Modular Walker Handles for a Motorized Posterior Walker

Healthcare Disparities Amongst the Disabled

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 Biomedical Engineering

By
Alex Price

December 15, 2023

Technical Team Members:
Sana Farrukh
Ethan Young

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.

ADVISORS

Rider Foley, Department of Engineering and Society

Dr. Shawn Russell, Ph.D., Department of Orthopedic Surgery and Mechanical Engineering

INTRODUCTION

In the United States, approximately 61 million adults, representing 26% of the adult population, live with a disability (Okoro et al., 2018). This includes a wide spectrum of disabilities, such as intellectual and physical. Among the 61 million adults, 39 million have motor impairments that limit their ability to walk and perform other physical activities (Martinez, 2022). Medical devices are used to diagnose and treat illnesses, as well as assist individuals with long-term physical disabilities (LTPD).

The motivation for my capstone project includes the further research and development of medical walking aids for people with disabilities. The utilization of medical walkers and other assistive devices can lead to improved gait patterns and patient position while walking. This not only enhances mobility, but also reduces hip and knee flexion, which decreases the risk of injuries (Krautwurst et al., 2016). The intricate process of designing and developing a medical device involves the integration of additional technological components. For example, a standard motorized walker is composed of a metal framework, handlebars on each side, four wheels, and the electrical system that allows movement. My project involves the design and development of modular handlebars, capable of detecting the applied force by the user.

The technical aspect of my project primarily focuses on children with cerebral palsy, which is the most common motor disability among the younger population. Given that there is no cure for cerebral palsy, it is essential for children with this condition to actively work on their development and motor skills to lead relatively normal lives. To achieve this, they need assistance in the form of machinery and human care. Research has shown that "timely access to health care services and durable medical equipment may have serious impact on the health status and maintenance of individuals with LTPD” (Wong et al., 2019, p. 373).

In spite of the increased demand for medical assistance among the disabled community, disparities persist within the healthcare system, affecting the quality and accessibility of care. In interviews with fourteen healthcare practitioners experienced in caring for physically disabled patients, "very few reported that they had accessible scales that could accommodate patients who used wheelchairs" (Mitra et al., 2017, p. 448). These inequalities result from various factors, such as insufficient medical education and biases held by physicians toward individuals with disabilities. A study focusing on medical education found that “only 20% of American medical/dental schools included disability awareness content" (Lee et al., 2021, p. 2). Further research is essential to reduce the disparities experienced by disabled individuals within the healthcare system.

This leads me to the fundamental question of how we can efficiently modularize and transfer the walker handle, equipped with force measuring capabilities, across various walkers to aid in the research of individuals with physical disabilities and their unique healthcare needs. The technical aspect of my project aims to improve data collection efficiency and accuracy by designing a modular handlebar system to assist children with cerebral palsy. The sociotechnical aspect examines the disparities that individuals with physical limitations experience in the healthcare system.

MODULARIZED WALKER HANDLES

The Motion Analysis and Motor Performance Lab at the University of Virginia is in the process of developing a motorized posterior walker for use by children with cerebral palsy. This study is currently in the testing phase, involving the utilization of both motorized and self-propelled walkers in each trial. The ultimate goal of this posterior walker, positioned behind the user, is to follow the patient based on their speed and direction, as calculated through the force applied on the handlebars (Russell et al., 2011).

In contrast to an anterior framed walker, research indicates that "for better gait pattern, less UE burden and energy consumption, the adaptive therapeutic posterior walker is relatively the proper choice among all" (Tao et al., 2020, p. 877). Our primary focus is the design of the modular handlebar, which aims to measure the load applied to the walker by the patient. These measurements are then used to generate how much force the motorized walker should use, aiding the patient in moving forward. The handlebar contains a 6-axis force transducer to accurately measure the applied load. We aim to improve and modularize the handles to allow for faster and easier assembly and testing. The need to create a modular version is due to the fact that the force transducers used in the lab cost roughly $6,700 (ATI, n.d.), making it impossible to utilize multiple handles and transducers in each trial. To accomplish this, our design will include a cylindrical locking mechanism to hold the transducer in place and a clamping method to quickly mount and dismount the handle upon the existing walker base.

