FLINGO

STABILIZING WALK ASSISTED EXOSKELETON

INDUSTRIAL DESIGN THESIS REPORT

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by

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Abstract

Walking on nature trails is an effective and scenic way to conduct cardio and maintain a healthy lifestyle. However, those who are physically impaired, such as patients suffering from hypokinetic disorders like Parkinson's disease, face the risk of falling when approaching the outdoors. These individuals rely on external aids that offer support and suspension made for uneven terrain; there is, however, a lack of appropriate walking equipment that fits this description. How can we improve the nature trail experience for the physically challenged? Keeping these patients safe, comfortable, and moving would increase the quality and enjoyment of the walking experience, which will, in turn, promote healthy living and mindfulness. This creates a vibrant community of individuals who recognize that everyone has the potential to be happy and healthy, regardless of ability. This thesis evaluates the needs of the physically impaired and improves upon current mobility instruments through innovative thinking, in-depth ergonomic study, and analysis of maneuverability through the help of selected doctors and specialists that concentrate on movements of the lower muscle group. The result of the studies will maximize the impact of increasing the quality of living of patients with Parkinson's disease. Interviews and observational studies will provide details for a better understanding of user behavior. A scaled model will assist in establishing guidelines of the necessary ergonomics and evaluate the correct full-bodied human interaction points. A solution will be developed for the physically impaired to enjoy the simple pleasures of walking.

ACKNOWLEDGMENTS

I would like to dedicate this project to my fallen loved ones and friend that have passed during the COVID-19 pandemic. To my great uncle, my uncle, and my aunt, it pains me that I was not able to see you when you left this Earth. To say that you made me the man I am today is a complete understatement because for you to leave is also leaving a part of me with you. Claudia Chau, your ferocity to stand by your rights and morals always inspired me to become who I want to be, but your kind words will never be forgotten. I wish you were still here with our group of friends and there are times when I wished I had done more to keep you with us. I am still recuperating from your loss, but I hope that somehow, the message is relayed to you that I finished my studies and I'm moving on to the next chapter of my life.

My sincerest gratitude to Catherine Chong and Sandro Zaccolo for dealing with my terrible sketches and tardiness. Thank you both for assisting me with concepts and giving creative input whenever I had a mental block. Most importantly, thank you for encouraging me and my classmates to never give up and always making sure I am pushed to perform to the best of my abilities, even if I can not perform well. This gratitude spans all of the professors and instructors that I have had the pleasure of learning from. Thank you to my advisor and friend, Vivian Lo, for your guidance and assistance in navigating me through the world of neurodegenerative disorders. It was a true pleasure to receive your insight and learn about the people who go through this struggle. Thank you to Mahjub Kazi, my good friend who let me use his 3D printer in times of panic and stress.

I am incredibly happy to be finishing this degree with my fellow peers. I have been with these tremendous people since my first year. We laughed together. We spent many late nights stressing in the workshop together. Though the final two years have been primarily online, that does not diminish the friendships I have made along the way. I pray you all will find success in your respective fields.

To my mother, thank you for giving me the opportunity to go into the field and supporting me when I left my mechanical engineering studies. From the moral support to your delicious food, I cannot think of any way to repay you. To my sister, Michelle, though you had your internal battles, you were there for me when I needed to have fun and decompress. Now that I am done with this program, I can be there for you whenever you need me.

To the friends that have been with me since high school, nothing makes me happier than seeing you all succeed as well. Even if we diverge into different careers, it brings me so much joy to know that we are still able to meet up, have a good time, and forget our troubles, even for a moment. Leena, last year was one of the hardest hurdles life has ever thrown at me. I would not have been able to recover as fast as I did if you were not there for me. Thank you for being there for me when I needed to decompress. Thank you for being there for me when I took life so seriously when it did not need to be complicated. Thank you for being there for me when I wanted to get some ice cream.

Chapter 1: Introduction

Figure 81. Image by Hermann Traub from Pixabay

1.1 Problem Definition

Walking is one of the easiest ways to conduct cardio and maintain a healthy lifestyle. It has been demonstrated that walking in natural environments, especially areas with high vegetation, has been linked with lower activation in areas of our brains that are associated with depression, anxiety, and “morbid rumination”. (Bratman, 2015) These terrains, however, can be difficult to navigate, which limits users that require mobility devices to move.

According to UCB Canada, “Parkinson’s disease affects 1 in every 500 people in Canada. Over 100,000 Canadians are living with Parkinson’s today and approximately 6,600 new cases of PD are diagnosed each year in Canada”(Parkinson's Disease, n.d.) Individuals with Parkinson's disease may face fatigue even when engaging in low-intensity physical activity; this can result in patients feeling lame, which can affect one’s diet and mental health. There should be a way for the physically challenged to not only navigate through terrain but also find the motivation to do so and the enjoyment in the activity to continue.

This thesis report will explore some of the limitations that individuals with Parkinson's disease experience, including shuffling steps, freezing gait, rigidity, slow movement, and resting tremors. It will also explore how the individual interacts with the environment they are placed in. The collected information will then be used to design a solution for Parkinson’s disease patients that will provide support to the body to allow them to maneuver efficiently and safely.

1.2 Rational and Significance

To understand the difficulties a person diagnosed with a hypokinetic disorder, specifically Parkinson's disease, has when walking in natural terrain, the following methods were applied to extract data:

- Online Research Literature
- Statistical Review
- Existing Product Benchmarking
- Advisor Interview
- User Observations
- User Journey Mapping
- Ergonomic studies
- Sustainability Studies

The gathered information will lay a foundation for the user's mannerisms and what they deem important for walking in uneven terrain. Understanding how the environment affects the user, as well as how the user interacts with the environment, will reduce the risk of injury while preserving the user's independence. This information will inform the way the following questions are answered during the design process:

- What triggers tremors and shuffling movement?
- How can the comfort of Parkinson's disease patients be enhanced?

- Does changing the diet improve movement?
- What other exercises are prescribed to patients with this behavior?
- How quickly does Parkinson's disease progress?

Research tools will be used to extract and organize the information to provide a solution that satisfies all the criteria for the thesis.

1.3 Background, History and Social context

Parkinson's disease primarily affects the elderly age group. Symptom onset typically starts at the age of 50, the majority of patients being men. The total number of cases in the United States approximates around 10 million people in total (Marras, C., Beck, J.C., Bower, J.H. et al, 2018).

Parkinson’s disease is a neurodegenerative disorder that is most widely known for disturbing gait movement and balance. The ability to walk is often taken for granted by an abled person, while individuals with this disease have to make a conscious physical and mental effort to do so.

The simple act of walking has long-term effects on happiness and harmony. According to Boulware D. R. (2003), regardless of where they were from, tourists that visited New Zealand responded positively to natural sceneries and the wildlife that lived there; this has positive implications linked to walking. These activities lower stress and improve the quality of sleep, which directly correlates to an enhanced positive mentality. Although walking through trails can be considered challenging for individuals who are dependent on resources and equipment, the physical and mental benefits gained from doing so may be an encouragement to commit to the activity.

Grouped alongside Huntington's disease and other neurodegenerative disorders, doctors often limit surgery options and recommend physiotherapy instead. These patients rarely go outside and exercise; most of the time, they stay home due to the difficulty of managing stuttering walks and joint tremors. Van der Kolk, N.M. and King, L.A. (2013) encourage any physical activity for these patients, as it can improve motor skills, balance and gait movement, especially when in a rich vegetative environment.

Currently, there is a large range of support systems that have been made to combat the stuttering movement that most patients with Parkinson's disease have. They range from more solid support devices, such as wheelchairs, to support systems that allow for greater mobility, such as crutches and walkers. Over the past decade, many have tried to model older support systems with modern design tropes, but no design has overtaken traditional methods, which can be less than ideal in uneven terrain. Overall, there is an untapped market for a product that allows Parkinson's disease patients to walk with relatively fast movement without being obtrusive to surrounding people.

Chapter 2: Research

Figure 82. Image by monkeybusinessimages from Getty Images/iStockphoto

2.1 User Research

The purpose of the research is to lay a foundation of focused background knowledge and identify challenges that are faced by individuals with Parkinson's disease in nature trails; this will ideally lead to a greater understanding when creating a product that will enhance the experience of walking. Van der Kolk, Nicolien M, & King, L. A. (2013) state that "exercise has the potential to help both motor (gait, balance, strength) and nonmotor (depression, apathy, fatigue, constipation) aspects of Parkinson's disease as well as secondary complications of immobility (cardiovascular, osteoporosis)". Canada is a country that has various opportunities for sightseeing, and many of these sites are naturally occurring and scenic; the majority of people experience these historic sites through walking and hiking. In areas with high vegetation we may expect that this will have a positive impact on well-being because "stepping into Nature has been proven to provide health benefits such as: increased energy and immunity, increased weight loss and fitness, increased Vitamin D production, and reduced risk of diabetes, heart attacks, and cancer" (Conservation Ontario, n.d.) .Humber Library Search Engine, Library Databases, and Google Scholar will be used to access information to gain a better understanding of the topic. By benchmarking current market products, exploring user demographics, and conducting interviews, an in-depth understanding of the subject matter will be gained to optimize product design.

2.1.1 User Profile/Persona

Figure 1 - Retrieved from https://pixabay.com/photos/adult-casual-caucasian-glasses-1851571/

Name	Shawn Sanzabar
Age	52 (Caucasian Male)
Occupation	Senior lead of accounting firm
Family	Wife with 2 daughters
Location	Edmonton, Alberta
Walking Frequency	Some weekdays, every weekend
Duration	2-4 hours
Social	Enjoys walking with family, very active, cheerful, enjoys the natural breeze of fresh air

Table 1. Fictitious User Profile

“The upcoming demographic shifts toward older individuals in western nations have led to major efforts to project the health-care burden over the coming decades, particularly for diseases for which incidence rises considerably with age, such as Alzheimer’s disease and Parkinson’s disease. The projected increases in dementia have been referred to as a “Rising tide,” emphasizing the sheer volume of this problem and warnings of the public health challenges of caring for these individuals have been issued.” (Marras, C., Beck, J.C., Bower, J.H. et al, 2018). A fictitious Parkinson's disease patient was developed to fit the demographic based on the background data discovered in the report by Marras et al. Having a persona aims to condense the data for design constraints to the user. To better understand the person, an in-depth backstory of Shawn Sanzabar was made as follows:

"*Growing in the province of Alberta, Shawn always loved the outdoors. All of his free time was spent in the forest, enjoying mountain biking. In his later years, although he has been focusing on his job in his accounting firm, whenever he has the chance, he will gladly take a walk outside to clear his head. Now, in his early 50s, Shawn has recently been diagnosed with Parkinson's disease and it has affected his work, as well as the time he spends with his family outdoors. His walking is delayed and it takes more time for him to keep up with everyone. All he wants now is to be able to walk at the same pace as his wife and daughters and not worry those around him.*"

As stated before, most people suffering from Parkinson's disease may start developing symptoms and are diagnosed around the age of 50. The prevalence of Parkinson's disease in the population suggests that men are more likely to develop this disorder in comparison to women.(https://www.parkinson.org. n.d.)

Due to these statistics, it is reasonable to assume that the age at which people typically get diagnosed with Parkinson's is towards the end of their career or approaching retirement. Identifying as a senior may imply that the user has significantly more freedom to explore nature trails in their area and rest.

The early stages of Parkinson's disease present themselves as mild interferences in daily activities due to slight tremors. Stages can progress into significant impairment in which users must use a wheelchair to move around. The final stages of this disease require full-time nursing care. This thesis project is mainly focusing on the middle stage in which tremors, muscle stiffness, and struggles with balancing have become inherent, regular problems. In this stage, the user is still able to be independent to a certain degree, but some daily tasks, such as dressing and bathing oneself, require assistance.

The neurodegenerative disease causes a person to experience uncontrollable tremors and shuffling walks. This can make walking in general extremely difficult and slow, let alone walking recreationally. This can easily frustrate a patient as walking for them requires more effort and discipline in controlling their steps than the average person. Oftentimes, patients can feel fatigued and discouraged due to the overexertion required for them to do small, menial tasks. This, in turn, can make being healthy sound like a physical and mental gauntlet.

Parkinson's disease patients usually try to find a trail near their house; as they become more familiar with it, it becomes easier and more comfortable to navigate. If the user is using a support apparatus such as a wheelchair, crutch, or walker, they have to account for storage in the car when traveling far distances. Once their support system is set up, they can finally walk on their preferred trails.

2.1.1.1 Primary User

Primary users can be described as patients with neurodegenerative disorders such as cerebral palsy, Huntington's disease, and, as discussed, Parkinson’s disease.

2.1.1.2 Secondary User

Secondary users include family members, caregivers, or social workers that support the family and contribute to the well-being of patients.

2.1.1.3 Tertiary Users

These users can be described as physicians, physical therapists, or any movement disorder specialist who personalizes care for an individual's symptoms and needs.

2.1.2 Current User Practice

Collecting data will improve the understanding of scenarios that people with Parkinson's disease come across in their lives. By providing context and asking patients how they would move in the context shown, it provides a deeper perspective on why patients move in certain ways. Collecting this data will be used as a parameter when designing a solution for the thesis.

2.1.2.2 Research Plan

User research was conducted in the forms of a one-to-one interview and user observations (see Appendix C - Current User Practice for a complete overview)

In the months ranging from March to November, people may start to come outdoors and walk due to this time being the peak of spring and summertime. In the time frame of those months, the average high temperature from the year 1985- 2015 got to a temperature of 25°c and the lowest -11°C (https://www.timeanddate.com, n.d.). At these times, the humidity is high, but the weather is often cool with a comfortable breeze and little amounts of rain. In times of heavy precipitation, the user may choose to stay indoors. When the user does decide to go on a walk, they may have a few, small belongings so they do not feel tired carrying larger objects.

The activities that users might do are as follows:

- Bird-watching
- Floral exploration
- Stargazing
- Animal-watching
- Fishing
- Photography
- Sketching
- Sightseeing

An interview was conducted with Vivian Lo, a Bachelor of Science thesis student and soon-to-be graduate, who excels in neurology as one of the leading executive members in the Science Student Association at McMaster University. She agreed to do a casual online interview to share her professional input on the neuroscience of Parkison's disease and how neurodegeneration occurs. Prior to the interview, questions were developed in preparation for the interview. The questions used are as follows:

- Does Parkinson's disease affect genders, ages, ethnicity, and mental levels differently? What about how individuals walk?
- Does diet change after symptoms arise? What about physical activities?
- Are there preventable steps to negate some of the effects of Parkinson's disease?

- Other than walking, what were some other physical activities patients do?
- Are you familiar with Nordic walking? Would you recommend it?
- What are some of the most common walking supports you have seen?
- What are some frustrations patients have with walking equipment?
- Are there any trips and tips you recommend for Parkinson's patients to improve their gait?

This interview was casual. In some cases, during the interview, the word structure of the question was adjusted based on the circumstances. The following takeaways from the interview with Vivian Lo are as follows:

- “I'd say the most common is probably the walker. Canes? Not so much because canes can be quite slippery, especially in our Canadian winter, the Walker is a lot more stable. And it provides individuals with a place to sit if they get too tired.”
- “It not only comes with motor control but also problems with cognitive control. So not only are they are losing the ability to be able to move their bodies but in a way, they sort of are losing cognitive functions that are important to them”
- “Like most neurodegenerative diseases, it affects older individuals. And before it used to be sort of a death sentence, where if you were diagnosed with Parkinson's, it was really about palliative care. And just making sure you are comfortable until he passed away”
- “The most you can do is get genetic screening and just be aware that you may have an increased risk of developing Parkinson's disease but there isn't really anything preventative that you can do”

Keywords and phrases extracted from the interviews are:

- Parkinson's - A gradual nerve system condition that interferes with mobility
- Walking - Moving at a regular pace by lifting and setting down each foot in turn
- Canes - A length of cane or a slender stick, used as a support for walking
- Disease - A disorder of structure or function in a human, animal, or plant, especially one that produces specific signs or symptoms or that affects a specific location
- Neurodegenerative disorder - Affect many of your brain and body's processes, including balance, movement, speech, breathing, and heart function
- Nordic walking - A Finnish-origin total-body version of walking that may be done by both athletes and non-athletes as a health-promoting physical exercise

2.1.3 User Observation - Activity Mapping

The best way to experience the outdoors is to simply walk down nature trails. The majority of people overlook their ability to walk and take it for granted. For a person that has a neurodegenerative disorder, this can prove to be quite difficult as the act of walking also includes avoiding obstructions, stopping when needed, and other unforeseen, strenuous occurrences. This is why it is important to understand how patients conduct their regular walks is done; this will be explored by generating scenarios of steps that an individual with Parkinson's disease may take on their daily walks. Objectives that are examined are as follows:

1. How the user reacts to different terrains
2. Specific times at which the user freezes
3. Mental preparation for certain acts

4. Physical preparation for certain acts

An observational analysis of a video was conducted to research how users interact with equipment along with their pain points. A timeline was written out to show the findings of this research (Appendix 2).

Walking can be a complicated activity for an individual with Parkinson’s disease depending on the range of ability that a person may or may not have. This thesis will go into specific actions completed by patients, and how they progress through the day with their equipment.

A Parkinson's disease patient's mobility is dependent on how severe the disease is. For example, a person with stage one Parkinson's disease is still able to conduct everyday tasks, although they may experience light tremors. This is in strong contrast with a person that is suffering from the late stages of Parkinson's disease, in which a user is wheelchair-bound and unable to complete small tasks without assistance. The goal of this thesis project is to try to understand the middle stages of Parkinson's disease, specifically stages two and three.

An able-bodied person has higher stamina and the ability to travel through a nature trail for a long time, compared to a patient with Parkinson's disease. These patients would normally have to switch up their movements, and potentially, even their equipment when interacting with new terrain, such as moving from a wooden bridge to a gravel-based terrain. This hinders the enjoyment of the overall walking experience and will slow down walking speed.

Due to COVID-19 restrictions, finding participants who were willing to openly share their personal experiences was difficult. However, the Parkinson's disease community is incredibly vast; individuals openly share their struggles in videos and showcase struggles when they are walking. This allows others to gain insight and react to others' experiences and, potentially, find common ground. One video highlights an older gentleman named Matt Eagles, who has been living with Parkinson's disease since the age of eight. He shares his daily struggles and how he copes with them when walking.

PREPARATION/SET-UP Before going out for a walk, dress in the right apparel for the walk. The cane is stretched at the most optimal length and the shoes fit that day's weather.	 Figure 2 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc
STEP 1 With all the right equipment, go down the steps from the house and start walking on the pavement. If there is no sidewalk, walk down the street to the crosswalk. The user holds the handrails of the stairs, the cane is not in use at this stage.	 Figure 3 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

STEP 2

There is some traffic, but the crosswalk light is on. Walk across to the side with sidewalks.

From Step 1 to Step 2, the user has been walking on the pavement and has changed elevation. The user is using the cane to assist them.

Figure 4 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

STEP 3

Changing the elevation and traffic took a lot of effort to overcome. The user stands on the side for others to walk as they take a break.

The user finds any empty space they feel comfortable on to recuperate. They interact with the pavement by trying to level themselves with the help of the cane.

Figure 5 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

STEP 4

When walking on the sidewalk, be careful as there are prevalent cracks that cause uneven surfaces. The user takes longer strides with each step. The cane is rarely used for support.

The user finds that walking on the sidewalk is easier to do. With the cracks, it is easier to pace and take larger steps with limited support coming from the cane.

Figure 6 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

COMPLETION After a nice afternoon of walking, they return to their home and clean up before supper.	 Figure 7 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

Table 2. User Observation

Not only was relevant information extracted with the advisor when examining the video, but the feedback from the videos and comments confirms pieces of information that were previously mentioned throughout the report. These comments showed steps and tips from individuals who experience Parkinson's disease, whether it be themselves who are affected by the disease or loved ones who know someone close to them who is affected.

