

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

**The Impact of the 2010 Vancouver Paralympic Games on Canadian Perceptions of People with Disabilities**

A Thesis Prospectus  
In STS 4500  
Presented to  
The Faculty of the  
School of Engineering and Applied Science  
University of Virginia  
In Partial Fulfillment of the Requirements for the Degree  
Bachelor of Science in Mechanical Engineering

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October 27, 2023

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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## **Introduction**

It is estimated that 16 percent of the world's population experiences a significant disability. People with disabilities worldwide are subject to stigma and discrimination perpetuated by harmful stereotypes. As a result, people with disabilities face inequalities in employment, education, and transportation, in addition to higher rates of homelessness and poverty (World Health Organization, 2023).

According to the Centers for Disease Control and Prevention (2023), strokes are among the leading causes of chronic disability in the United States. A stroke occurs when a blood clot or burst artery prevents blood flow in the brain (Centers for Disease Control and Prevention, 2023). Disabilities resulting from strokes are associated with substantial financial burden due to costly rehabilitation programs and medication, as well as the lengthy duration of care. A study published by the American Heart Association estimated the average lifetime cost of a stroke to be \$140,048 per patient (Go et al., 2014). In the over 65 population, strokes result in decreased mobility in more than half of patients, which is exacerbated by the lower brain plasticity in older adults as compared to their younger counterparts (Stanford Health Care, 2013). Today, more than 1 in 6 Americans are 65 or older. America's population demographic is expected to continue aging, as improved healthcare allows for increased longevity and fertility rates fall (He et al., 2016). It is predicted that there will be more than double the number of 65 and older Americans by 2040 than there were in 2000 (Searing, 2023). As this shift in the United States' age demographics continues, there will be a greater disability burden caused by stroke, which will require heightened demand for stroke recovery support.

As the United States ages, if engineers fail to develop technology to accommodate the growing demand for stroke rehabilitation, the rate of disability will increase markedly. My senior

design group's technical project addresses the need for affordable and accessible stroke rehabilitation technology. The development of a soft exoskeleton which provides fine motor and arm rehabilitation would allow patients to access intensive care from their own homes. This would alleviate pressure on already burdened healthcare systems, while providing a high quality and frequency of care to those that may not be able to afford it otherwise.

In addition to physical interventions to improve the disabled lived experience, it is crucial to investigate the effectiveness of attempts to address the discrimination faced by people with disabilities. People experiencing disabilities will continue to suffer from the impacts of ableism in the workplace, education, transportation, and sports if our society fails to provide effective social interventions. If I identify whether the worldwide broadcast of the Paralympics has dispelled stereotypes and improved the perceptions of people with disabilities for a statistically significant portion of viewers, this conclusion can inform the future of disability rights advocacy.

Because people with disabilities experience both social and physical barriers to equality, I plan to investigate whether the broadcast of the Paralympic Games was an effective social intervention for discrimination against people with disabilities in Canada, as well as developing technology to lower the financial and physical burden of stroke induced disability. Strokes are one of the primary causes of disability in North America, and the physical limitations resulting from strokes are subject to stigma and discrimination. Technology can be used to alleviate physical challenges posed by disabilities whereas social interventions are required to mitigate social barriers faced by people with disabilities. When both types of interventions are implemented, there is potential for the quality of life of those who experience disability to be significantly increased.

## **Technical Topic**

We are developing a soft robotic upper-limb exoskeleton for stroke rehabilitation. Following a stroke, many patients have limited mobility in one or both of their arms and hands. Physical therapy can help stroke patients recover their neural pathways to relearn how to use their arms and hands. Currently, most stroke rehabilitation exoskeletons are hard exoskeletons which help patients complete repetitive physical therapy exercises. Although extremely useful and effective, this technology is exceptionally expensive and thus is only available in hospitals and physical therapy centers. The implementation of a soft exoskeleton would increase the potential for recovery because it would allow patients to access physical therapy at home at a higher frequency and convenience. Our soft exoskeleton design has the benefit of increased wearability, meaning that the duration of therapy can be increased. Increased duration of care will enable stroke patients to improve their quality of life faster. Additionally, our design is constructed from affordable materials, meaning that a broader socioeconomic demographic would have access to high quality stroke rehabilitation care. Providing more intensive and frequent care would have the potential to improve recovery rates (O'Neill, 2020). As a result, developing highly accessible stroke rehabilitation technology could have widespread positive implications on overall recovery rates.

In addition to its soft property, our design differs from previously developed designs because it will combine a fine motor rehabilitation exoskeleton with an arm rehabilitation exoskeleton. The extension of the fingers will provide one additional degree of freedom. Our idea will incorporate ideas explored by researchers at the Harbin Institute of Technology's hybrid soft-rigid hand exoskeleton, which incorporates cable systems to assist with post-stroke fine motor rehabilitation. These researcher's attempts at creating soft rehabilitation robots

struggled to produce accurate mathematical models for the way soft exoskeletons will behave when subjected to the forces of a human hand or arm, and a cable system, resulting in their modification of the design to be a hybrid soft-hard model (Lin et al., 2021). We anticipate that the mathematical challenges of being able to accurately ascertain the impact of forces on a soft exoskeleton to be a major obstacle in our design project. We have used previous studies to determine that soft exoskeletons have the advantage of having superior ergonomics and more user comfort (Dinh, 2017). These findings have motivated us to pursue the soft model regardless of the expected setbacks. During the development of our design, we will test our design on our own arms to collect iterative feedback. We will be checking to ensure that our motors provide the correct amount of torque in the correct locations to simulate physical therapy exercises. If the correct physical therapy exercises are simulated successfully, this indicates that the robot would likely be effective for stroke rehabilitation. We will contact members of the stroke rehabilitation team at the UVA Medical Center to confirm this evaluation.