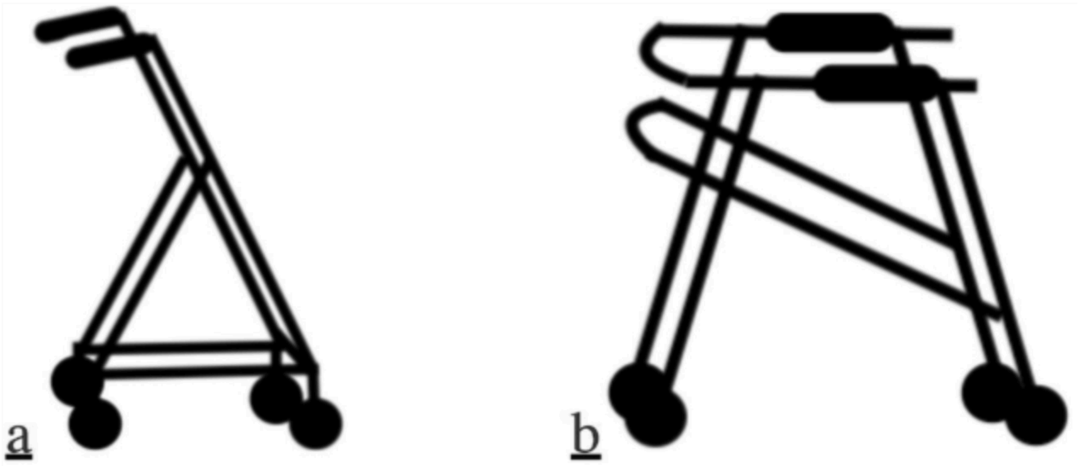

Figure 1. (a) Anterior framed walker (b) Posterior framed walker (Source: Tao et al., 2020)

When working with children, assembly time is very important, so it is essential to quickly and properly switch between the various types of walkers used without impairing the function of the force transducer inside the handlebar. Oftentimes, the longer it takes between steps of data collection, the higher chance of altering other measurements, such as the markers on the patient and the attached electromyogram (EMG) which are used to monitor the patient's physical movements and muscle contractions. Currently, the handle used in the lab requires three people and several minutes to mount and dismount. One person holds the walker base, one holds the handle, and the other person unscrews the mounted handle. We plan to design a handle that only requires one person, one hand holding the walker and the other dismounting it. The universal, modular design reduces the waiting time for each patient between each trial, which in turn increases the amount of data, as well as the accuracy that can be collected.

Throughout the design and development process, strict adherence to certain standards and regulations is crucial to ensure patient safety. For example, The Health Insurance Portability and Accountability Act (HIPAA), the International Organization for Standardization (ISO), and the

Americans with Disabilities Act (ADA) are three of many federal regulations that we have to obey. We must also follow certain ethical and legal standards related to clinical research involving children. These regulations and expectations for proper care are essential in reducing health disparities among individuals with disabilities. According to a recent study, “Physicians in all three groups noted the lack of sufficient knowledge, experience, and skills among themselves and their clinic staff concerning care for people with disabilities” (Rodriguez, 2022). This gap in knowledge leads to inequality in healthcare accessibility and quality, which needs to be further researched and improved.

HEALTHCARE DISPARITIES AMONGST THE DISABLED

Despite the greater need for health care services among individuals with disabilities, research has shown that able-bodied people "were more likely to have better physical access to healthcare on several measures than persons with a disability" (Mutwali & Ross, 2018, p. 6). These physical barriers, such as inaccessible buildings and equipment, limit their ability to receive help they may desperately need. This topic is tightly coupled to the research associated with my capstone technical project by advancing equipment for better data collection and treatment methods regarding individuals with disabilities.