2.1.4 User Observation - Human Factors of Existing Products

Since most devices for individuals with Parkinson's disease cater to aiding the legs, it is important to know the ergonomics of other support devices on the market when designing a similar device. Examining different types of walking devices will provide insight into how many features are incorporated into the design. This will help provide features that are needed for the user as well as implement different and new features. The next objectives are as followed:

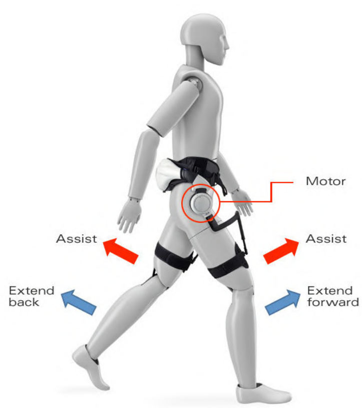
1. Identify the features of existing progress products

2. Show different touching points of the products
3. How the product is manufactured
4. Discuss if the product is innovative and helpful

The most effective way of discovering new walking supports and design layouts is to go online and explore what is currently being developed and sold. There is a large margin of products that try to offer support for those who are physically disabled with varying degrees of success.

The products below are different supportive apparatuses. These products are at different stages of the process; they may be purely theoretical, in development, or on the market and available for purchase.

	U-Step Figure 8 - Retrieved from https://attainability.co.uk/u-step/
	ProBasics K2 Standard Hemi Wheelchair Figure 9 - Retrieved from https://www.performancehealth.com/probasics-k2-standard-hemi-wheelchair

	ACTIVATOR Poles for Balance and Rehab Figure 10 - Retrieved from https://walkwithpath.com/products/path-finder-2-0
	GYENNO Figure 11 - Retrieved from https://www.medgadget.com/2018/01/gyenno-gait-aid-helps-avoid-gait-freeze-parkinsons-patients.html
	SPORTSMATE 5 Figure 12 - Retrieved from https://global.honda/innovation/robotics/WalkingAssist.html
	NOTCH Figure 13 - Retrieved from https://wearnotch.com/

	Forearm Crutches Figure 14 - Retrieved from https://www.amazon.ca/Forearm-Crutches-Adjustable-Lightweight-Ergonomic/dp/B07V5HJB6X
	Tango Belt Figure 15 - Retrieved from https://www.tangobelt.com/
	SPORTSMATE 5 https://www.xenhanced.com/pages/sportmate5-prelaunch

Table 3. Current Products in Market

2.1.5 User Observation - Safety and Health of Existing Products

Though this thesis project is meant for recreational use, health and safety are two important aspects to visualize when creating a support system for people who struggle with movement. People with physical disabilities are prone to falls; this suggests that incorporating a support system that can withstand different terrains with different surfaces is key for this thesis project.

Potential safety concerns include:

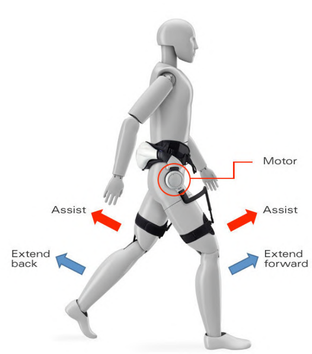
- Falling on uneven surfaces
- Back pain
- Shoulder pain
- Muscle fatigue

Parkinson's disease patients may have an issue when walking for long periods of time, even with support systems. Following the physical exercise of walking, Parkinson's UK found that patients experience significant pain and stiffness along the body. To be specific, this may include stiffness in the shoulders and back, resulting from slouching. Wrist pain is another large factor to consider, due to some walking support devices requiring the wrist to be extra support or stabilizer when walking.(parkinsons.org.uk, n.d.)

2.2. Product research

Exploring current devices on the market creates a better understanding of what the user needs and wants. The problem with current devices being sold is that they cater to all stages of Parkinson's disease, meaning the products may all tackle different types of ability and situations. As stated before, these products range from theoretical, in development, and accessible. Through the prior literature research, this stage finds what equipment features work best for the user and what can be negated.

Ten products were evaluated in total (see appendix C), but four will be highlighted to identify the features that benefit users, materials of the products, and a benchmark for the overall profile. With all of these products benchmarked, it would create opportunities that can be implemented in the new design.

 ASIMO Figure 12 - Retrieved from https://global.honda/innovation/robotics/WalkingAssist.html	 U-Step Figure 8- Retrieved from https://attainability.co.uk/u-step/

 Forearm Crutches Figure 14 - Retrieved from https://www.amazon.ca/Forearm-Crutches-Adjustable-Lightweight-Ergonomic/dp/B07V5HJB6X	 ProBasics K2 Standard Hemi Wheelchair Figure 9- Retrieved from https://www.performancehealth.com/probasics-k2-standard-hemi-wheelchair

Table 4. Benchmarked Products

2.2.1 Benchmarking - Benefits and Features of Existing Products

How products are benchmarked depends on multiple factors, but one of the most important things to look at is the features each product has and what makes it ideal for a user. One must ask if the user really benefits from the product. The products selected targets the user's needs in different areas such as price range and adjustability. It is important to know what can be enhanced later in the design process for the thesis project. After gaining background knowledge upon researching online articles and literature, as well as speaking to an expert in the field, the features that can benefit the user are as follows:

Key Features:	**Key benefits:**
• Laser and Vibration guide • Weather Resistant • Customizable height • Emergency GPS message • Stabilization	• Lightweight • Durable and Shock absorbent • Traction • Rest support and Walking Propulsion • Boost of agility • Easily worn and collapsible

Table 5. Benefits and Features

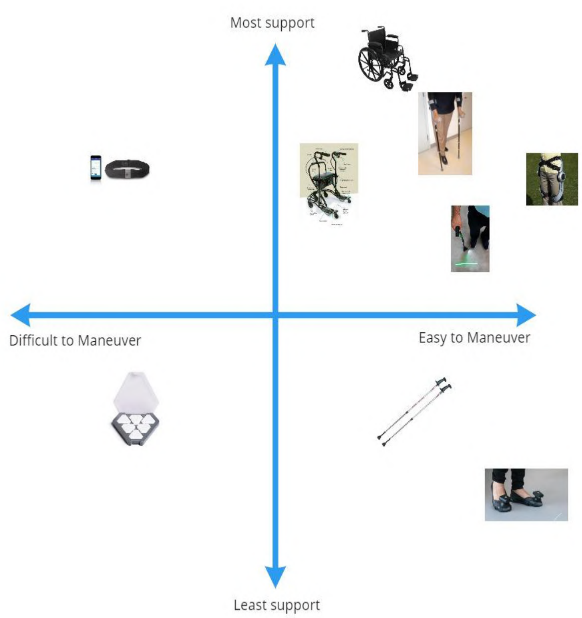


Figure 15 - XY Product Functionality Graph

This table condenses all the information to features that a user may want and need in a device, this should be examined during the design development stages.

Agility, traction, and shock absorbency are important elements that can improve the performance of the walking gait. The product matrix X-Y graph shows what is left to be desired in the market, this table will help create a concrete device to fill the void of what users/consumers really want.

2.2.2 Benchmarking - Functionality of Existing Products

After breaking down the data of products into a list of benefits and features, one thing to consider is the range that each product presents. This could effectively be broken down into two categories. Though each product may provide support when walking, each product offers varying modes of inputs to be proven effective. Some present the user with a freeing, lightweight solution with minimum support, while others are more rigid, but offer greater stability. The data researched on the functionality of the products are as follows:

- Less-expensive products have the option to be only independent but less supported or dependent but more support, while the most expensive product incorporates incredible stability and support without needing assistance
- Products with auto-activated features create a somewhat-symbiotic relationship with the user
- Products that have a seat incorporated are not well-suited for this project as it is meant for the recreational exercise and wellbeing; having a long-term sitting feature may encourage dependence on the product and inactivity
- Products that allow the user to stand upright have are easier to maneuver and allow the user to control their support device better
- Auto-assisted devices are larger and not compact, which is not ideal to be carried during trips

Establishing the functionality of each product during this stage of benchmarking will help create a concrete design. As presented on the X-Y graph beforehand along with the listed points, it is shown that there is an untapped potential that can provide agile, stabilized performance, all while being portable when conducting walking trips.

2.2.3 Benchmarking – Aesthetics & Semantic Profile of Existing Products

For all intents and purposes, this thesis project is meant for recreational use, not just medical use. After examining the products from an aesthetic and styling standpoint, they are lacking in catering to the human form. In particular, the one that comes close to addressing this problem is the ASIMO walk assist. The current design is having the form follow the function; these devices serve the user to reach basic necessities. From an engineering perspective, it is indeed effective, however, the design of the device could be improved in certain ways.

The general design composition of these products is very heavy and obstructive. In terms of medical equipment, their semantic profile works well within their context. Medical equipment provides what is necessary, as opposed to what is wanted. These products appear rigid and strong because their design philosophy is catered to this message. While it is true that these supports emit those characteristics, the design language must change if it were to be passed off as recreational. Reducing the visual disturbance offers a sense of normality for patients who have Parkinson's disease.

The overall color scheme of the selected devices are utilitarian, ranging from black, grey, white, other desaturated colors, or stripped-down exposed metal. These colours serve value when developing the final product. Changes in color in this case are unnecessary as these products are colored in this fashion to reduce attention to the user from others. The finished surfaces of the product tend to have a satin finish. However, when designing for a product that moves with a body, a different material may be necessary, but it would be mainly reserved for joints of the body and may serve as accent pieces.

The current solutions presented are rigid and lack personality for good reason. They are meant to attend to medical means instead of recreational ones. For the final product, the shape and form should cater to how the body moves without feeling and looking obtrusive.

2.2.4 Benchmarking – Materials and Manufacturing of Existing Products

The materials used for the device will be evaluated to help the designer understand their benefits and shortcomings. This may include material used for other walking devices and other potential variants of materials that are more conscious to the manufacturing process and environment.

The decision to use a particular material depends on the cost of transportation and the material itself. Other characteristics to consider may include its longevity, durability, weight/how lightweight the material is, and aesthetic/look. These traits are important when accounting for the stress the device will go through and will prove useful in the final design. Common materials found in the walking devices are as follows:

- Vinyl seat - a lightweight and strong solution
- Coated Steels Frame -strong and durable while protecting user from the raw element
- Aluminum Frame - Very strong and lightweight material, with different finishes
- Urethane wheels - Shock Absorbent, and durable during rough terrain
- Particulate Composite Handle- easy to cast and manufacture.

It is worth mentioning that these components are from products that have handles and wheels. As the project pertains more to the body, the product that has similar design parameters as this project are the ASIMO Walking Assist and the SPORTSMATE 5 exoskeleton. The components for each product are as follows:

ASIMO Walking Assist

Material	Benefits	Disadvantages	References
Magnesium alloy	• Low weight/height strength	• Casting the metals can be difficult to work with	https://www.sciencedirect.com/topics/engineering/magnesium-metal
Plastic resin	• Easy to mold and cast • Low cost	• High ventilation for exhumes • Corrosive handling	https://netcomposites.com/guide/resin-systems/resin-comparison/
Lithium ion battery	• Low maintenance Higher stability • High energy density	• Battery Life reduces as it ages	https://www.electronics-notes.com/articles/electronic_components/battery-technology/li-ion-lithium-ion-advantages-disadvantage

			s.php

Table 6. ASIMO Materials

SPORTSMATE 5 exoskeleton

Material	Benefits	Disadvantages	References
Carbon Fiber reinforced plastic	• Lightweight • High tensile strength •	• Relative cost • Brittle under certain condition	https://www.china-composites.net/news/advantages-disadvantages-of-carbon-fiber-1585756.html
Aluminum alloy	• Malleable • Stamping manufacturing • Light • recyclable	• Easily dented • Warped easily • Expensive than steel	https://mperryassociates.com/blog/advantages-and-disadvantages-of-aluminium-in-structures/
Lithium ion battery	• Low maintenance Higher stability • High energy density	• Battery Life reduces as it ages	https://www.electronics-notes.com/articles/electronic_components/battery-technology/li-ion-lithium-ion-advantages-disadvantages.php

Table 7. SPORTSMATE 5 Materials

The ASIMO walking assistant uses a lightweight magnesium alloy with plastic resin to hold the parts together, creating a durable yet lightweight machine. While impressive, these materials and the manufacturing of said materials are relatively expensive.

All metals in the chassis are extruded through tubes and bent to the dimension of the schematic. Plastics are molded to fit the palm of the hand. Urethane is used for the wheels, which are injected, held, and fitted around rings with ball bearings. All these parts will then be assembled on the production line, with smaller subsections working on other mechanics depending on the device. Some devices incorporate technology and wires for their features, while others simply add extra foam for support.

If the thesis project were to secure funding and be manufactured, aluminum should be considered for the build of the frame, as well as incorporating 3D printed PLA handles, rather than a particle composite, to improve grip and ergonomics. Since the model might emulate a symbiotic machine, such as the ASIMO, it is worth considering stamping parts as a viable option in manufacturing. The shell of the body can be replaced with Polyethylene Terephthalate, a recyclable brand of resin that can be used for injection molding and tubing to shape the profile.

2.2.5 Benchmarking – Sustainability of Existing Products

Every product that is currently being developed is now cautious of what they produce by accounting for sustainability. Manufacturing and transportation have been the biggest contenders for pollution. That is why production lines utilize local materials to reduce the carbon footprint of product production. Steel and aluminum are used for the chassis; while this can be recycled properly, particle composites cannot as they are not capable of decomposing.

Assembling the parts with screws and glue increases the time it will take to recycle due to issues with disassembly. At the end of a product's life cycle, users might have the intention to throw the whole product in the trash, instead of recycling properly through the means of the community.

Though most companies that manufacture these products have not shown any signs of implementing any sustainable requirements, this creates an opportunity for the manufacturing of this project to create something more environmentally cautious. Whether that be implementing reusable plastics or having repair services for the equipment, efforts can be made to lower the carbon footprint. Thus, this allows production to create a loop that generates new products by reutilizing old materials instead of products having a linear lifespan towards a landfill.

This thesis project will implement ECOZEN, a high-quality bio-copolyester resin that can be used in various applications. Its most impressive properties include its strength and heat distortion. SK Chemicals is a leading producer of plastic resins such as SKYGREEN PETG. This resin can be used in food storage, cosmetic packaging, medical packaging, and much more. It will also implement Econyl for the straps of the device. Econyl is used to make nylon textiles by extracting the fibers from waste that floats in oceans and in our homes. After the nylon is shredded and re-used, the remaining scraps are recycled and put into the production of new strings. This process is very simple and can be done an infinite number of times.

2.3 Summary of Chapter 2

After dissecting information from products in the current market, it suggests that the user may want something more unique. There is more that can be done from looking at what current products have to offer. Utilizing the research data will outline what the user group needs, so that it can be implemented in the few concepts of the design.

The next chapter will analyze the outcomes of research on the necessities of the product and how they can be rectified when developing the concepts.

Chapter 3 Analysis

Figure 83. *Image by PublicDomainArchive from Pixabay*

3.1 Analysis - Needs

Exercise for Parkinson's disease patients is one of the most vital activities to improve the user's wellbeing, with the exception of dieting. Performing small tasks that were once capable of doing independently is now harder to do. It is devastating when not being able to keep up with the loved one in the family during nature trails and hiking trips. Physical activities, especially walking, help negate further deterioration of the mental state and stunts stages of Parkinson's disease. This project will help walking accessible for people with Parkinson's disease so they can live a healthier lifestyle by becoming active.

By creating a device that can stabilize the walking pattern, as well as improve the gait of the walk, it can create a healthier lifestyle. The previous chapters touched on the research findings from other devices and compared them with one another to understand what can be changed and what should be implemented. In this chapter, the needs of the user will be analyzed to grasp the user needs of the project.

3.1.1 Needs/Benefits Not Met by Current Products

As stated in the previous chapter, this topic has a very broad number of products to account for the many stages and range of different abilities that patients with Parkinson's disease live with. The focus will remain on those in stages two and three of Parkinson's disease. The problem with the current support devices on the market, other than the ASIMO and SPORTSMATE 5, is the lack of change in the last few decades. The form has not changed and the new technology implemented is not enough to rectify any recognition. These products are obtrusive to the user when walking and they are also not agile enough to maneuver as a result of its size, which can also make them difficult to maintain and pack. These users face balancing and gait issues when walking on nature trails. While they may work for a product that was designed for the medical background, for the current context of the thesis, there is an opportunity to improve what is currently present in the consumer market. The list of improvement are as follows:

Needs	**Improvement**
Compact/storage	• Companies can ship with ease • Users can transport it to walking trails
Stability	• Balance user and in control • Adjustable to appropriate height
Safety	• Emergency protocol in case of danger
Agility	• Walking at the same speed as others • Able to participate
Comfort	• Less muscle fatigue • Controlled energy

Table 8. Immediate Needs

3.1.2 Latent Needs

Comfort and Ergonomics

The duration of a nature trail hike can last from two hours to half a day. Comfort is an unequivocal benefit to apply to the scenario. For any users that over-exert themselves when conducting any movement, any reassurance to make them comfortable encourages them to continue on the path.

Health and Safety

As previously stated in the abstract, users suffering from hypokinetic disorders face the risk of falling. This is due to their blocked movement momentum, followed by overexertion of their steps to compensate, which can lead to falls or stumbles.

Ease of use

The set-up of many walking-support apparatuses can be handled with minimal training. Being able to walk as soon as possible gives a sense of independence and willpower to the user, which can boost their self-esteem and pride.

Size/ Appearance

As previously stated in benchmarking, having products that are heavy and obstructive can create unwanted attention from the public, which can quickly build up anxiety and discomfort. Having a less-noticeable style may keep the user at ease and bring a sense of belonging and normality akin to able-bodied users.

3.1.3 Categorization of Needs

With the information gathered from user observations, interviews, and literature research to focus on the different needs of the user, the next step would be to organize/categorize the information and determine which needs are most important. This will help understand and differentiate what is necessary and what is wanted from the user. The user needs are categorized as follows:

Wishes/Wants	Immediate Needs	Latent Needs
• Resting support • Adjustable • Cushions for comfort	• Increase agility • Improve gait • Durable • Portable • Emergency beacon	• Shock absorbent • Easily worn and taken off • Less conspicuous design • Feedback rhythm system

Table 9. Categorization of Needs

This project must also fulfill the needs that are highlighted in Maslow's hierarchy of Needs and illustrate the relationship between said needs and the product's needs. After examining Maslow's Hierarchy of Needs and implementing these teachings into the thesis project, the result will mold the thesis into a stronger proof of concept which will require these fundamental human needs. The needs categorized are as follows:

Benefit	Fundamental Human Need	Relationship with Benefit
Comfort and Ergonomics	Control/Security/Self Esteem	Strong
Health and Safety	Safety/Security/Adaptability	Strong
Ease of use	Accomplishment/Autonomy	Strong
Size/ Appearance	Esteem/Belonging/	Strong

Table 10. Latent Needs

3.2. Analysis - Functionality

3.2.1 Journey mapping

To understand the comprehension of the procedure of taking a walk down a nature trail, a user observation video was found on YouTube. The video showcased internal thoughts, as well as tips while walking down the streets of England. It may not appear to have correlation to nature trails, however, the internal monologues that were shared as well as other people commenting their personal experiences provide intimate information that will determine the direction of the design. The video was also analyzed with the advisor to have a deeper understanding of the user from a professional standpoint.

PREPARATION/SET-UP The cane has to be maintained and clean in order to deliver a better performance. When stored away in a compact area, keep in mind adjusting the device after it has been used, the user alters the height and measurements to make the product neat.	 Figure 2 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

STEP 1 The cane is used very heavily, every time pressure is being applied to the device, the body pushes down on the wrist and the posture is now slouched. This can lead to a sprained wrist and back after prolonged use.	 Figure 3 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc
STEP 2 Moving from the sidewalk to the streets excites/scares the user. Any change in elevation causes the user to spasms and can either stunt the gait or eagerly throw them forward. It cannot be controlled. This increases anxiety due to the increased risk of falls and accidents.	 Figure 4 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

STEP 3

In times of exhaustion or uncontrollable spasm, stretching the lower limbs can really reduce the tension. Sitting can regain balance of the gait and reduce the spasms, making it manageable to walk again. Stopping is necessary in order to continue walking.