Our anticipated deliverable is providing 2 degrees of freedom to help repair arm deflection and extension and finger deflection and extension neural pathways simultaneously. In doing this, we will face challenges of creating multiple degrees of freedom in our design, as well as developing mathematical formulas to ensure that the IMU feedback we are receiving is accurate, and that we are providing the correct forces. If these obstacles can be overcome, our design will serve as a uniquely accessible and ergonomic solution to the growing demand for stroke rehabilitation.

### **STS Topic**

The Paralympic Games are held every two years in conjunction with the Summer and Winter Olympic Games. They allow elite athletes with a variety of physical and intellectual

disabilities to partake in Olympic events which they would otherwise be unable to participate in. Discrimination against athletes with disabilities are enforced by both legal frameworks and social systems. Ableism in government policies results in unequal access to employment, healthcare, and education. These factors result in increased rates of poverty, poor living conditions, and mental and physical health problems. Social stigmas and discrimination create, enforce, and perpetuate these ableist frameworks (World Health Organization, 2023).

The 2010 Vancouver Paralympic Games were attended by 230,000 spectators, and its broadcast was viewed by 1.6 million (2010 Vancouver Winter Games, 2010). This iteration of the Paralympic Games can be taken as a case study to demonstrate the potential mass media has for improving perceptions of people with disabilities. The Olympic Committee polled Canadians before and two months after the 2010 Vancouver Winter Olympic and Paralympic Games to assess their social and environmental impacts. A quarter of respondents said that their overall acceptance of people with disabilities increased “a lot” following the Games. Following the Games, 50 percent of respondents believed that the Paralympic games promoted an increase in accessibility of buildings, sidewalks and public spaces, 49 percent felt it increased athletic programs for athletes with disabilities, 41 percent felt it increased government support for people with disabilities. 16 percent of employers who responded to the survey felt that their willingness to hire people with disabilities had increased after the 2010 Paralympic Games (OGI-UBC Research Team, 2013). These statistics demonstrate that the Paralympic Games promote positive change in attitudes towards people with disabilities.

Although the 2010 Vancouver Paralympic games were widely praised for promoting inclusivity in the ableist world of elite athletics, the Paralympic Games have been subject to criticism by disability rights activists. One of the main concerns is that the physical ability of

Paralympics athletes grossly and harmfully misrepresents the experiences of the overwhelming majority of people with disabilities by portraying only disabled bodies which are at the peak of athletic ability. Another criticism is that to be eligible to compete, an athlete must fit into a specific category of disability within their sport. Disability is experienced in extremely diverse ways, meaning many people with disabilities are ineligible to compete in the Paralympics despite its praise for being inclusive. This leads to questions about how the categories are chosen, and why the people selecting the categories may view some disabilities as more desirable or marketable than others. Additionally, the constant comparison of Paralympic athletes to Olympic athletes is viewed as problematic, as it creates a sense of “othering” (Braye et al., 2013).

I will employ bodies and disabilities STS theory as my framework. Through this, I will gain an understanding of the social interventions necessary modify our environments to be compatible with the demands of people with disabilities (Blume et al., 2014). My methods will include analyzing data from the *Olympic Games Impact study for the 2010 Olympic and Paralympic Winter Games: Post-games report* and investigating if the change in attitudes seen two months after the game translated into any real action in the years following the game. I will study this change over the five years following the game using Canada’s National Statistical Agency’s data about accessibility. I will watch footage from the archives of CTVglobemedia, now Bell Media, who broadcasted to Games across Canada. When watching this footage, I will examine the language and imagery used to ascertain the qualities that this company was assigning to Paralympic athletes, and the moral messages they were attempting to convey. I will read opinion articles published about the Paralympics by disability rights advocates, and journal articles which have elicited the opinions of Canadians with disabilities to diversify the perspectives I am examining. I will contact people that worked on the games to gain insight into

the underlying social agenda of the Paralympic Games, and how the marketing and broadcast of the games were intended to impact Canadians. My research aims to investigate the message that the Paralympics have about living with disability and deduce whether the Paralympic Games are effective at dispelling stereotypes and promoting disability rights.

## **Conclusion**

My technical design addresses the high cost and burden of accessing stroke rehabilitation care to provide effective, affordable, and accessible at-home stroke rehabilitation care. My STS research aims to understand the impact that the Vancouver Paralympic Games have had on public perception of people with disabilities. Stroke patients, especially those who face financial barriers to accessing care, would benefit greatly from the invention of this technology. Disability rights advocates or non-profits would find this project useful in guiding the programs and ways they attempt to reduce bias against people with disabilities, as well as developing a comprehensive understanding of the critiques that events like the Paralympics face. Technology can be used to alleviate physical challenges posed by disabilities whereas social interventions are required to mitigate social barriers faced by people with disabilities.



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