A study by Unver and Erdem (2019) examines the relationship between motor function, cognitive function, and the quality of life experienced by children with cerebral palsy. Quality of life was assessed through a questionnaire regarding the patient’s physical and mental well-being, including self-esteem and general health perception. They determined that impaired motor and cognitive functions have a detrimental effect on the child's well-being (Unver & Erdem, 2019). Therefore, it is essential to maintain cognitive and physical function, through additional machinery and human care, to ensure patient safety and well-being.

Individuals with physical limitations require unique methods of care that demand further medical education to understand. Insufficient knowledge of how to care for people with disabilities (PWDs) results in inadequate treatments of these conditions. A study conducted by Gonzalez and Hsiao (2020) examined the differences in education curriculums across various healthcare programs and discerned that "diversity in health care will improve the quality of care and access to care for underrepresented groups" (Gonzalez & Hsiao, 2020, p. 54). Prior research has also indicated that physician biases, such as ableism, can reduce the accessibility and quality of healthcare for those with disabilities (Mulcahy et al., 2022). Hence, it is essential to advance disability awareness and education of their specific healthcare needs.

A study conducted by Shon et al. (2020) interviewed various healthcare professionals from medical, academic, and government sectors to gather their opinions regarding the information PWDs require and their awareness of such information. The majority of interviewees "felt that most health-care facilities and medical professionals do not have a sufficient understanding of the conditions experienced by PWDs" (Shon et al., 2020, p. 4). This deficit in knowledge results in inadequate care concerning the medicine and assistive devices given to them for treatment. They also discussed financial aspects that can reduce the quality of care given to PWDs, "as these cases generally involve a relatively low medical fee" (Shon et al., 2020, p. 4).

Another crucial aspect is health insurance coverage. Individuals with disabilities are more likely to have health insurance due to their greater need for medical assistance. However, research has shown that “disparities in access to health care based on disability status remain even for persons who have insurance” (Henning et al., 2013, p. 1015). Although they still experience inequality, it is significantly reduced when the patient is insured (Miller et al., 2014).

My research involves various stakeholders, including the doctors and physical therapists providing care, as well as the patients receiving this care. Healthcare administrators and insurance companies also play a significant role in healthcare regulations. Strengthening the relationship between stakeholders is essential to understand their needs and ensure accountability within the healthcare system. For example, the Hippocratic oath is used to uphold ethical standards regarding patient safety and providing proper care. However, the knowledge gap regarding disabled communities leads to inadequate healthcare and potential harm to patients.

The Social Construction of Technology (SCOT) serves as a theoretical framework for analyzing complex systems and emphasizing the influence of social interaction on the development of technology. I will utilize SCOT to examine the various factors surrounding my research, including technical and social factors, and how they impact the care received by individuals with disabilities. This allows for better understanding of the socio-technical relationships, which could improve the interaction between the patients, providers, and the medical equipment used.

The design and implementation of such equipment depends on the social group it is being applied to (Pinch & Bijker, 1984). For example, individuals with disabilities require more assistance when moving around. Therefore, an improvement to the original design, made for those without disabilities, must be made in order to accommodate and deliver adequate care to those in need.

The efficacy of medical treatment is significantly influenced by the machines employed by doctors, shaping the treatment process and its outcomes. Additionally, the social aspect affecting the patient's health is the extent of the doctor's knowledge and their ability to care for the physically disabled. Enhancing the overall understanding of disabilities and their unique healthcare needs will allow for advanced care and improved well-being for these patients.

RESEARCH QUESTION AND METHODS

Individuals with disabilities encounter numerous obstacles when seeking healthcare, resulting in disparities that affect the quality of care they receive. This prompts the question: How can we improve the quality and accessibility of healthcare for individuals with physical disabilities?