Figure 5 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

STEP 4

User’s have a better experience when focused on the lines of the sidewalk. The lines guide the user to where to step, as there is a need to take long strides to overcome the line. Legs have no problem moving and generating movement. Parkinson's disease patients break up walking into steps, and since the lines act as a guide, the user does not have to worry about how far to step forward.

Figure 6 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

COMPLETION When walking up the stairs, users have little difficulty lifting their legs. This suggests that moving the limbs up and down is not as difficult as walking forward.	 Figure 6 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

Table 11. Workflow Mapping

Analyzing the observational video provides an in-depth process of how the user is able to prepare themselves for a walk and how they act during their walking trips. This will be processed through an experience map to graph what part of the process is the most difficult to comprehend and overcome.

3.2.2 User Experience

The previous section indicates how the user utilizes a cane when walking. All the research from the steps has been put into a timeline generating emotions the user may feel and the primary pain points as they complete each task. Experience mapping collects the pain points and puts them on a scale throughout the timeline, which will be compared to the projected levels of pain from the experience. This will be analyzed to see what part of the process can be improved, which will be implemented in the final design.

The graph showcasing the data collected and samples as well as how the activity map should be are put into an activity map as follows:

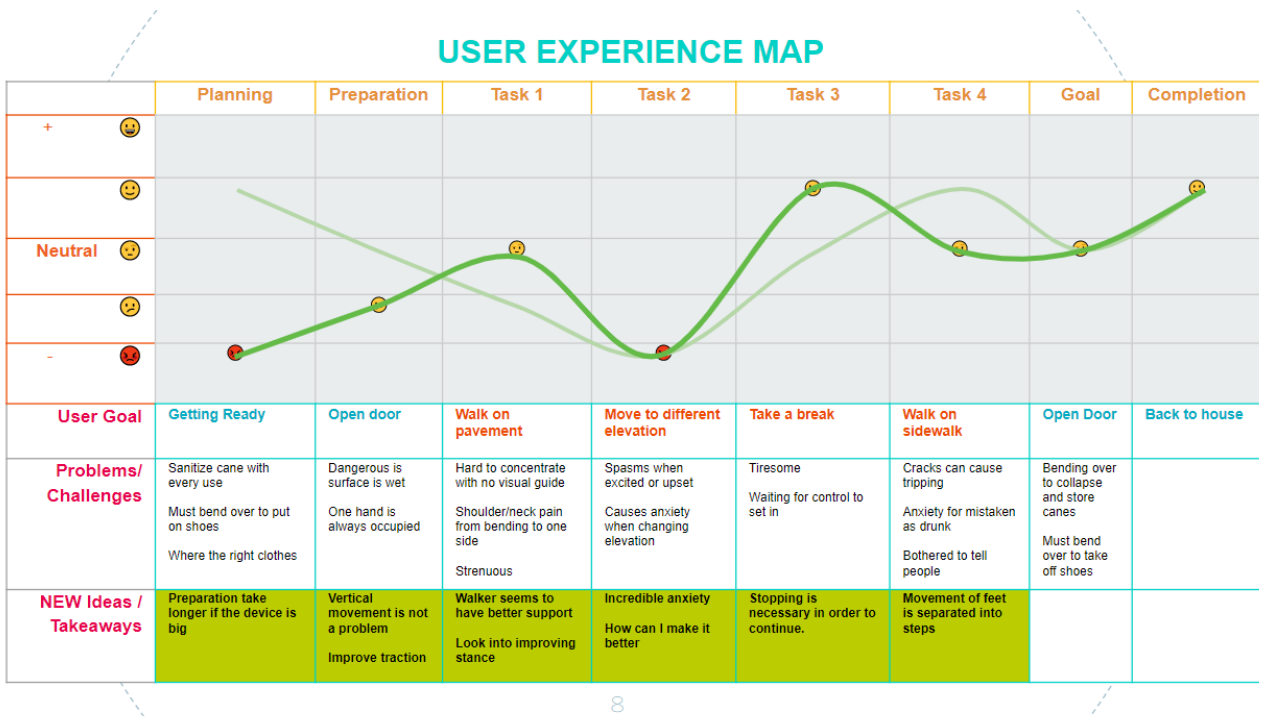


Figure 17 - User Experience Map

From the chart above, the user starts at low satisfaction due to the preparation process, which involves putting on shoes and adjusting the cane. Though it may seem mundane, Parkinson's disease patients are diagnosed with tremors, which can limit their motor capabilities. The mood rises once kinetic motion is initiated and the user feels excited and motivated. Once physically motivated with the progression, the user decides to walk relatively slower than an abled person. They may stumble and lose momentum, but with concentration, they can continue with the momentum they deem comfortable. When switching onto different terrain, moving from the sidewalk to pavement in this case, there is heavy resistance, forcing the user to exert more energy to their legs to step forward. This can cause the legs to jump and have the body leap farther than intended, leading to falls and accidents. In this scenario, a crosswalk with cars waiting can stunt the movement even more due to the fact that people add social pressure by depending on the user to move. This creates an anxious situation, resulting in a decrease in mood after the fear and excitement; the user would rest and regain some calm while easing the spasms coming from the legs. Resting brings control over the legs from shaking and regains confidence knowing that the spasms are maintained and tamed to a certain degree. The satisfaction dips as they continue walking, however, this time, the user is able to walk even faster with the help of the lines on the sidewalk. Every line acts as a finishing goal for each foot, which is why patients try to step over it and repeat it. This is an effective and cheap alternative for Parkinson’s disease patients to walk, resulting in a confident mindset while knowing they are just as fast as everybody else.

3.3 Analysis - Human Factors

The goal of the ergonomics analysis is to redefine problems to investigate improvements to basic mobility devices. The first solution for a short-term resting device was to reduce muscle fatigue and make Parkinson's disease patients feel supported and comfortable to continue on nature trails. Creating the knee-support brace was the most important component of the project. The user was asked to wear the device temporarily to see how comfortable the resting stance was and determine if more support was needed. The squat resting position was mainly looked upon to see if it would restrict any movement. Data to look for are as follows:

- Changing into the brace
- Ability to move from one destination to another
- Comfortability
- How each limb feels supported

3.3.1 Product Schematic - Configuration Diagram

The Measure of Man and Woman (Tilley & Dreyfuss, 2002) will be the main source of reference. It will be used to find the accurate dimensions of the 1:1 ergonomic mockup. The 1st percentile of women and the 99th percentile of men will be the measurement parameters as they range from the smallest to the largest bodies. This mockup will help refine the product and explore problems so they can be resolved to a cohesive state that works on a large range of body sizes. A report on ‘Falls in Parkinson's disease Subtypes: Risk Factors, Locations and Circumstances. ‘(Pelicioni, 2019) will provide insight into the environmental dangers that need to be accounted for in order for the device to be deemed safe.

To undertake ergonomic testing, two positions were developed. This comprised of the most common position the user would experience:

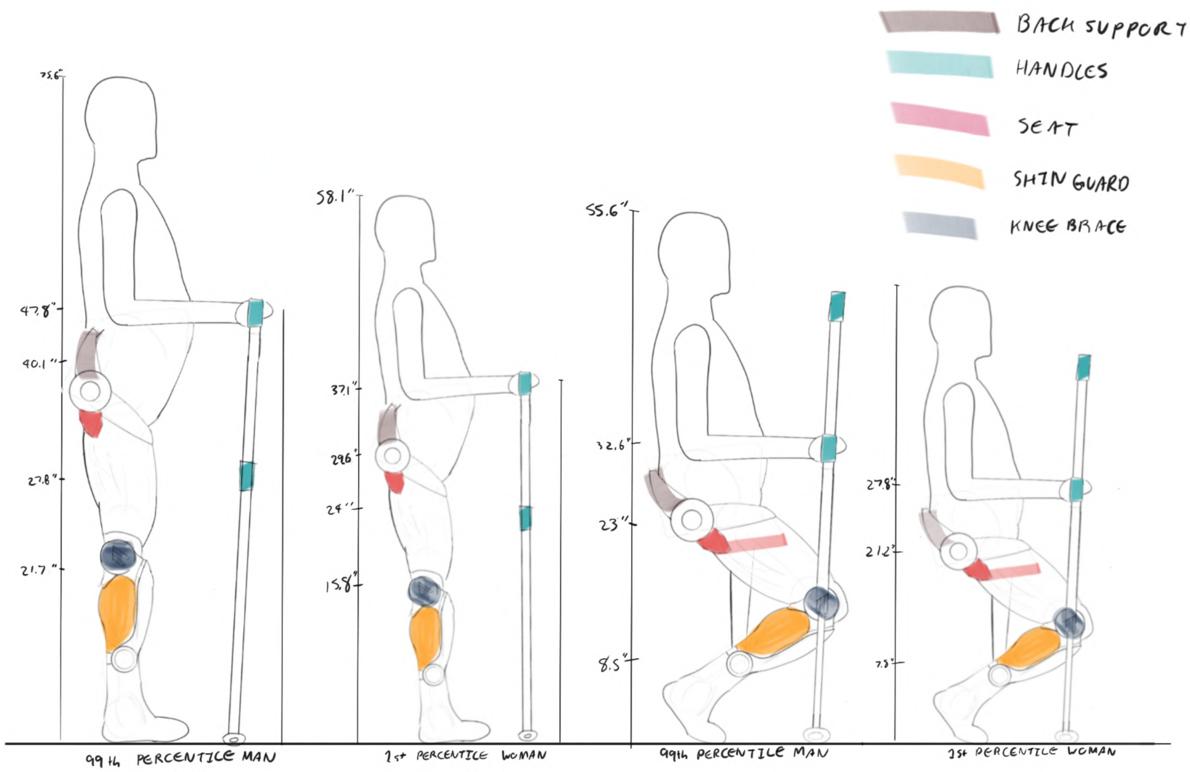


Figure 18 - Side view of Potentials

Standing position

This ergonomic stance focuses on the user when they are standing or resting. Studying where the rotational points and resting points are an aid in focusing on how the solution can be made.

Squatting position

This ergonomic stance sets to see the max limit of a person's range of motion, which helps put a parameter for the thesis solution. This is also done to see how far the user can extend and retract their legs when walking.

3.3.1 Ergonomic - Human Scale Study

Most patients with Parkinson's disease range from ages 50-60 when they are first diagnosed. The 95th percentile was tested with the ergonomic scaled mock-up to fit the target range. Even in a semi squatting position, it was still supported and the user was able to walk with no interference. Since it is meant to fit the majority of the percentile size, the mock-up was a bit small but manageable with the adjustable straps for more sizes to fit. The test subject was asked to stand, walk, and squat, all while providing feedback on how they felt about the model. They stated that the knee needs a strap as it was somewhat loose and the bottom of the mock-up needs to be shifted up and cradle the back. The thigh strap was able to be supported along with the calves. One thing to keep in mind is the pivoting of the knee, in regard to whether the knee should be able to pivot or be limited to a linear swing.

Figure 19 - Squatting ergonomics

The current limitation of the brace mock-up is the material. Being unable to touch and understand the feel of the materials makes it harder to integrate them and know how they can be manipulated. Design proposals could incorporate soft plastics in order to stretch and be resilient in case of any falls. From what was gathered from the feedback, parts of the back-seating support should be condensed into a compact sitting platform to reduce weight and interference of the walking motion.

Figure 20- Squatting ergonomics side view

When talking about personalized walking-assist supports, it is important to consider the implication of making the device adjustable instead of having many sizes. This may be more difficult to account for different body types, however, it gives the user more options to grow with the device, and see what they find comfortable and adjust it themselves with straps for security. It would also prove to be useful when taking off equipment as well. Being able to condense the device into a package is also very important, considering the fact that most users might have to commute first before walking down nature trails. This may prove difficult because the human body does not align and is constantly shifting. Designing a free form device catered to the body may be difficult when packing, thus a modular solution should be considered to reduce square footage in transportation vehicles. The overall form of the mock-up to the user was comfortable and successful in proving the concept as well as solving developing problems. Though poles were not tested for support, this element will serve to support the device’s stability as the user was already comfortable with the brace in a squatting position.

3.4 Aesthetics and Semantic Profile

The target users range from 50 years old and older. The users are considered elderly, therefore, the stylization should be kept to a minimum. Trends in the medical industry focus on function over form, but as previously mentioned, the thesis project is not meant to only be used as a medical device, but also as a recreational device. The project should not be limited to a medical design, but it should be enhanced.

The form of the solution can dictate the amount of confidence the user may portray. Granted, no user is the same, but there is a slight uneasiness when attention is caught by another person. The design composition of current solutions is very heavy and obstructive. This can create unwanted attention for those who are not content with the disease they were diagnosed with, increasing anxiety. The symptoms of Parkinson’s disease are not discrete; visual cues of the disease are prominent, identifiable, and unapproachable. Of course, society understands that the user has no control over the spasms, however, genuine curiosity and confused glances can look similar to looks of disdain or disgust. This is potentially why most trends do not have any vibrant colours and are limited to saturated colours to make products less noticeable. The colour that is shown will be an accent piece. To present the product as less intrusive, it should follow the form of the lower limbs to present the user as independent and capable.

3.5 Sustainability – Safety, Health and Environment

Sustainability can have a great impact on the longevity of the product, whether it be environmental or societal. It's a process that involves taking into account all the factors that contribute to the well-being of the ecosystems. This discipline also focuses on the lifestyle aspects of a product. Having the best possible product can make a huge difference in how we live. After conducting extensive research and analysis on various aspects of the mobility industry, a comprehensive list was created to identify the most critical factors that matter most to the user in terms of safety, health, and environment.

3.5.1 Safety Initiatives

Patients with Parkinson's disease are more prone to tripping and falling from uneven surfaces. That statement is exceptionally true when it comes to the uneven paths when exploring trails. Though this project is mainly used for recreational purposes, it should be clear to acknowledge the basic safety concerns to ensure the longevity of the user. Most of the time, the danger comes from the users themselves.

With the constant tremors that occur when performing walks, a Bluetooth emergency beacon will be implemented to ensure the safety and location of the user in case of an emergency. This signal will notify family members if the user has been on the ground for more than 30 seconds, just in case there are any mishaps that may be incorrectly presumed as emergencies.

The atmosphere is accountable for the success of the project. A metal chassis must not rust in humid and moist conditions; this can deteriorate the product and make the device malfunction and cause more damage to the user.

3.5.2 Health Initiatives

Though walking is considered a healthy pass time, users with Parkinson's disease may have difficulty enjoying the activity, leading to exhaustion, joint stiffness, and muscle fatigue. The goal is to minimize any disdain and provide a space of relief for when the user needs to rest. Any sort of padding should be considered for resting to ensure the user feels comfortable and does not feel fatigued. It is crucial for users to rest to regain back balance and gait before continuing down a nature path.

Mental strain is a factor to consider. For users that are newly diagnosed with Parkinson's disease, it can be quite challenging to adjust to a new life and future. Having heavy equipment may bring unwanted attention to the user and can induce high levels of anxiety. Mental health is just as important as physical health, especially with a condition that deteriorates the mind, thus it is best to design a product that increases the confidence of the user.

It should also be noted that this is not a device to be used for medical reasons, it is meant for recreational use. This product is not meant to be a permanent solution but instead a device that encourages users to walk normally. The user should not rely on the device for modern activities as it can reduce muscle growth and require the user to rely on a permanent walking apparatus. With this technology, the device is used to guide users and provide some encouragement with the help of visual and tactile stimulation on the body.

3.5.3 Environment Initiatives

The topic should focus not only on the user traversing the environment but also on the biodiversity that lives within it. As a general rule, the solution should ideally generate no harmful emissions and be easy to implement. As previously stated in the report in Benchmarking Sustainability of Existing Product, PETG and Econyl will be implemented to ensure that the product does get recycled by utilizing the materials and implementing them back into the manufacturing cycle.

There are a number of companies and start-ups working on ways to solve the issue of recycling Li-Ion batteries. Although rechargeable batteries are considered sustainable, their base materials used to create them have a negative impact on the environment. Some companies, such as Lithion Recycling, have decided to recycle batteries to be reused again. This mindset can be used for the device as well. Being able to recycle broken parts for discounts creates an incentive to return items to the manufacturer to be reused back into the process.

3.6 Innovation Opportunity

3.6.1 Desirability

People with Parkinson's disease may be overwhelmed by the idea of having someone take care of them and desire to be self-sustaining and independent. Like many people in this world, they require their motor functions to complete tasks, but being diagnosed with this disease hinders their skills, which can bring about feelings of being a burden. That is why there is an opportunity to rectify the desire to walk freely and independently on nature paths without the fear of accidents.

3.6.1 Viability

As stated in the beginning of the report, Parkinson's disease is one in a family of neurodegenerative disorders. Although the thesis project is geared towards Parkinson's disease patients, it is not the case that it cannot be utilized for other neurodegenerative disorders. Any disorder that debilitates the lower motor body functions can benefit from having a support system that brings the user independence and confidence.

3.6.1 Feasibility

Current high-end products in the market use basic simple motors to function, but they are not specific enough to target Parkinson's disease patients. Being able to track the length of the stride, the angle of the legs, and the speed of the user can all be done using a basic Arduino Nano 33 IOT. This small computer is compact and small enough to be placed in the project without interfering with the person's ability to walk. Small rumble motors that are used in video game controllers can give haptic feedback for the user. After researching current high-end market products, no product has incorporated this small piece of technology.

3.7 Design Brief

The goal of the design brief is to create a solution that addresses a specific set of issues faced by Parkinson's disease patients by providing an ergonomic walking support that maximizes agility and control when walking down a nature trail.

