The Development of a Head and Neck Support Device for Children with Cerebral Palsy

H. Cooke1, C. Davies1 and Q. Li 1

1 Department of Mechanical Engineering, Queen’s University, Kingston, Ontario

INTRODUCTION

Children with cerebral palsy (CP) that are classified as levels 4 and 5 on the Gross Motor Function Classification System (GMFCS), struggle with posture and sitting upright [1]. The proposed research will develop a head and neck support device for children with CP. A user-centered design approach has been taken through partnerships made with children with CP, in the Kingston community. A quality function deployment (QFD) was performed to identify the engineering specifications. A series of tests were performed to gain information about the participant, which is vital for the development of the device. The first objective was to measure the range of head motion during cervical flexion, and the second was to quantify the force exerted during these movements. The device will be designed using AutoCAD software, SolidWorks and manufactured using a combination of computer numerical control and three-dimensional printing. Once manufactured the device will be evaluated both quantitatively and qualitatively.

II. Methods

Co-design Process

By conducting a QFD, clear design requirements can be established between the client and the primary researcher. Design requirements were categorized by aesthetics, usability, performance, and structural properties. These design requirements were then translated into technical engineering specifications. Throughout the entire project, the primary researcher and the client have met biweekly. They have reviewed and ranked multiple design options and have worked through many different weighted design matrices. Their feedback has been crucial to create an optimal design.

## Testing

Prior to the design phase, a detailed assessment of the client's specific needs and preferences is critical to inform the development process. Thus, two testing scenarios were created to collect data on head/neck force and motion. To assess head motion as the client moves from an upright position through cervical flexion, inertial measurement units were used. Two sensors were placed on the forehead and neck, and the data was recorded and plotted. A second testing scenario was created to quantify the force exerted by the client when they moved from the upright position through cervical flexion. A strap force sensor, which included a strain gauge, was placed on the client’s forehead and the data was recorded and plotted in a spreadsheet. The tests will be repeated once the device is developed, to evaluate improvement in these areas.

## Design

The design process has included reviewing the literature, hosting a parallel design session, and working with the client to design the device. To ensure the device addresses the issues that the client experiences with other assistive devices, it is important to understand the types of head and neck support devices currently available. The primary researcher and the client discussed available devices and identified why they didn’t or wouldn’t work for the client. To begin the design process, a parallel design session was hosted within the laboratory group. These sessions helped to generate many different, diverse ideas and ensure that the best features from each design can be integrated into the final concept. The final design was divided into two components, the mounting system, and the helmet. The load from the client’s head is transferred to the mounting system, which attaches to the client’s wheelchair. The mounting system connects to an outsourced helmet “Blue Opti-Cool EVA Soft Helmet” [2].

CONCLUSIONS

Co-design will be prioritized throughout the duration of this project, to optimize the device. When people with CP have better posture, they can experience reduced muscle tone, improved comfort and better upper extremity functioning which can help with functioning in society.

REFERENCES

1. E.-Y. Park, “Stability of the Gross Motor Function Classification system in children with cerebral palsy for two years,” BMC Neurology, vol. 20, no. 1, 202
2. [9] S. R., “Opti-cool headgear single shell EVA foam cooling helmet,” Rehabmart.com, https://www.rehabmart.com/product/opticool-headgear-single-shell-eva-foam-helmet-45521.html (accessed Mar. 19, 2024).