To examine these disparities, surveys and interviews will be conducted of various hospital staff members within the University of Virginia Health System. First-hand information is essential for analyzing a system as complex as healthcare. The primary stakeholders surrounding my research are doctors and patients receiving care. Directly observing the interactions between these stakeholders is crucial for gaining insight into their relationship. Through interviews, I aim to gather information regarding the doctor's extent of knowledge of various disabilities and their unique healthcare needs.

In addition, I plan on researching prior literature and legislative regulations related to individuals with disabilities, such as the ADA and HIPAA. Reviewing various healthcare regulations will allow for comparison of the current healthcare practices affecting the disabled community and how to better align them with these federal standards. For instance, a study conducted by Pellegrini and Geissler (2020) discusses the importance of federal disability-based benefits. Given the many obstacles individuals with disabilities experience in receiving proper health care, government assistance plays a vital role in reducing these barriers. According to their research, when faced with these barriers to healthcare, “individuals with a disability have been shown to be more likely to delay/forego care”, which can have adverse effects on their overall health (Pellegrini & Geissler, 2020, p. 1).

Through the lens of SCOT, I can better analyze these research methods and the various stakeholders involved in the healthcare system to determine their roles in addressing this inequality.

CONCLUSION

When individuals with disabilities experience substantial barriers at receiving proper health care, they tend to be less inclined to seek needed care. This stems from past experiences of either being denied care or receiving inadequate treatments. According to Kim and Jeon (2023), the disabled community faces a significantly higher rate of unmet healthcare needs and preventable hospitalizations, compared to those without disabilities (Kim & Jeon, 2023). Furthermore, a study regarding breast cancer screening among women with and without disabilities revealed a large disparity in the frequency of these screenings (Shin et al., 2020). Additional factors affecting the likelihood of individuals with disabilities seeking care include health insurance coverage and the provider’s insufficient knowledge regarding these conditions.

These social issues are tightly coupled to my technical project by working to improve the quality of care and machinery designed specifically for those with disabilities. By evaluating and advancing healthcare procedures and equipment commonly used by individuals with disabilities to better align with their unique needs, the disparities affecting the quality and accessibility of this care can be diminished.

REFERENCES

ATI: 6-axis force and Torque Sensor (Mini45 series) 9105-TW-mini45-R-5-IP65. motionsupply.com. (n.d.). Retrieved from https://www.e-motionsupply.com/product_p/9105-tw-mini45-r-5-ip65.htm

Gonzalez, H. C., & Hsiao, E.-L. (2020). Disability inclusion in nursing education. *Teaching and Learning in Nursing*, *15*(1), 53–56. doi:10.1016/j.teln.2019.08.012

Henning-Smith, C., McAlpine, D., Shippee, T., & Priebe, M. (2013). Delayed and unmet need for medical care among publicly insured adults with disabilities. *Medical Care*, *51*(11), 1015–1019. doi:10.1097/mlr.0b013e3182a95d65

Kim, S., & Jeon, B. (2023). Decomposing disability inequality in unmet healthcare needs and preventable hospitalizations: An analysis of the korea health panel. *International Journal of Public Health*, *68*. doi:10.3389/ijph.2023.1605312

Krautwurst, B. K., Dreher, T., & Wolf, S. I. (2016). The impact of walking devices on kinematics in patients with spastic bilateral cerebral palsy. *Gait & Posture*, *46*, 184–187. doi:10.1016/j.gaitpost.2016.03.014

Lee, M. S., Diaz, M., Bassford, T., Armin, J., & Williamson, H. J. (2021). Providing equitable access to health care for individuals with disabilities: An important challenge for medical education. *HPHR Journal*. *44*, 1-7. doi:10.54111/0001/rr2

Martinez, C. (2022). Disability Statistics in the US: Looking Beyond Figures for an Accessible and Inclusive Society. Retrieved from https://www.inclusivecitymaker.com/disability-statistics-in-the-us/