The objectives that will be factored into the design solution are as follows:

- Reduce anxiety that may occur from not being able to match the speed of other walkers
- Reduce impact shock of different terrain that may stunt momentum gait
- Ensure product can be easily worn and taken off
- Motivates and encourages movement
- Create something that is aesthetically unobtrusive and light
- Reliable and durable in the face of environment
- Monitors patient's position and vitals in case of exhaustion or falls
- Ensure comfort for resting points and walking points
- Incorporate sustainable materials in the final design solution

Chapter 4 Design Development

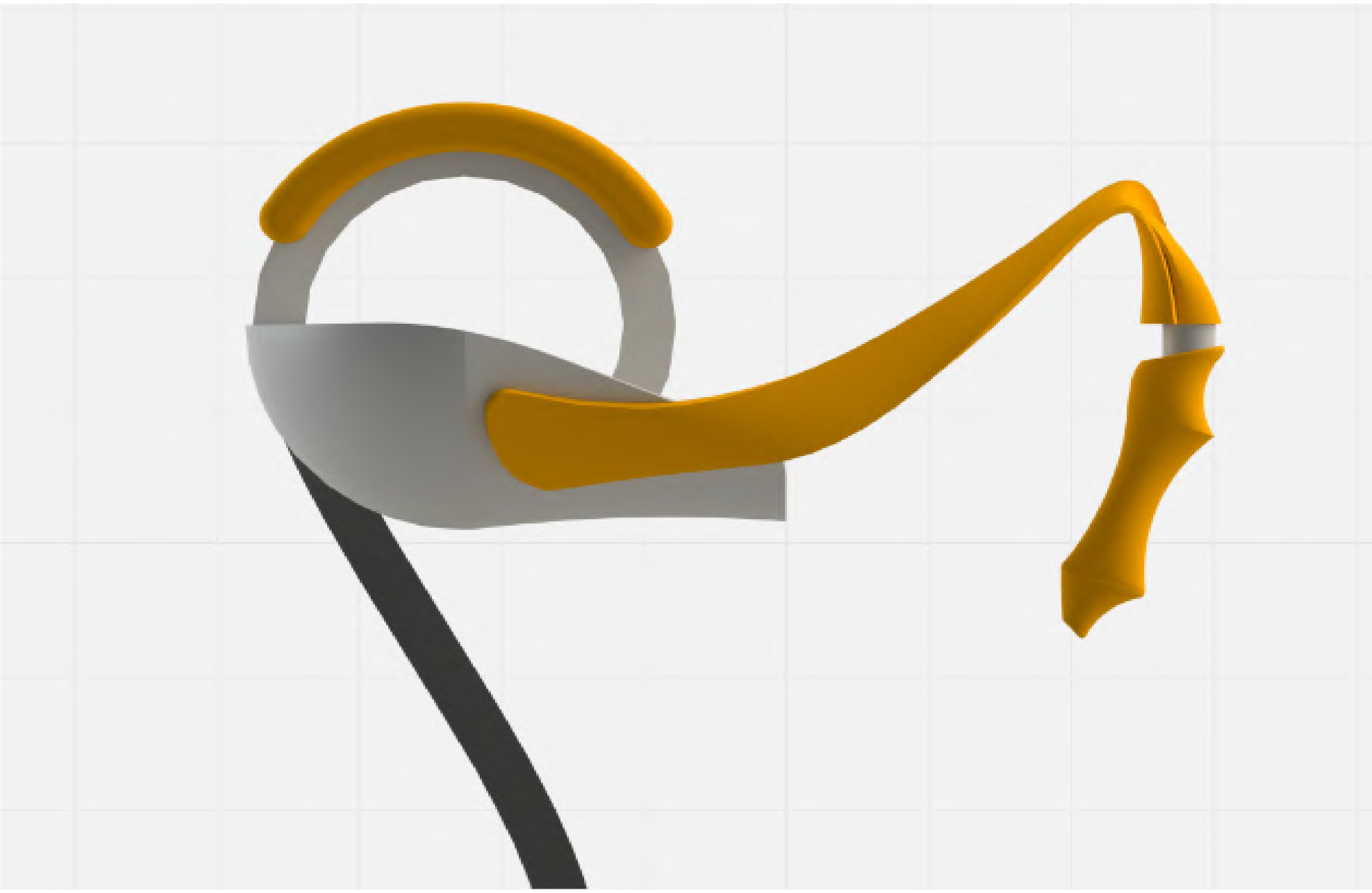


Figure 84. Arm Brace Render

4.1. Initial Idea Generation

4.1.1 Aesthetics Approach & Semantic Profile

With the key benefits researched from numerous articles, along with insights of the user from interviews, a fortuity of creating an interesting product awaits. After examining the trends that are currently on the market and dissecting the common aesthetics, it will aid in refining the overall aesthetic and profile of the project. Ideas and inspiration were brainstormed and refined, allowing one to be explored and expanded on to create an original concept.

4.1.2 Mind Mapping

The function of the mind map is to organize ideas and is the starting point for various design phases. This will provide ample amounts of information which can later be narrowed down to a solution to solve the problems for the user. This was done using the extracted information that was then organized and spread out into categories. The mind map that explores the potential problems and consideration are as follows:

How may we improve the nature trail experience for those who are suffering Parkinson's disease?

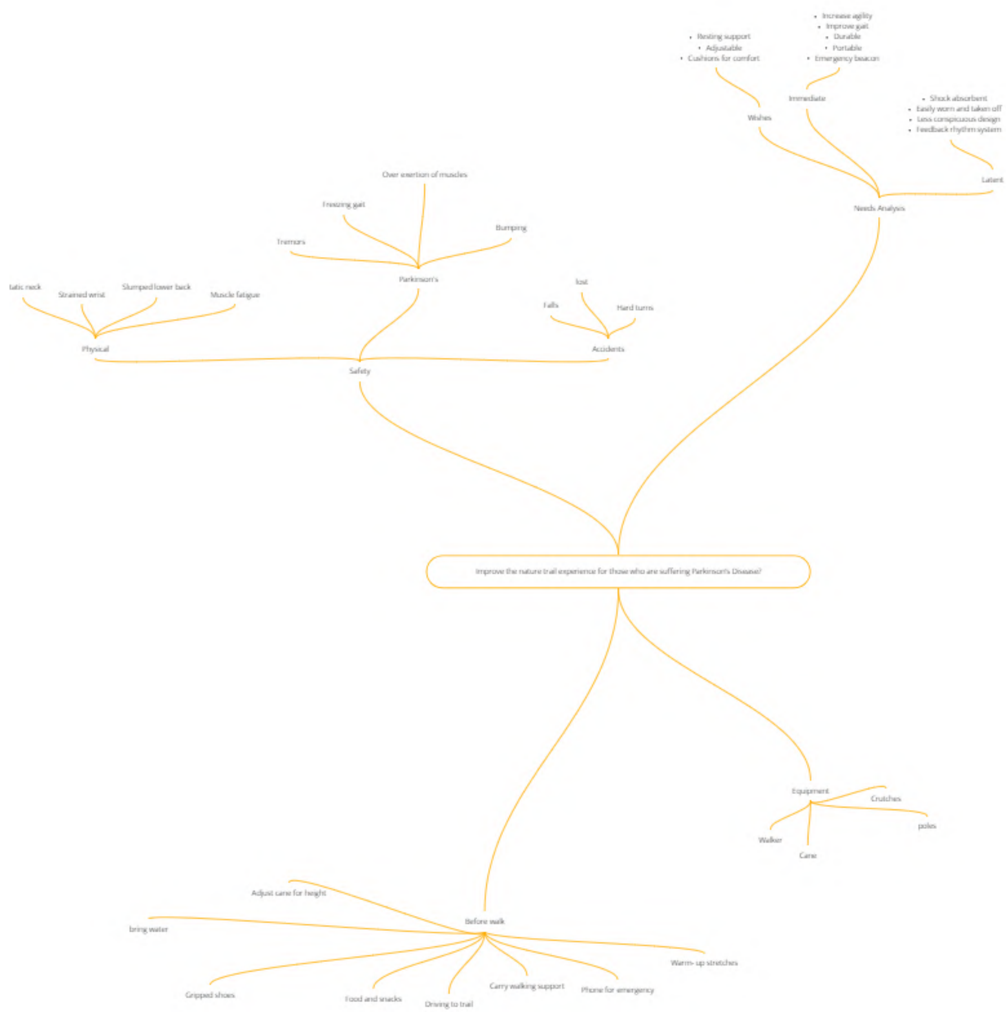


Figure 21- Mind Mapping Zoomed Out

- SafetyWalk
- Preparations
- Walking equipment

- Needs Analysis

Figure 22 - Mind Mapping Physical

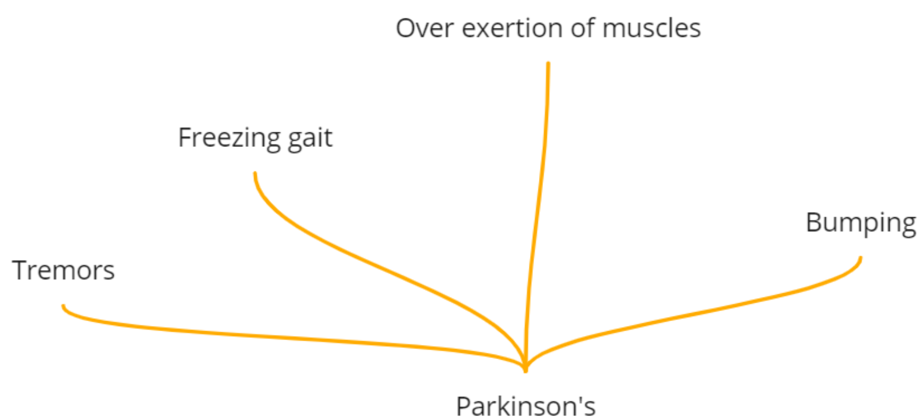


Figure 23 - Mind Mapping Parkinson's

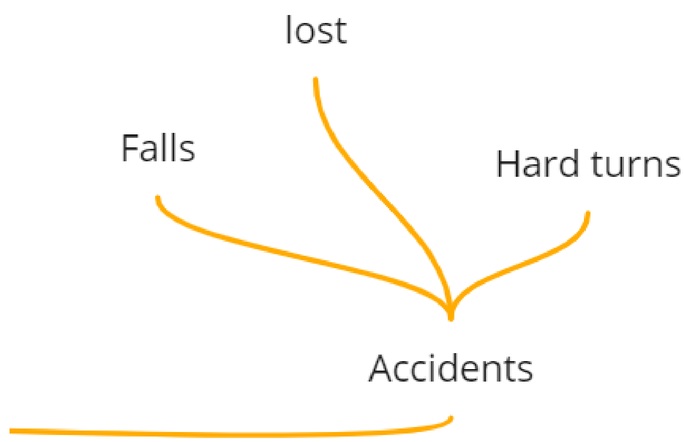


Figure 24- Mind Mapping Accidents

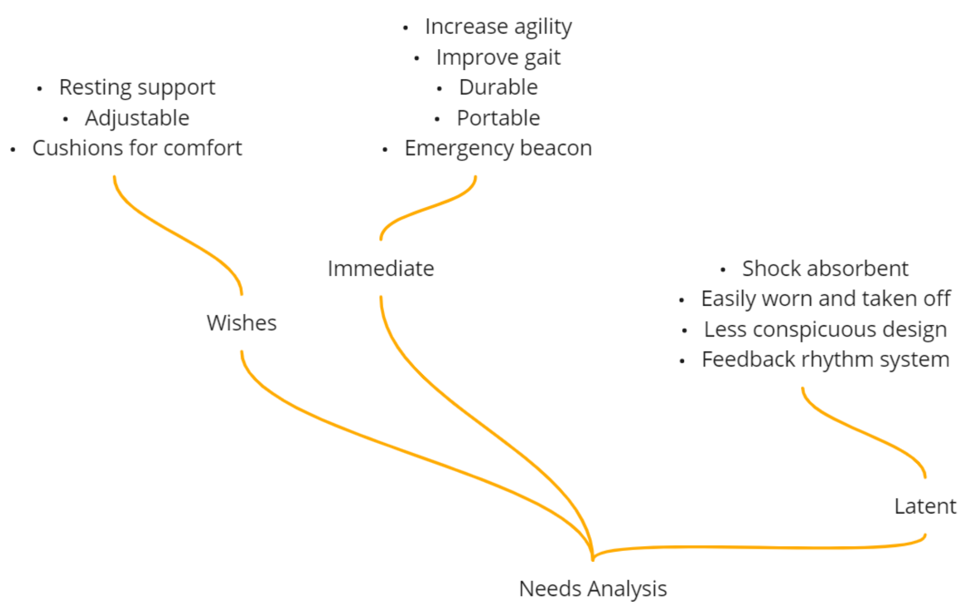


Figure 24 - Needs Analysis

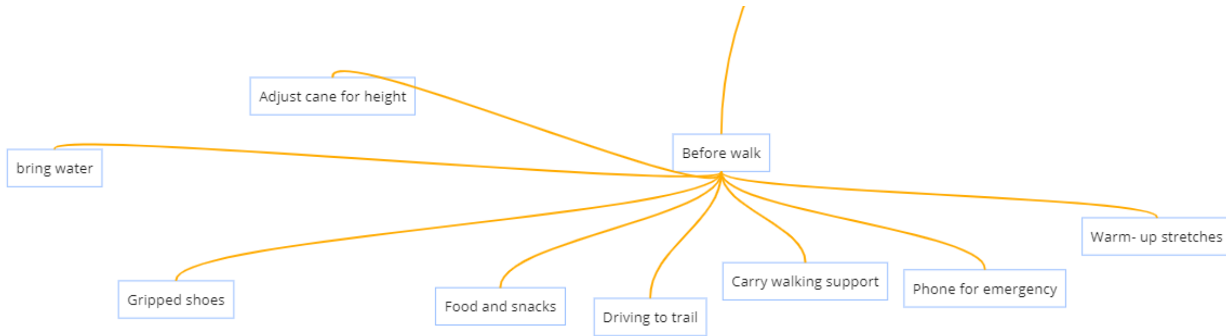


Figure 25- Mind Mapping Before Walk

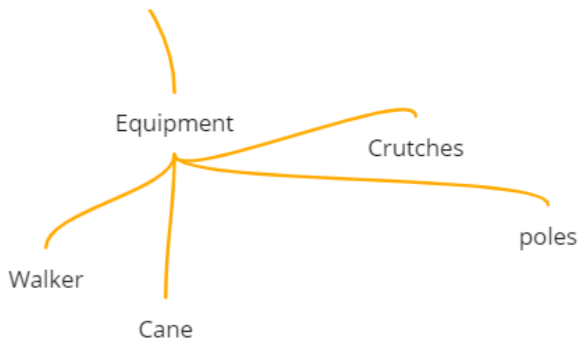


Figure 26- Mind Mapping Equipment

4.1.3 Ideation Sketches

At the ideation stage, various ideas of potential products were made to combat the pain points of the user and explore all slight variations of a support system. Some sketches were made to specifically combat sepsis pain points, while others had a broader range of tackling multiple problems with varying degrees of success. At this stage, the function is the focus, more than the overall shape. At this time, appearance and semantics will be implemented later.

4.1.3.1 Concept 1

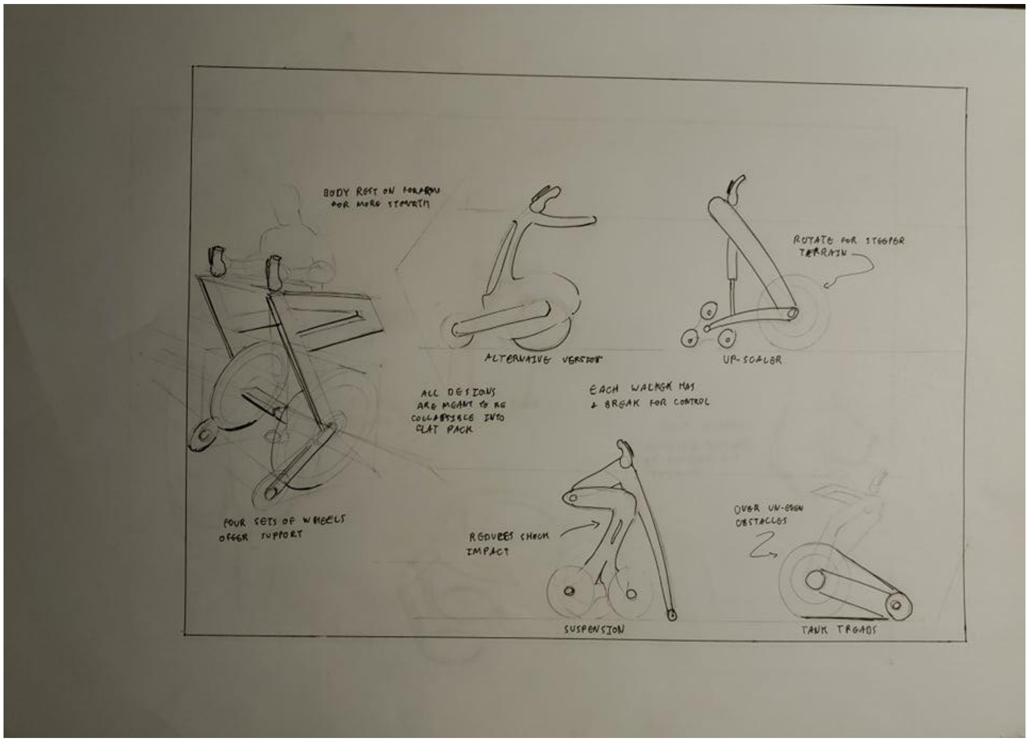


Figure 27- Concept 1

During the research of current products, walkers were the main support used for walking. According to the thesis advisor, Vivian, they were the most popular device for people to traverse, but the majority of them were meant for flat roads and streets. To counteract that, the sketches had wheels that were able to flip to go over certain terrain.

4.1.3.2 Concept 2

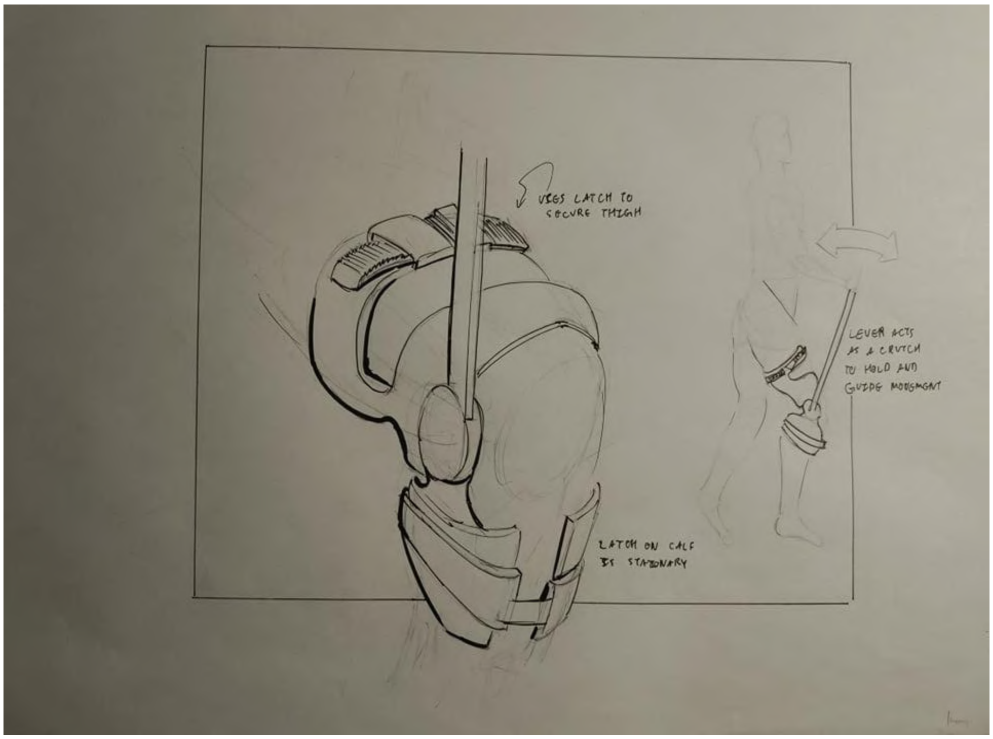


Figure 28- Concept 2

The next idea involved manually controlling the leg itself with another limb. This was inspired by nordic walking. Rather than the walking poles being separate like they are traditionally, they are attached to the knee in the sketch to increase power and maneuverability. This way, the user can control the speed and ferocity in the way they see fit to them.

4.1.3.3 Concept 3

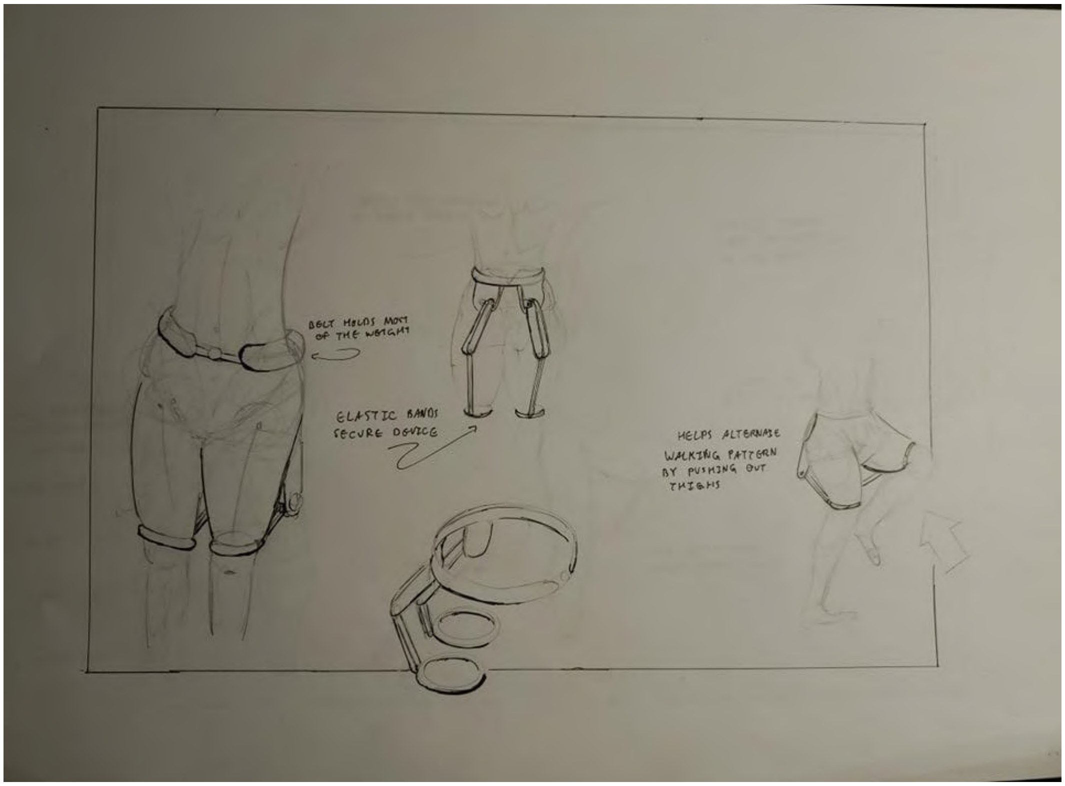


Figure 28 - Concept 3

The most challenging sketch to design was the exoskeleton, a device that was on the expensive side of the spectrum. At the time, there were problems with this idea, one mainly being it was not specific enough to be targeted towards Parkinson's disease patients. The device was very broad and was not specially made to cater to the Parkinson’s disease community. However, like the SPORTSMATE 5 exoskeleton, this exoskeleton was made for recreational intentions.

