- A Comparison of Vertical ROM between the passive and power assisted arms is illustrated in Figure 2 and detailed in Table 1. Of note, the ROM with the power-assisted arm exceed the passive arm assist by 265.8% (Table 1).
- The minimum system activation force required to operate this system ($F_{Min}$) is 0.22N(Table 2), approximately equivalent to the weight of 4 U.S. Quarters.
- Using the system, the team member was capable of generating upward forces in excess of 21x $F_{Min}$ and downward forces in excess of 9x $F_{Min}$ (Table 2). The output force of the system was greatly magnified compared to the activation force.
- A full demonstration video, filmed and edited by Zachary and Raegan Smith may be viewed from the PPMD Conference On-Demand Library under the Resources & Tools category, title: Restoration Of Arm Mobility With Power-Assist Exoskeletons (Figure 1).
- An admittance control system, developed by RUR, was evaluated and iteratively improved for safety and efficacy, prior to field testing by a research team member with DMD
- The device was then installed on our collaborating partner’s Permobil F5 power wheelchair and connected to a local WiFi to enable remote software downloads.

**Results and Discussion**

**Next Steps for Development and Test**
- In subsequent phases, the study will be expanded to include additional subjects.
- Vertical Range of Motion will be optimized across a DMD population with inhomogeneous arm strength.
- 3-dimensional motion tracking will be added to the system to map ROM and further our understanding of how enhanced assistance against gravity impacts variety and overall participation in ADLs

**Commercialization Plan & Partners**
- This study was funded by Parent Project Muscular Dystrophy under a global program to advance development in the area of assistive robotics in direct service of the DMD community.
- To ensure our research translates into real world tools, Talem Technologies LLC has partnered with Really Useful Robotics LLC (RUR)
- Design of the mechanical delivery component of this system was conducted in tandem with RUR during development of the control system.
- At the conclusion of this study, the resulting power assist device will have been thoroughly field tested and is anticipated to be a commercially viable design brought to market through Talem Technologies.

**References**

This study generously funded by Parent Project Muscular Dystrophy.