Miller, N. A., Kirk, A., Kaiser, M. J., & Glos, L. (2014). The relation between health insurance and health care disparities among adults with disabilities. *American Journal of Public Health*, *104*(3). doi:10.2105/ajph.2013.301478

Mitra, M., Smith, L. D., Smeltzer, S. C., Long-Bellil, L. M., Sammet Moring, N., & Iezzoni, L. I. (2017). Barriers to providing maternity care to women with physical disabilities: Perspectives from Health Care Practitioners. *Disability and Health Journal*, *10*(3), 445–450. doi:10.1016/j.dhjo.2016.12.021

Mulcahy, A., Streed, C. G., Wallisch, A. M., Batza, K., Kurth, N., Hall, J. P., & McMaughan, D. J. (2022). Gender Identity, disability, and unmet healthcare needs among disabled people living in the community in the United States. *International Journal of Environmental Research and Public Health*, *19*(5), 2588. doi:10.3390/ijerph19052588

Mutwali, R., & Ross, E. (2018). Disparities in physical access and healthcare utilization among adults with and without disabilities in South Africa. *Disability and Health Journal*, *12*(1), 1–8. doi:10.1016/j.dhjo.2018.07.009

Okoro, C. A., Hollis, N. D., Cyrus, A. C., & Griffin-Blake, S. (2018). Prevalence of disabilities and health care access by disability status and type among adults — United States, 2016. *MMWR. Morbidity and Mortality Weekly Report*, *67*(32), 882–887. doi:10.15585/mmwr.mm6732a3

Pellegrini, L. C., & Geissler, K. H. (2020). Disability, federal disability benefits, and Health Care Access after the affordable care act. *Journal of Disability Policy Studies*, *31*(4), 1–11. doi:10.1177/1044207320919959

Pinch, T. J., & Bijker, W. E. (1984). The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. *Social Studies of Science*, *14*(3), 399–441. http://www.jstor.org/stable/285355

Rodriguez, S. (2022). Discrimination Shapes Care Access for Patients with Disabilities. Retrieved from https://patientengagementhit.com/news/discrimination-shapes-care-access-for-patients-with-disabilities

Russell, S., Bennett, B., Sheth, P., & Abel, M. (2011). The gait of children with and without cerebral palsy: Work, energy, and angular momentum. *Journal of Applied Biomechanics*, *27*(2), 99–107. doi:10.1123/jab.27.2.99

Shin, D. W., Yu, J., Cho, J., Lee, S. K., Jung, J. H., Han, K., … Kawachi, I. (2020). Breast cancer screening disparities between women with and without disabilities: A national database study in South Korea. *Cancer*, *126*(7), 1522–1529. doi:10.1002/cncr.32693

Shon, C., Jeon, B., Lim, J. H., Park, S. Y., Lee, Y.-R., Kim, Y.-E., … Oh, I.-H. (2020). Focus Group interview regarding the accessibility of health information for people with disabilities and means of improving this accessibility in the future. *Medicine*, *99*(8). doi:10.1097/md.0000000000019188

Tao, R., Feng, L., Xiao, Z., & Zhang, B. (2020). Posterior versus anterior walkers for children with cerebral palsy-biomechanical analysis and Energy Consumption: A systematic review. *Journal of Developmental and Physical Disabilities*, *32*(6), 877–892. doi:10.1007/s10882-020-09731-3

Unver, B., & Erdem, E. U. (2019). Effects of intellectual disability on gross motor function and health related quality of life in cerebral palsy. *Clinical and Experimental Health Sciences*, *9*(2), 138–142. doi:10.33808/clinexphealthsci.516098

Wong, J. L., Alschuler, K. N., Mroz, T. M., Hreha, K. P., & Molton, I. R. (2019). Identification of targets for improving access to care in persons with long term physical disabilities. *Disability and Health Journal*, *12*(3), 366–374. doi:10.1016/j.dhjo.2019.01.002