4.1.3.4 Concept 4

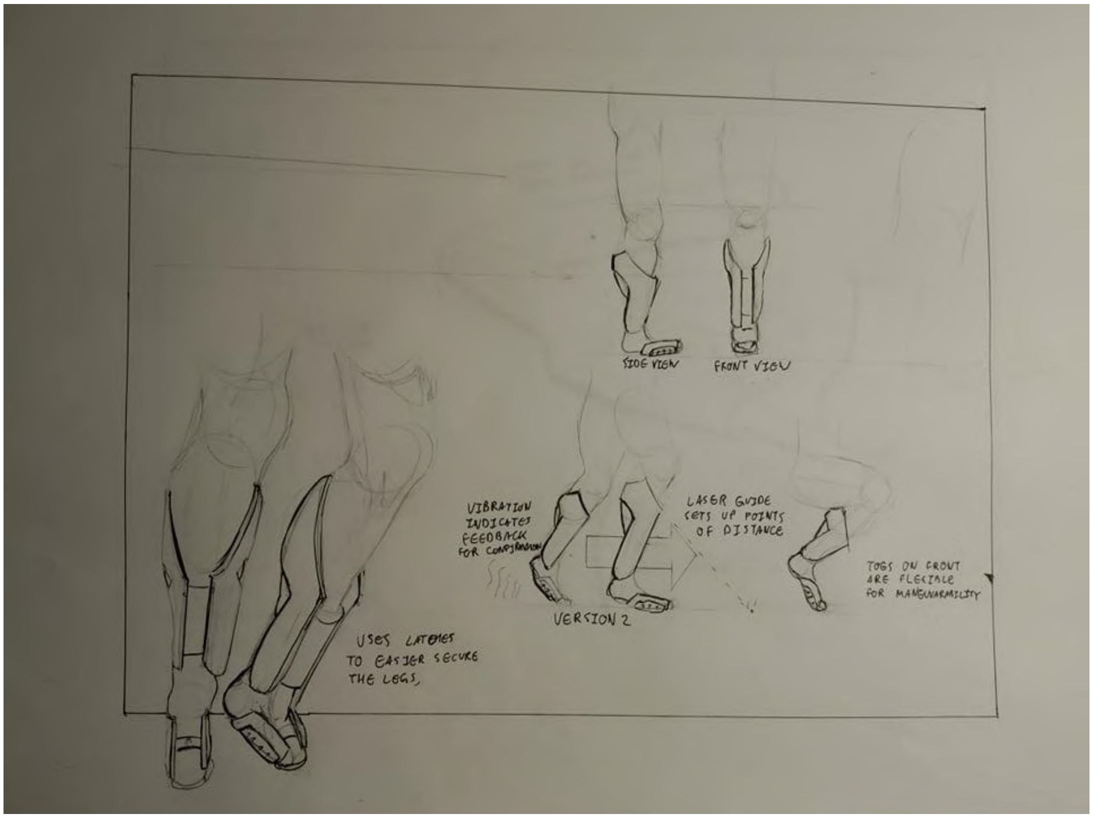


Figure 29 - Concept 4

This exoskeleton is different in that it was closer to the body and lighter. The main feature that supports Parkinson's disease patients is the laser guide line to help the user overstep. There are smaller devices that do similar things, but due to the projector level being on the foot, it was not as effective. In this concept, being able to project from the shins makes it easier to see, especially if the ground is uneven.

4.1.3.5 Concept 5

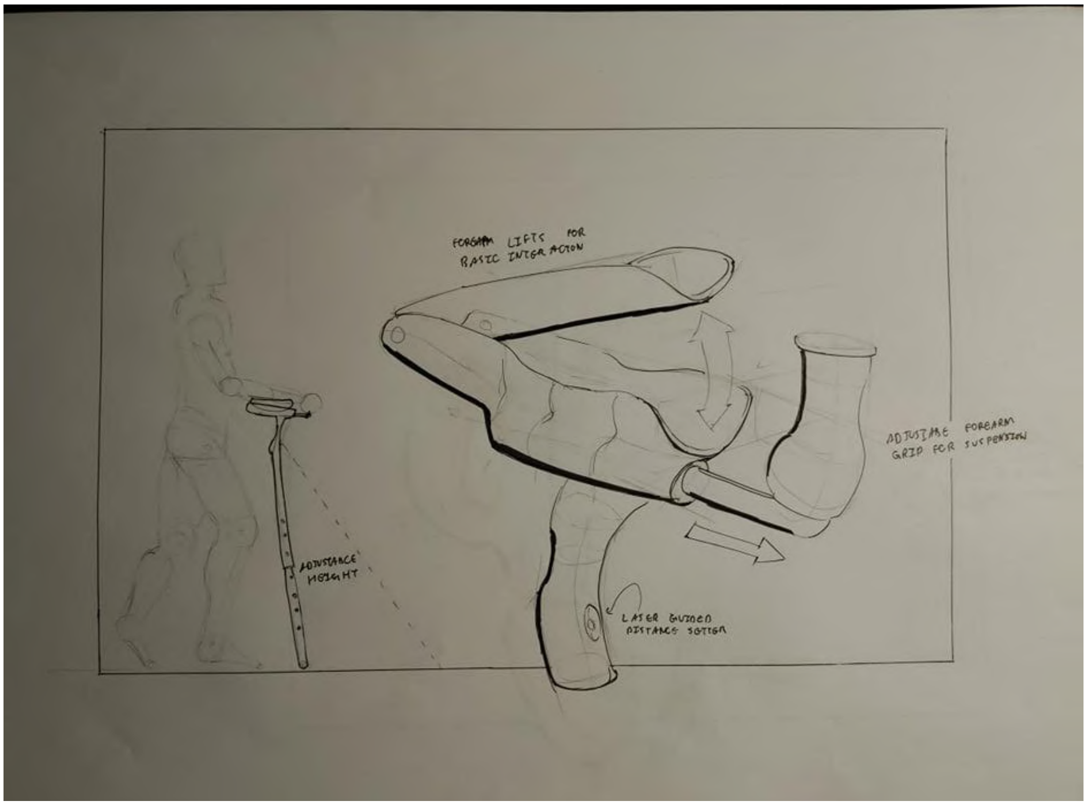


Figure 30 - Concept 5

This idea was never meant to be a pole for support, but the design style looks like it was a medical device. The idea came from Walking poles, but, as more information surfaced from the research, they were insufficient in balance and maneuvering abilities. Trekking poles applied significant pressure on the wrists, which could lead to sprains. This concept was made to support the forearm to alleviate pressure from the wrist while also being able to pivot the arms.

4.1.3.6 Concept 6

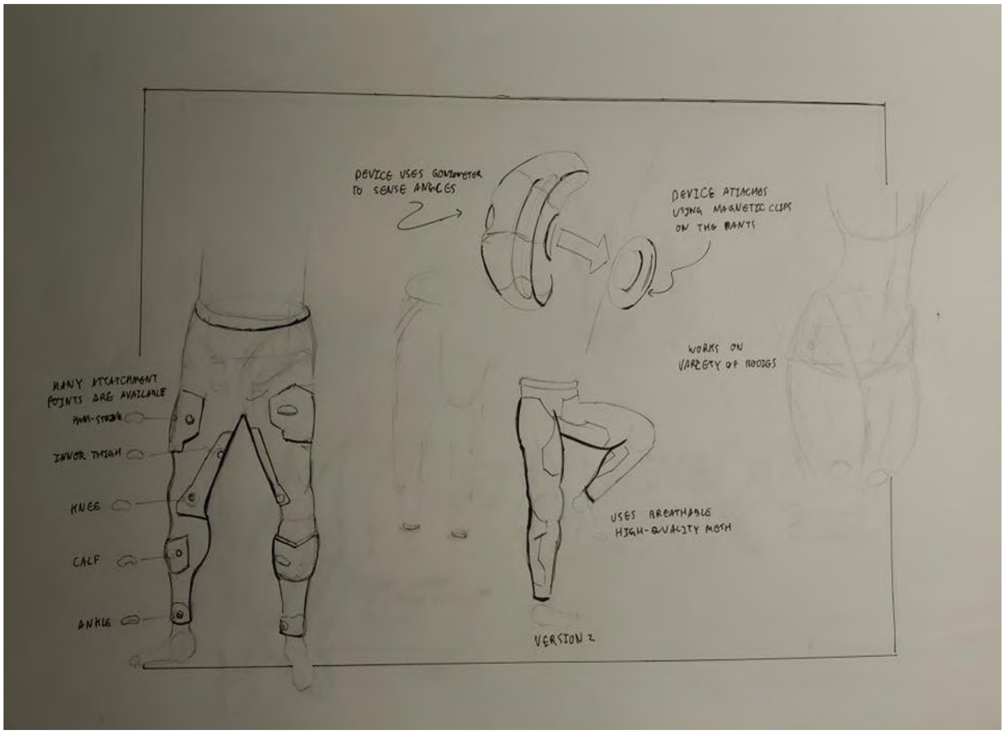


Figure 30 - Concept 5

This concept drew inspiration from an old studio class, specifically for interaction design. This concept essentially involves putting devices onto the body that can sense muscle movement, which in turn will help coordinate the user. The original concept was for people stretching, but the idea was modified to have the device rumble when the user moved to indicate how far their strides were.

These sketches were drawn to capture the general idea after reviewing the research information but should not be limited to current world constrictions. These sketches will be developed, with many of the ideas combined.

4.2 Concepts Exploration

With the feedback from the previous sketches, a development of sketches were composed that took inspiration from the original. Three ideas were chosen to bring to this stage. In addition, previous ideas were combined to create a cohesive concept. It is easier to create all the concept devices as they are all solving a specific problem rather than dispersed situations.

4.2.1 Developed Concept 1

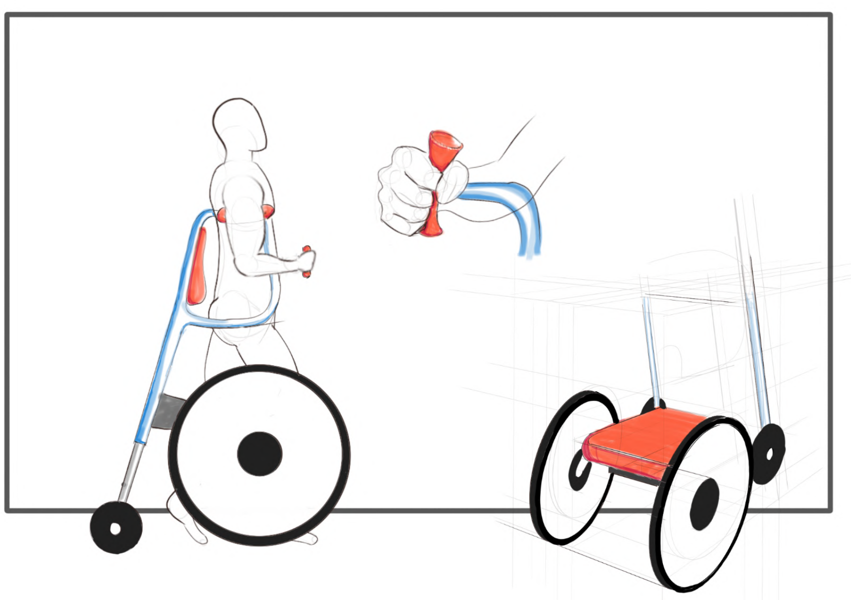


Figure 31- Concepts Exploration 1

The displayed concept shows a walker with wheels as large as a wheelchair and a seat to sit down. It gives the user the option to rest at any given moment and handles to grip in case the user needs extra support. The wheels, however, drew too much attention, and the frame was too rigid to maneuver the body around.

4.2.2 Developed Concept 2

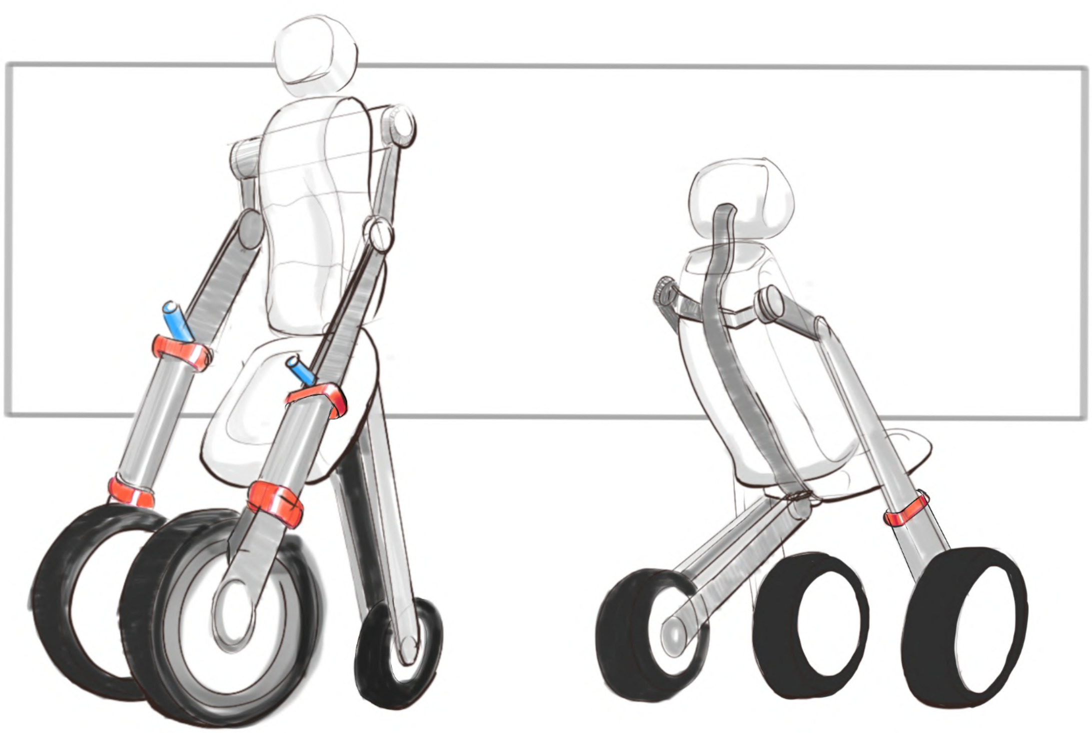


Figure 32- Concepts Exploration 2

This was a combination of the walker and pole idea. This product was considered to be more high-end; it was meant to provide a way for the user to sit down and relax like a walker, as well as being able to maneuver with its handles. If this concept was chosen, it would be necessary to compact the product somehow because the user is not able to transport this in a vehicle. Aside from this issue, some may say it resembles a mobile hospital bed, which may draw unwanted attention.

4.2.3 Developed Concept 3

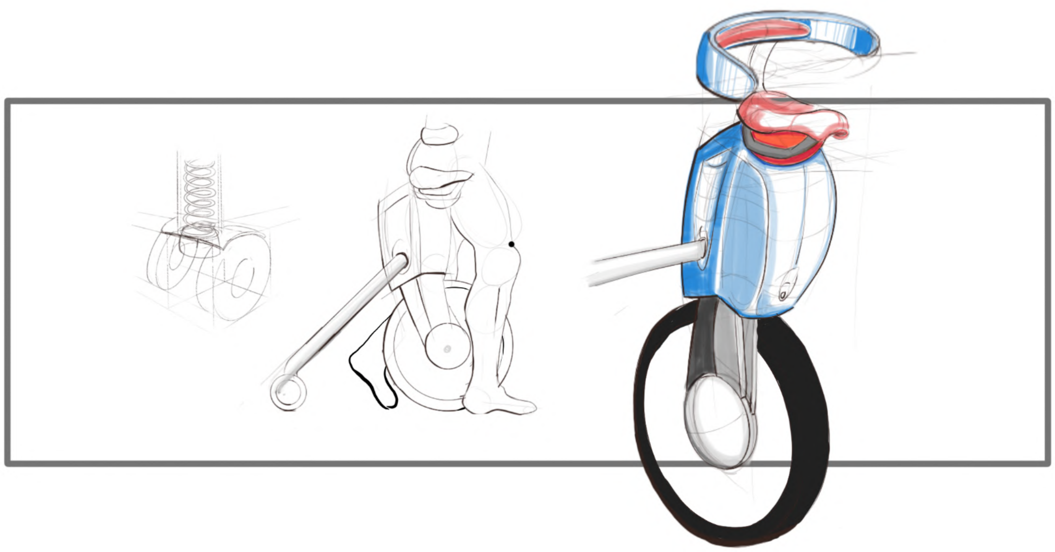


Figure 33- Concepts Exploration 3

The wheels in this concept are shown to be quite obtrusive. Upon further research, these types of support apparatuses are known to attract gazes. This can be uncomfortable for the user and may increase anxiety with the unwanted attention. Future developments will have to decrease the size of the wheels or remove them entirely.

4.3 Concept Strategy

With more cohesive feedback from the concept explorations, changes can be made and incorporated to create two extra concepts which will excel the aesthetic profile. Each concept was refined and incorporated feedback from professors, as well as taking different aspects of older sketches to create a cohesive device that attempts to satisfy the user’s needs. These concepts had the added benefit of highlighting user interaction points in their schematics and honing in specific mechanical components that operate the device.

