Thesis Project Portfolio

S.U.R.E.: Soft Upper-Limb Rehabilitation Exoskeleton

(Technical Report)

Identifying the Cause of Lower Physical Recovery Rates in Female and African American Stroke Patients

(STS Research Paper)

An Undergraduate Thesis

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Caroline Flanagan

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Department of Mechanical Engineering

Table of Contents

Sociotechnical Synthesis

S.U.R.E.: Soft Upper-Limb Rehabilitation Exoskeleton

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Prospectus

Stroke survivors often suffer from long-term cognitive and physical impairments, making stroke one of the leading causes of disability in Western countries (Carmo et al., 2015). Treatments have been developed to mitigate long-term disability and help patients return to daily activities. Despite the presence of rehabilitation methods, many patients continue suffering from symptoms including muscle weakness, partial paralysis, stiffness, and various cognitive deficits. Patients suffering from long-term disability may lose income due to inability to work, and may require full-time care from a live-in nurse or inpatient facility. This not only takes a financial toll on patients, but also impedes their quality of life. Both the STS and technical portions of this paper will pertain to improving stroke rehabilitation for motor functioning.

The technical research component aims to broaden access to rehabilitation by developing a soft upper-limb exoskeleton for stroke rehabilitation that can be purchased at a low cost and used at home, individually. Repetitive motions, such as raising and lowering the forearm, or clenching and unclenching the fist, are heavily utilized in physical rehabilitation. The goal of the exoskeleton is to generate these two motions using a small backpack to house electrical components, a wrist cuff, a glove, and cables. The total design is intended to weigh less than 5 pounds, and cost less than $300 to manufacture. I worked in a group of five students to assemble, code, and test this prototype. The product would allow for on demand, at home rehabilitation. Design features, including the wrist cuff and backpack, aim to allow for individual use for those suffering from partial paralysis. The low cost would make this device more accessible than a physical therapist or rehabilitation facility. Creating more accessible options for

stroke rehabilitation attempts to reduce the amount of patients suffering from severe long-term disability.

The STS portion of this research focuses on investigating the cause of demographic disparities in stroke recovery. Long-term physical disability post-stroke disproportionately affects female (Kelly-Hayes, 2003) and African-American (Horner, 1991, p. 1) patients. These demographics have endured varying forms of discrimination that have resulted in wage gaps and social divides. Higher rates of disability for female and African American patients perpetuate this issue, lowering income and independence. I specifically investigated the effects of treatment accessibility and medical trial representation, in an effort to narrow the scope of the research. The goal was to determine whether these factors had a greater impact on African American and female stroke survivors, and may contribute to the higher rates of mobility impairments in these patient groups.

The technical and STS research projects were limited due to time and resource constraints. Despite constraints, both projects produced valuable deliverables that can be improved upon by future researchers. The technical research succeeded in creating a prototype that generated the correct motions while being comfortable for the user. The design did not meet the goals for cost and weight, however, the research group has created a list of improvements that would help future prototypes meet these requirements. The weight of the prototype created is not large enough to compromise comfort, and the design remains under $600. We reasonably assume that large scale manufacturing, and the replacement of ABS plastic as the material for the circuit frame, would reduce the cost to below $300. My STS research question was narrower than

anticipated due to the time limit. Stroke treatment and rehabilitation may be affected by a wide variety of factors that would take years to investigate. The results of this research provided valuable deliverables for the factors studied. My research identifies the likelihood that healthcare and rehabilitation access, and medical bias contribute to the disparity in stroke recovery. The findings suggest that more research should be conducted to find ways to improve these shortcomings, and identify other contributing factors.

This research would not be possible without the guidance of my research advisors. Professor Forelle worked with me to develop my STS research question and discover the goal of my STS paper. Professor Wylie provided me with resources and feedback to create a plan for, and conduct, my STS research. My technical design project was under the guidance of Dr. Sarah Sun. She provided us with inspiration from past design teams and helped us troubleshoot our prototype. I would also like to acknowledge the hard work of my Capstone Design team throughout the course of the school year.