4.3.1 Concept Direction and Product Schematic One

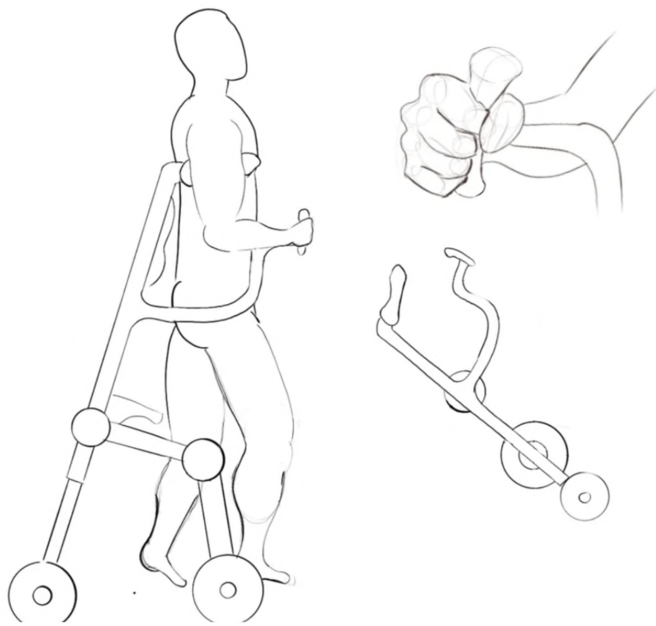


Figure 34 - Concept Direction One

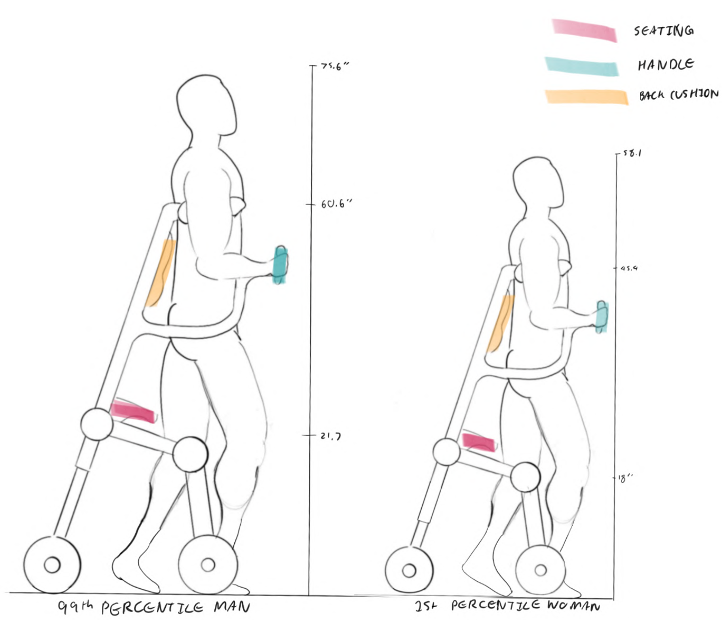


Figure 35 - Product Schematic One

The reason why this concept was selected was because of its characteristic of being lightweight in comparison to the other concepts. The points that are labeled on the concept brought attention to the fact that this product is only focused on comfort and maneuverability.

4.3.2 Concept Direction and Product Schematic Two

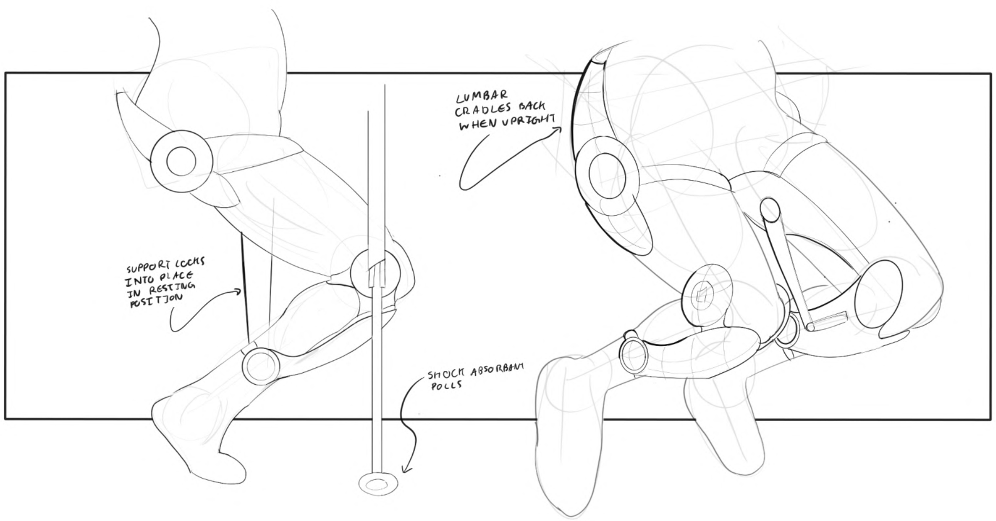


Figure 36 - Concept Direction Two

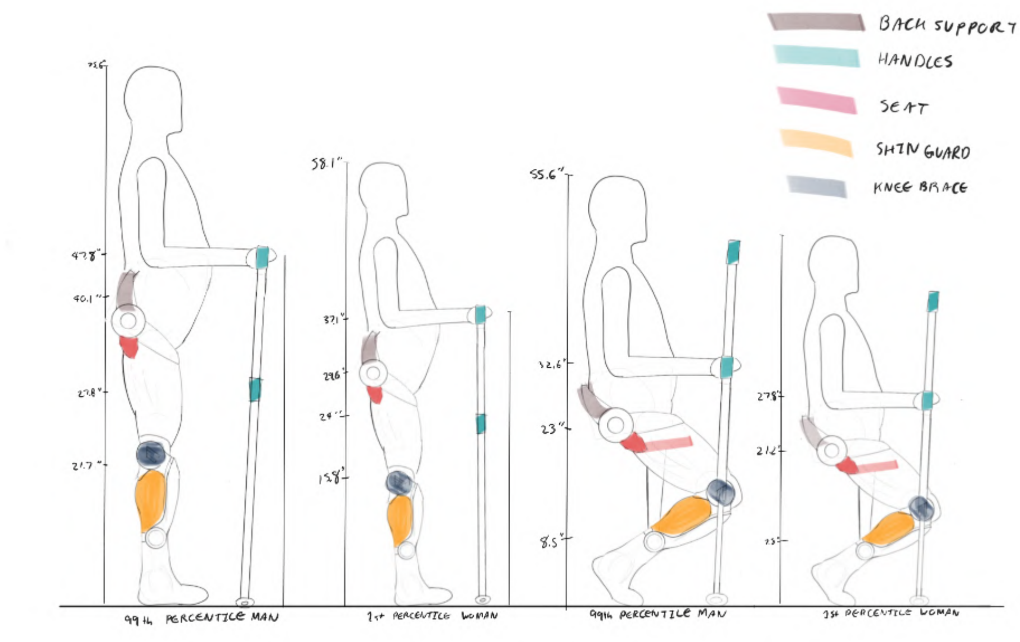


Figure 36 - Product Schematic Two

This concept was a combination of old ideations. This design was able to maneuver better and gave the user the ability to rest at any moment. It also appeared non-intrusive and looked lightweight, and was not too overly stylized in order not to not intimidate users.

After reviewing the sketches and listing out which product will be able to target and eliminate the pain points, the one that had the most potential was the second concept direction. The first concept direction had two main flaws, in that the frame would likely draw unwanted attention and it was akin to the design styling from the medical field. To my dismay of exoskeletons, the design and features of the second concept are able to tackle the user's needs and wants. Though there are still features to be tweaked and things to be added, this is now the foundation of the project.

4.4 Concept Refinement & Validation

4.4.1 Design Development

The final concept is an accumulation of ideas honed in to tackle the main problem of the user. This concept proceeded to be the foundation for the final concept. Details were added to refine the movement and explore the process of how the user would typically carry out their task. With the added equipment in terms of the walking pole, not only does the schematic have to be revised but the risk of operating a vehicle must also be understood.

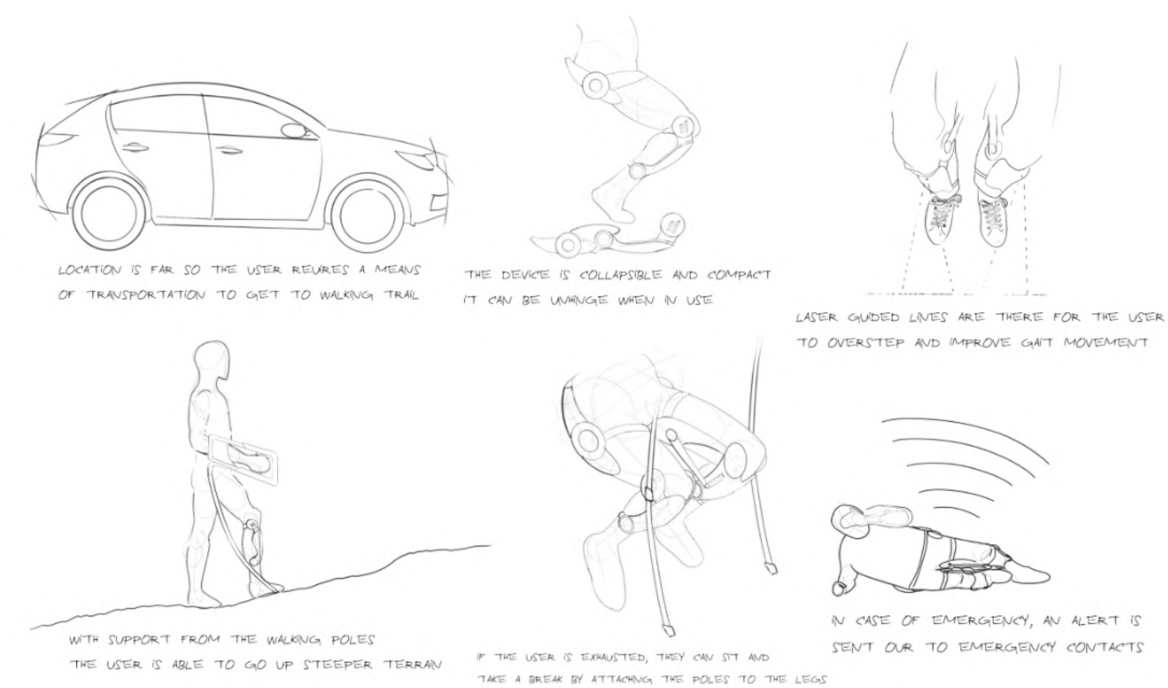


Figure 38- Storyboarding

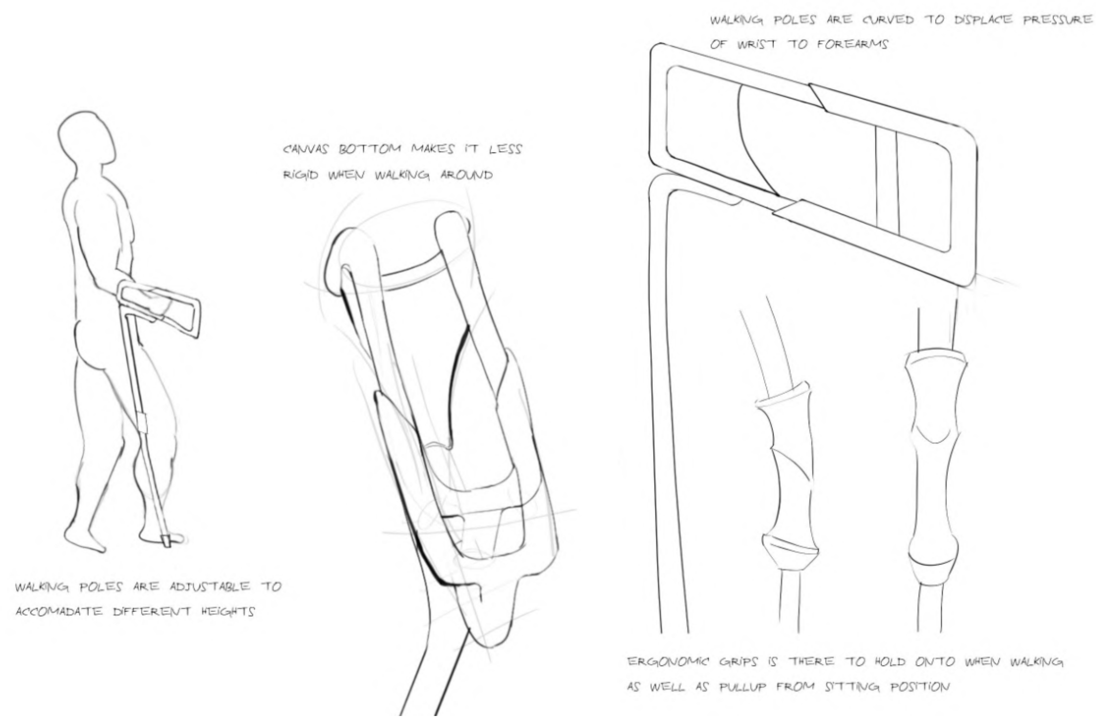
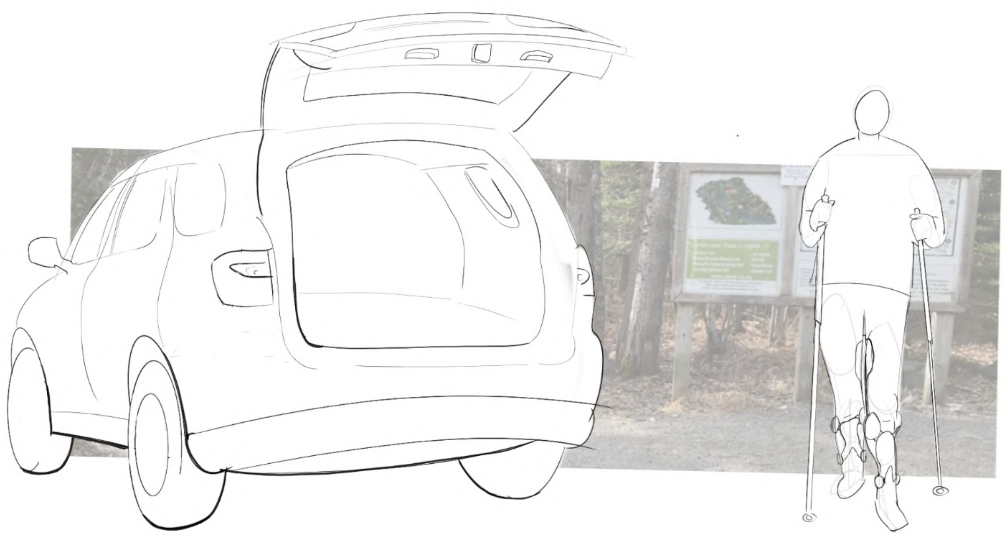


Figure 39- Trekking Pole Refinement



Figure

Figure 40 - In Situation

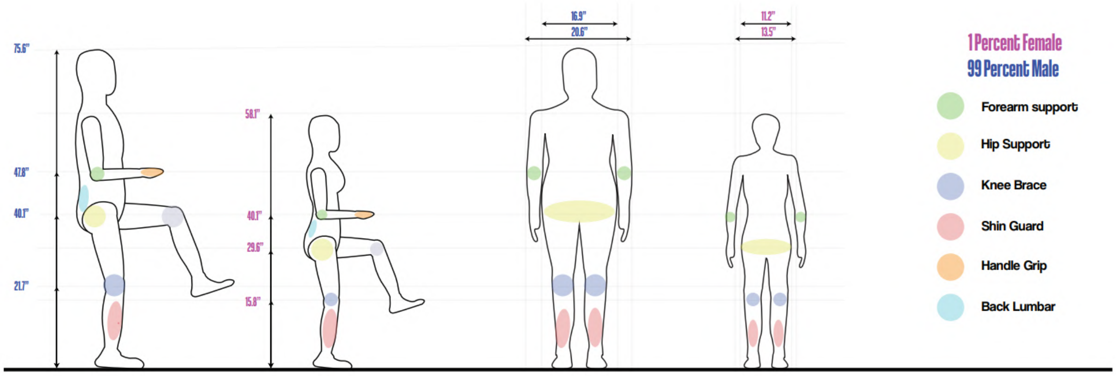


Figure 41 - Updated Schematic

4.4.2 Detail Development

Detailing takes a look at specific parts of the project to ensure that it is a cohesive design. This extends to where certain latches and features go, while also smoothing it out to fit the design language. It is important to ensure that too much of the functionality is not shown; in order to not draw attention, it was important to pursue a basic design in order to generate a friendly and approachable device. More detail was added near the production of the CAD stage. The exoskeleton in a CAD environment helps to better shape the form; the exoskeleton appeared much more substantiated in CAD compared to the sketch due to an increased level of skill in this area, which allowed an oversight to come to light.

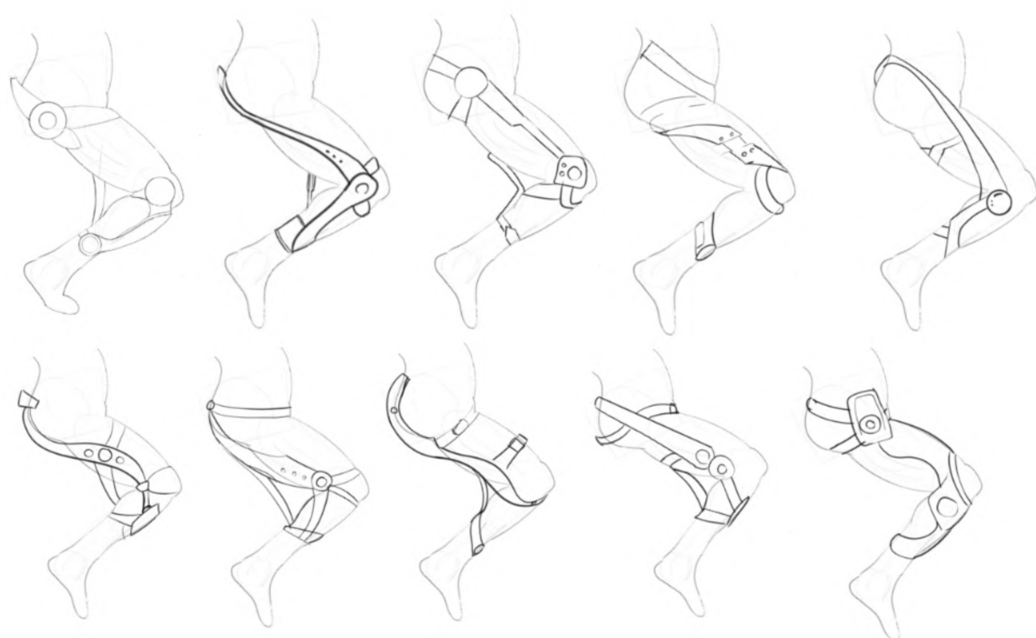


Figure 42 - Exoskeleton Variations

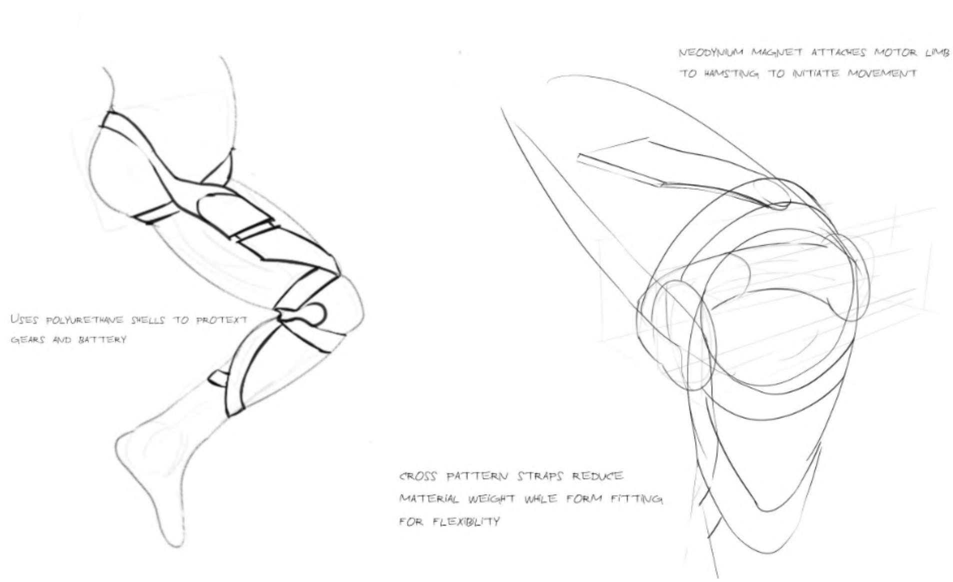


Figure 43 - Knee Brace Placement

Figure 44 - Latches

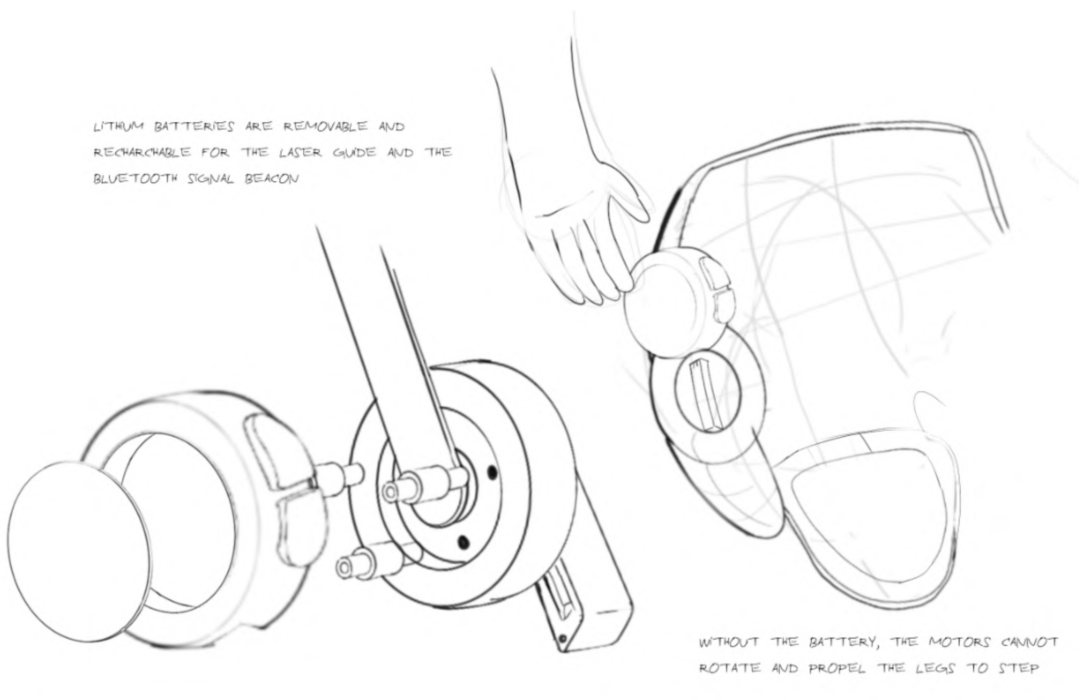


Figure 45 - Motor Exploded

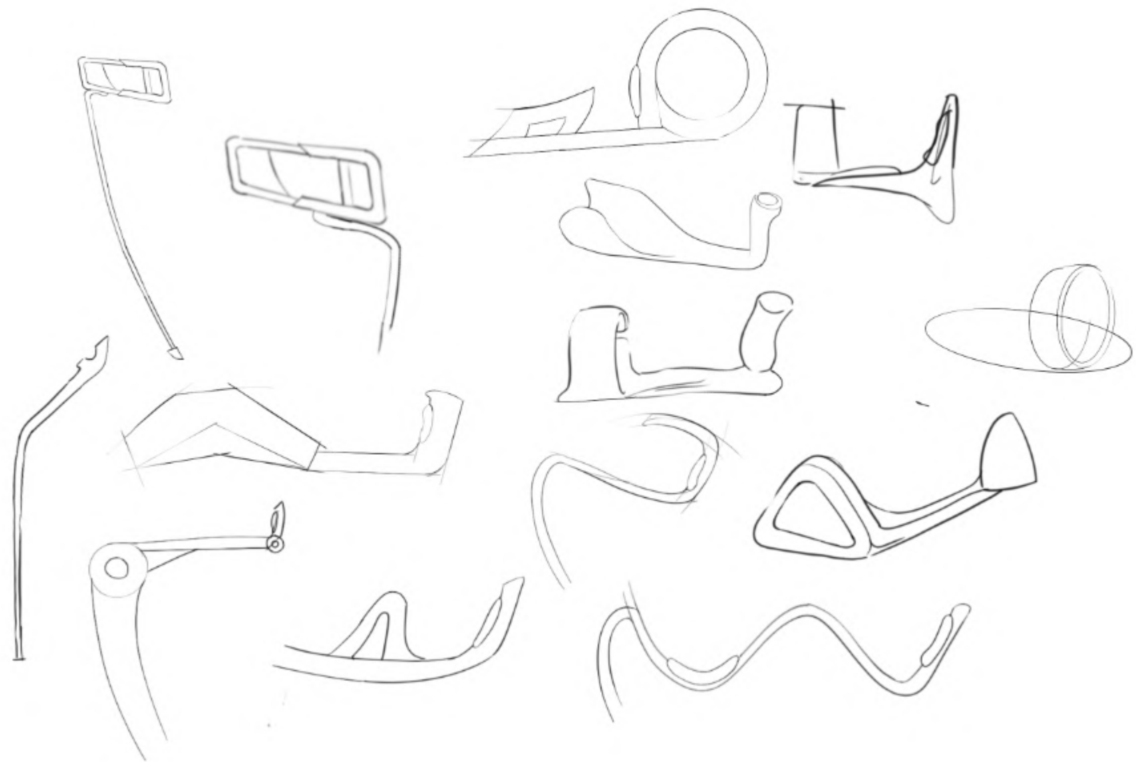


Figure 46 - Arm Variations

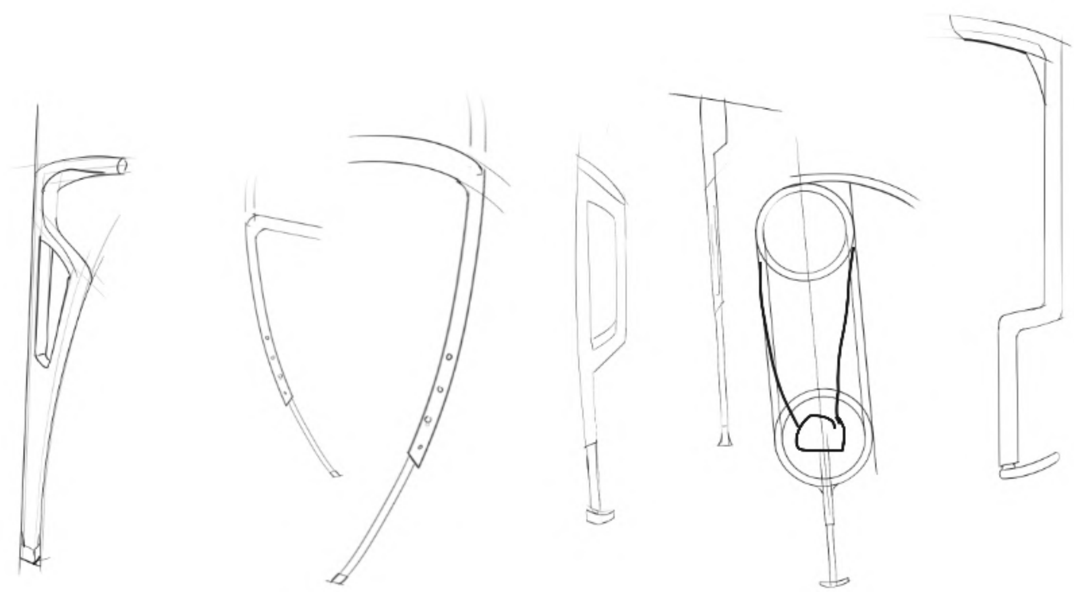


Figure 46 - Pole Variations

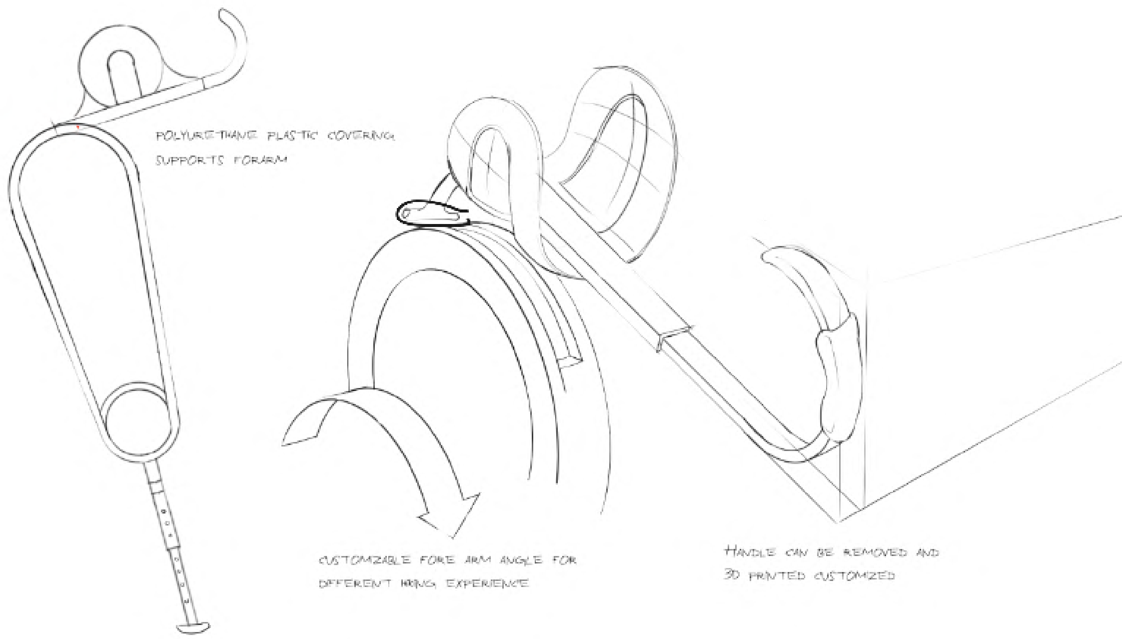


Figure 47- Arm Mechanics

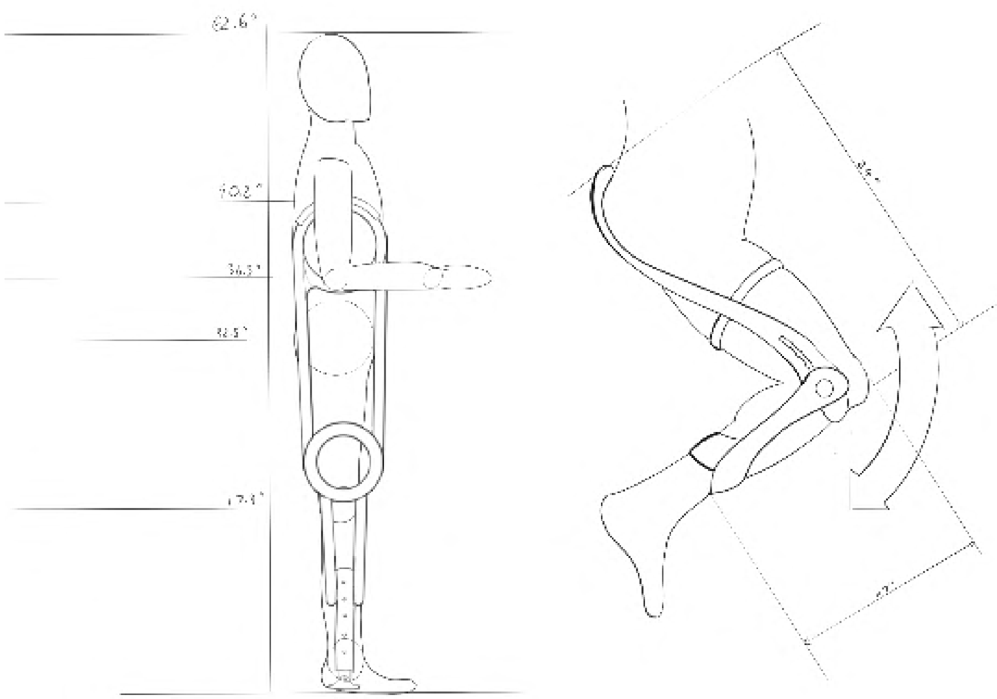


Figure 48- Rough Body Measurements

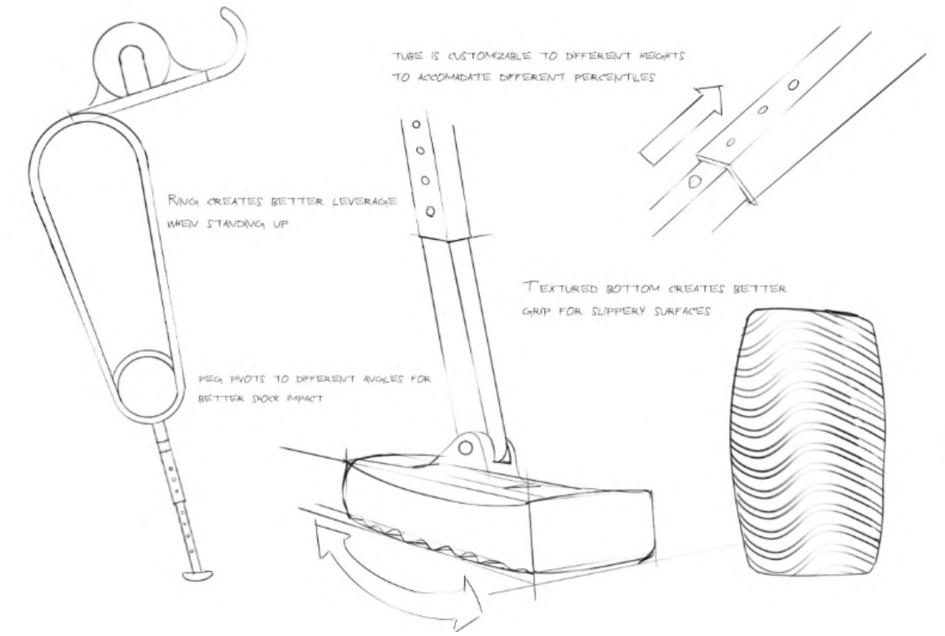


Figure 49- Pole Height Adjustment

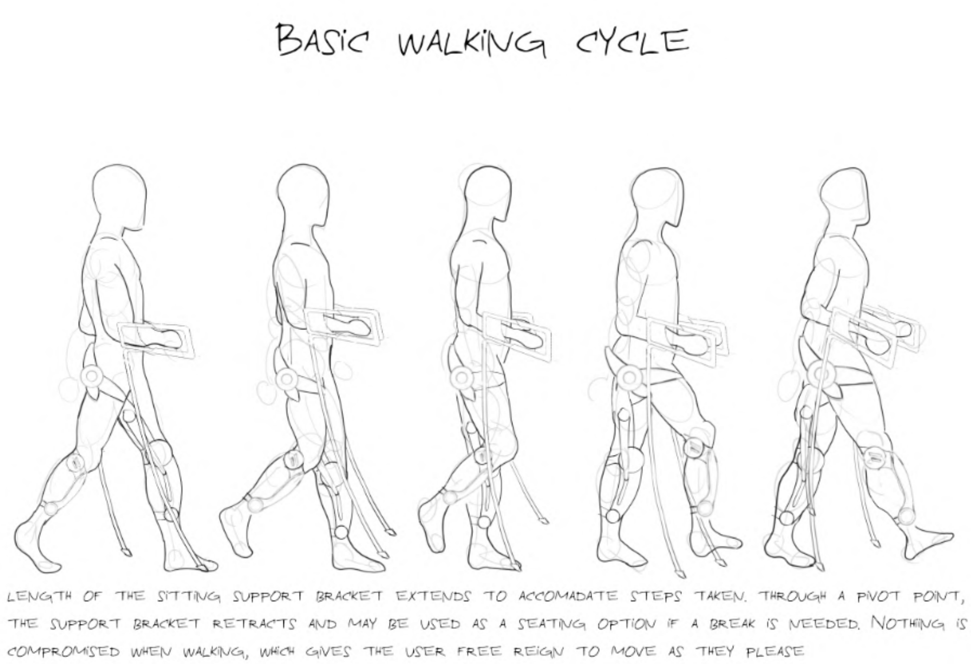


Figure 50- Walking Cycle

4.5 Concept Realization

4.5.1 Design Finalization

To better comprehend the mechanism of the walking pole and see if the exoskeleton could bend while not interfering with other components, a sketch model was built at a quarter of the scale to understand the ergonomics needed. The structure of the vehicle consisted of cardboard due to time constraints and lack of access to materials. Building the sketch model revealed some problems that could occur when constructing the final model, which resulted in minor alterations.

4.5.2 Physical Study Models

Figure 51- Walking Pole Sketch Model

Figure 52- Exoskeleton Sketch Model

After breaking down what essential ergonomics the user needs, building a sketch model was much simpler than anticipated, but also brought in needs that turned out to be wants from the user, specifically with regard to the resting position of the model. This reworked model led to the removal of this feature in favor of other characteristics of the exoskeleton, mainly being maneuverability.

4.6 Design Resolution

At this point in time, an overall form has been decided and an accumulation of all sketches and concepts have come down to this final design. Of course, that does not mean it can not be subject to change.This final idea will serve as the final product's design direction and foundation. With the help of professors and instructors, more characteristics were implemented at a later time. It was enough to dive in the digital realm of CAD, after all the ergonomic considerations and emphasis on the user features. This final design is a stabilizing walk-assisted exoskeleton, which allows people with Parkinson's disease to traverse open nature trails without the fear of falling, inspiring confidence, improving mental health, and increasing physical health.

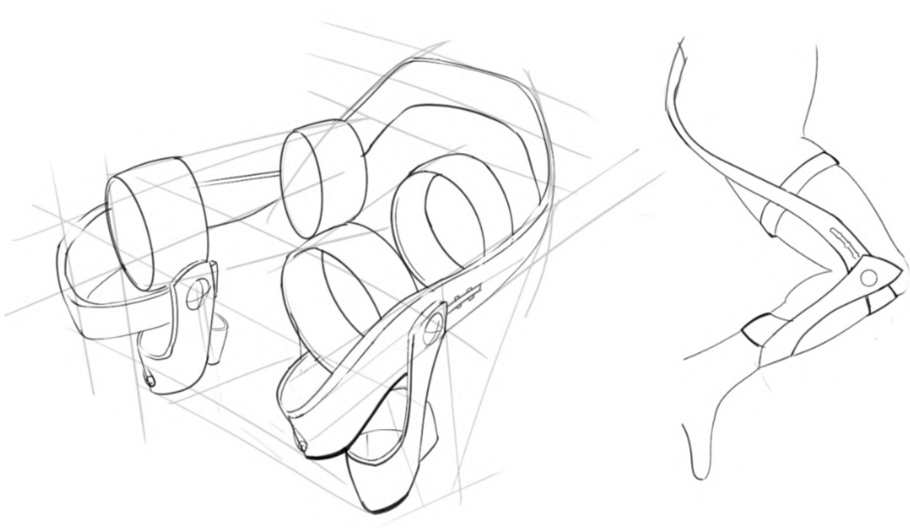
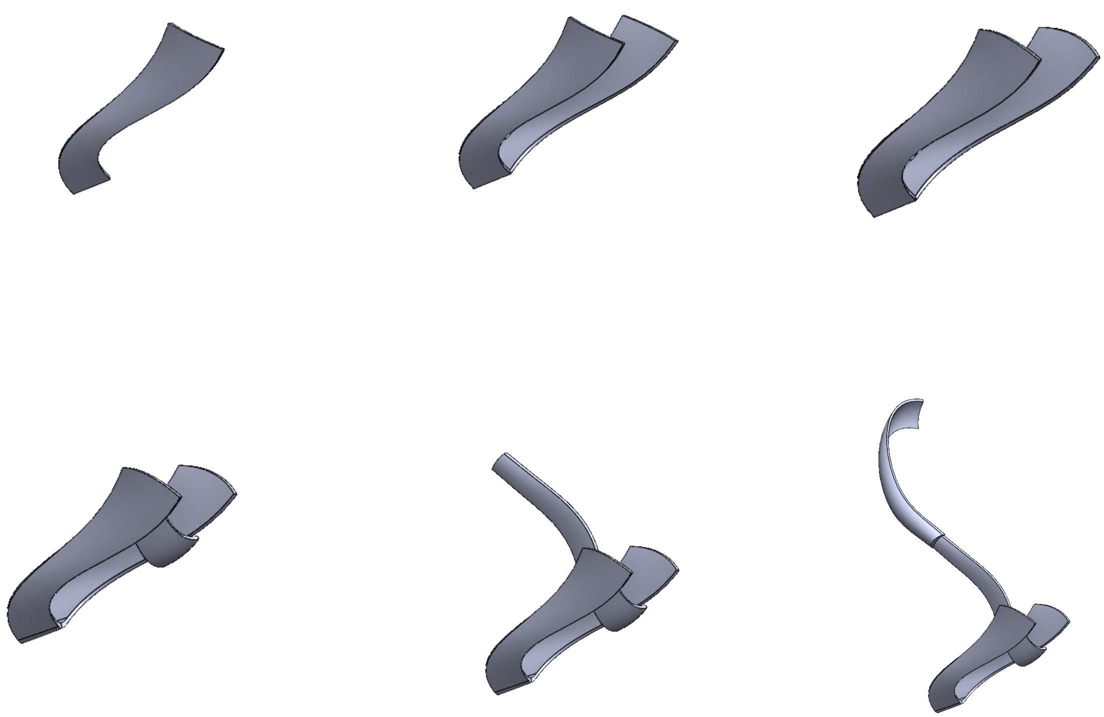
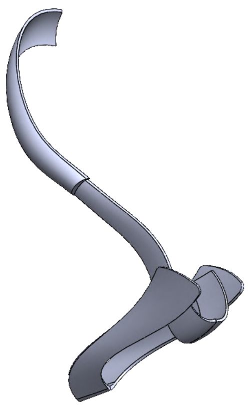


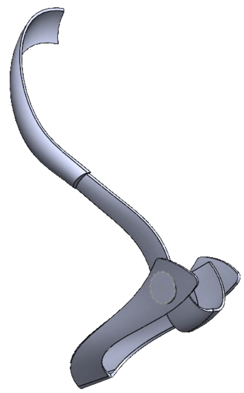
Figure 53 - Foundation Picture

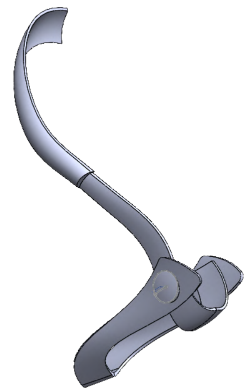
4.7 CAD Development

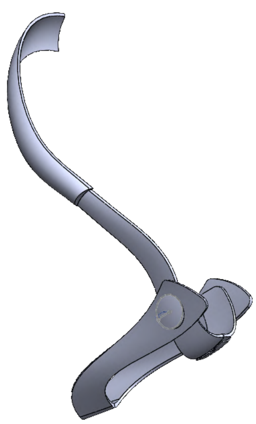
4.7.1 Exoskeleton

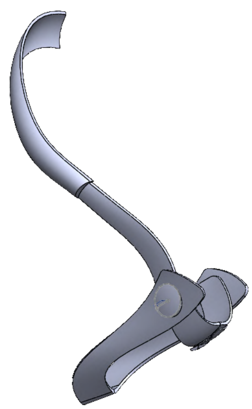


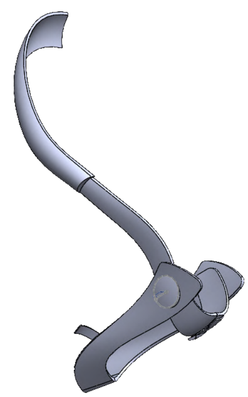


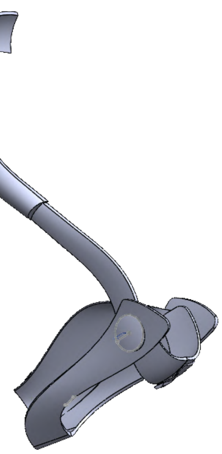
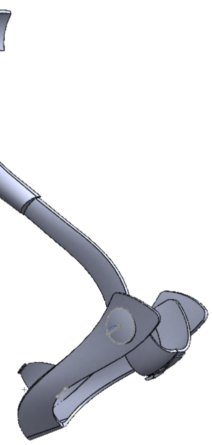
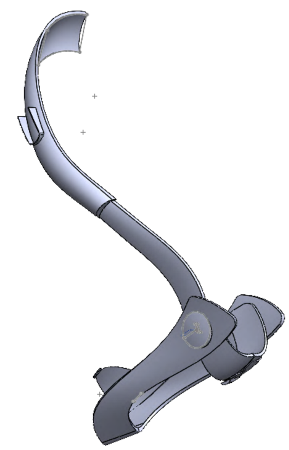
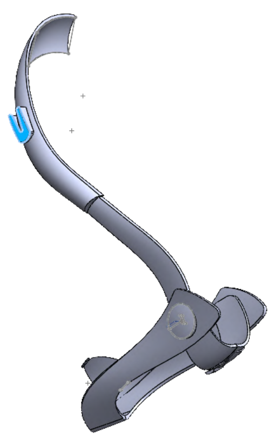
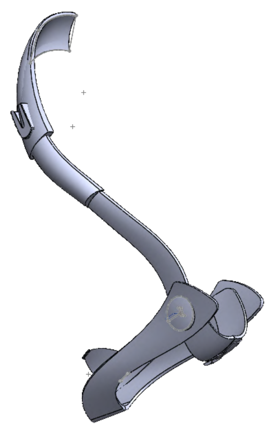
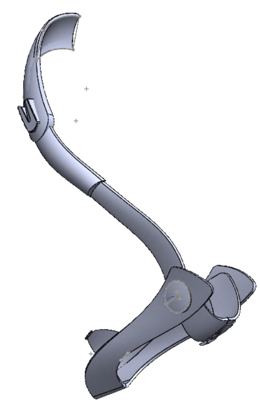


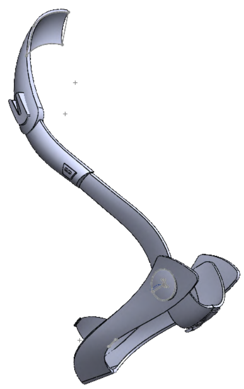


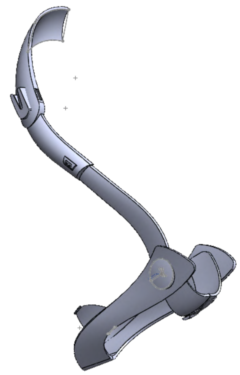


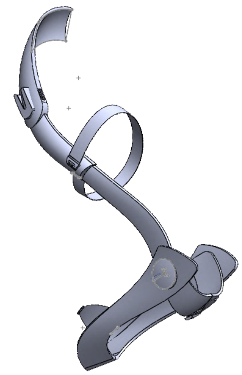


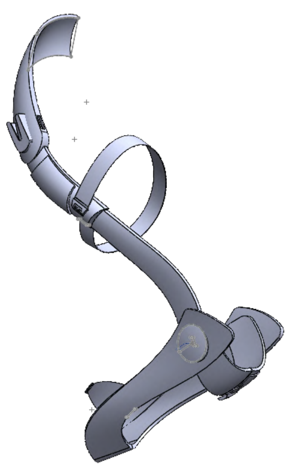


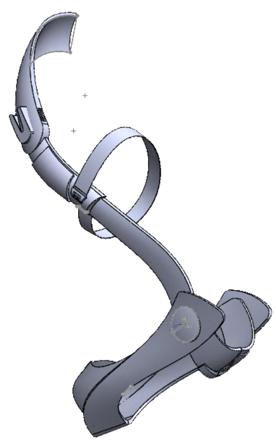







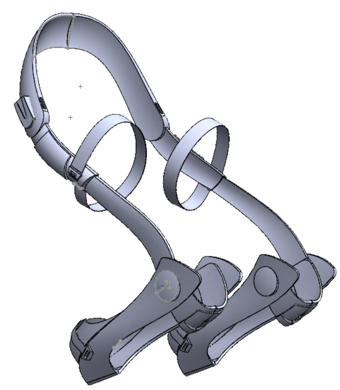












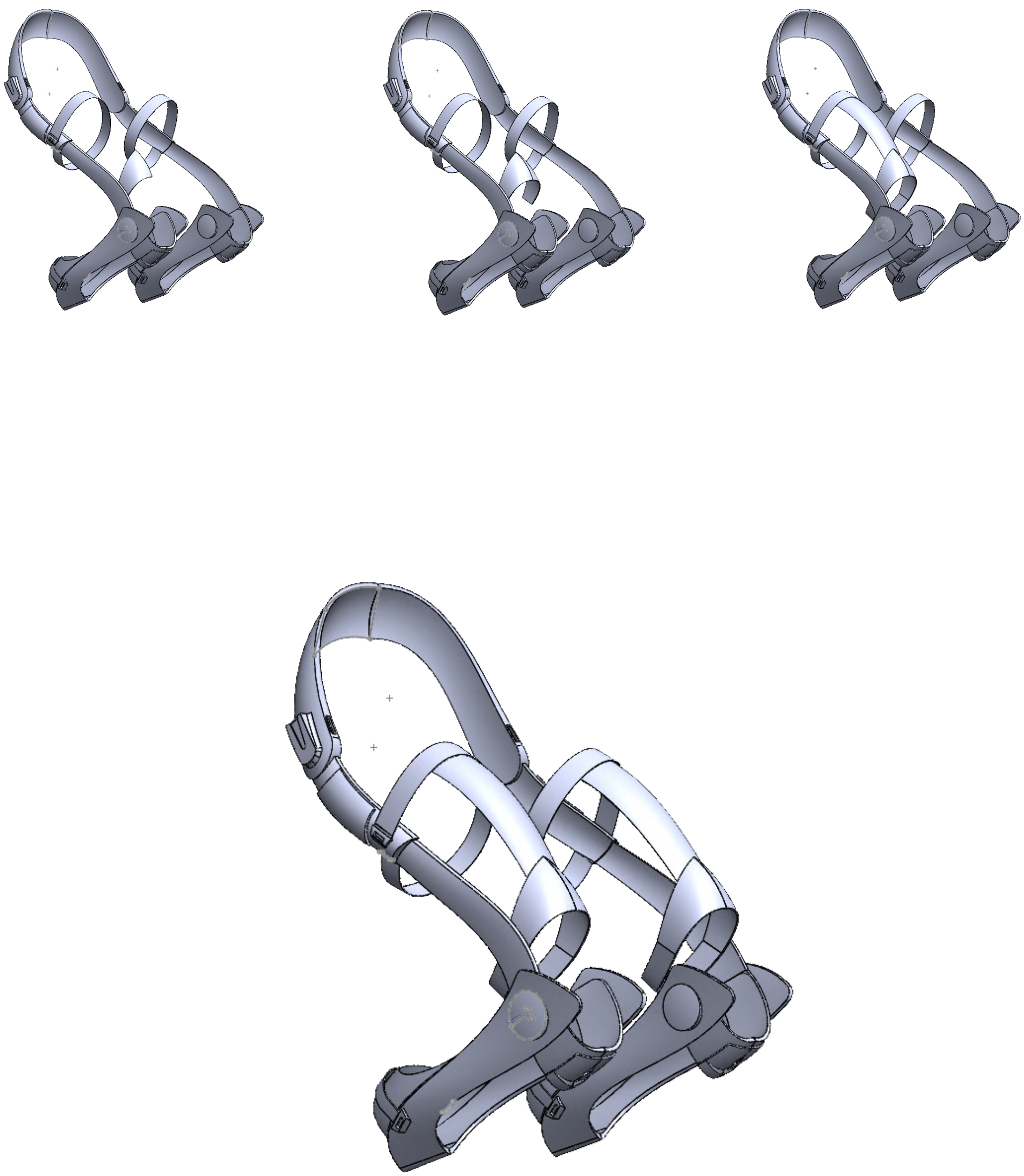
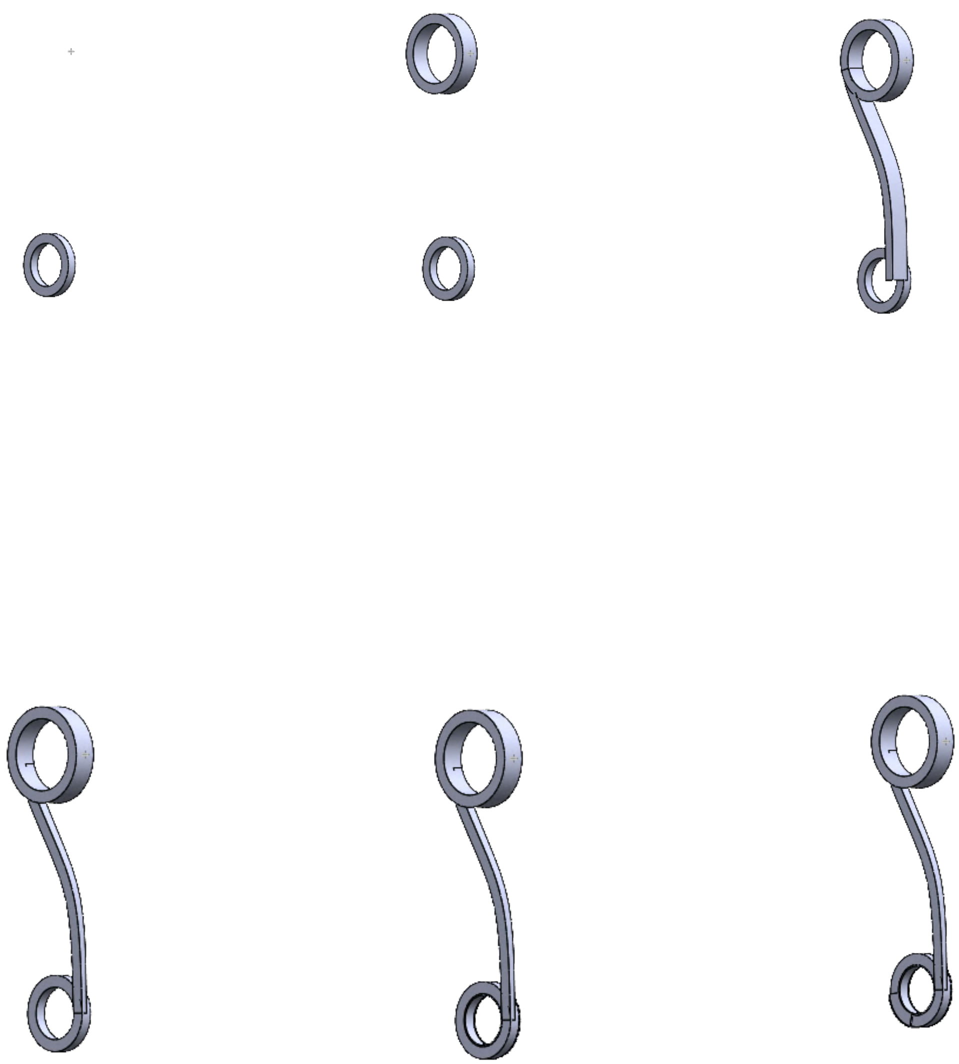
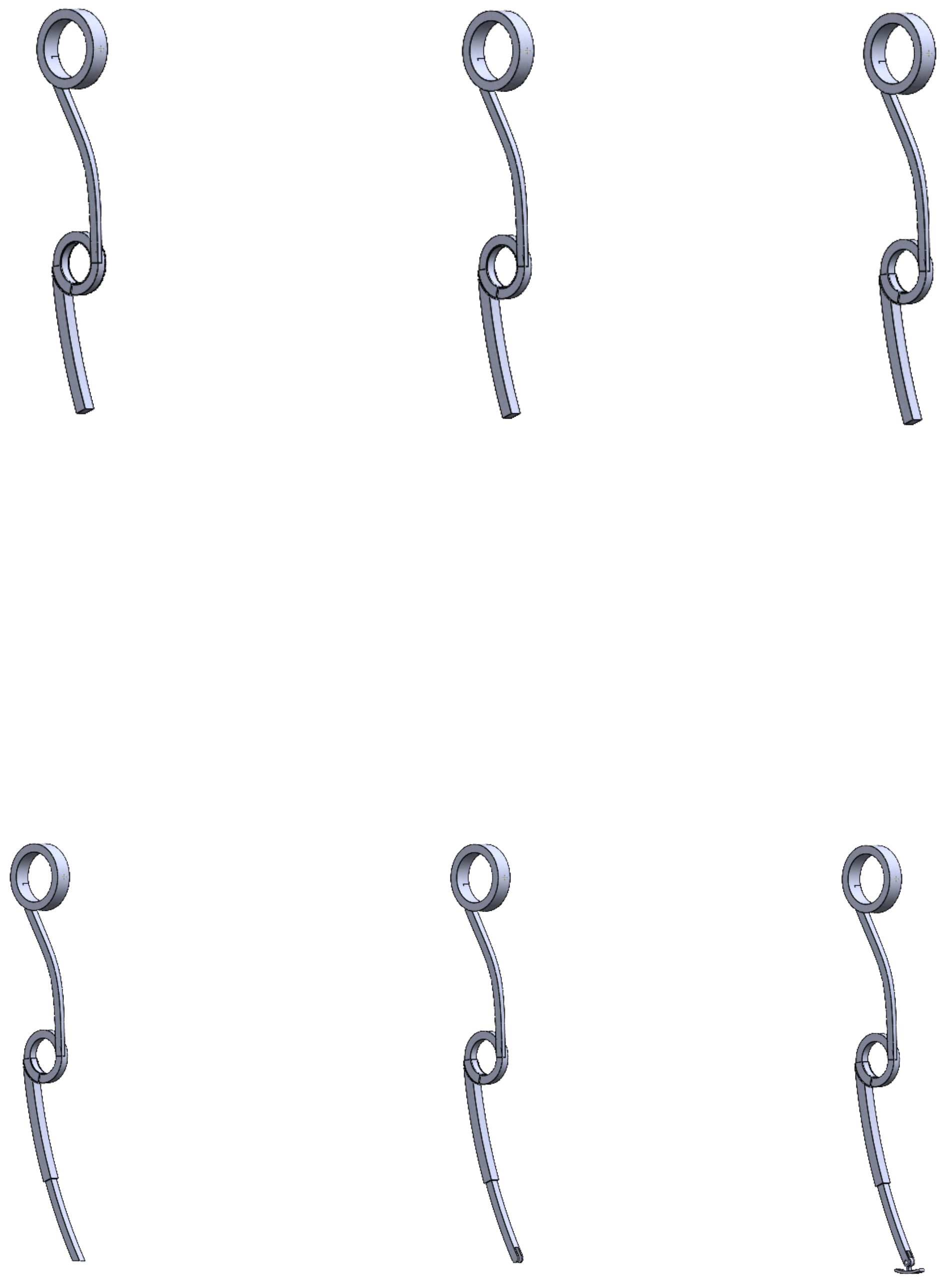
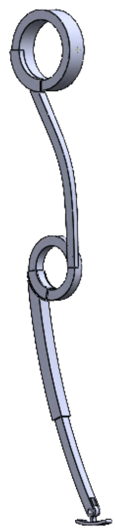
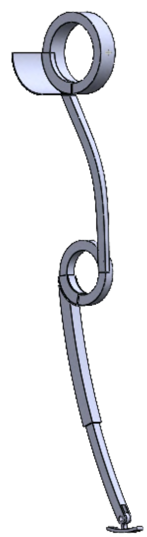
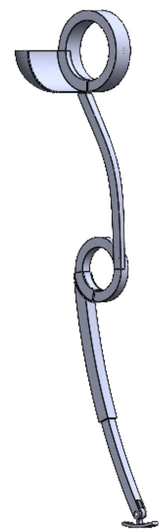
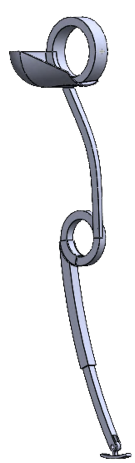
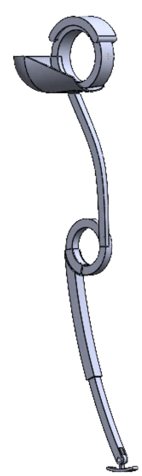
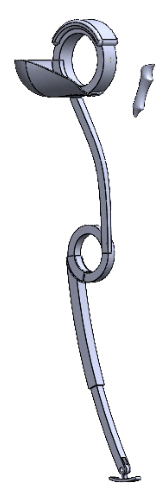


Figure 54 - CAD Exoskeleton

4.7.2 Trekking Pole





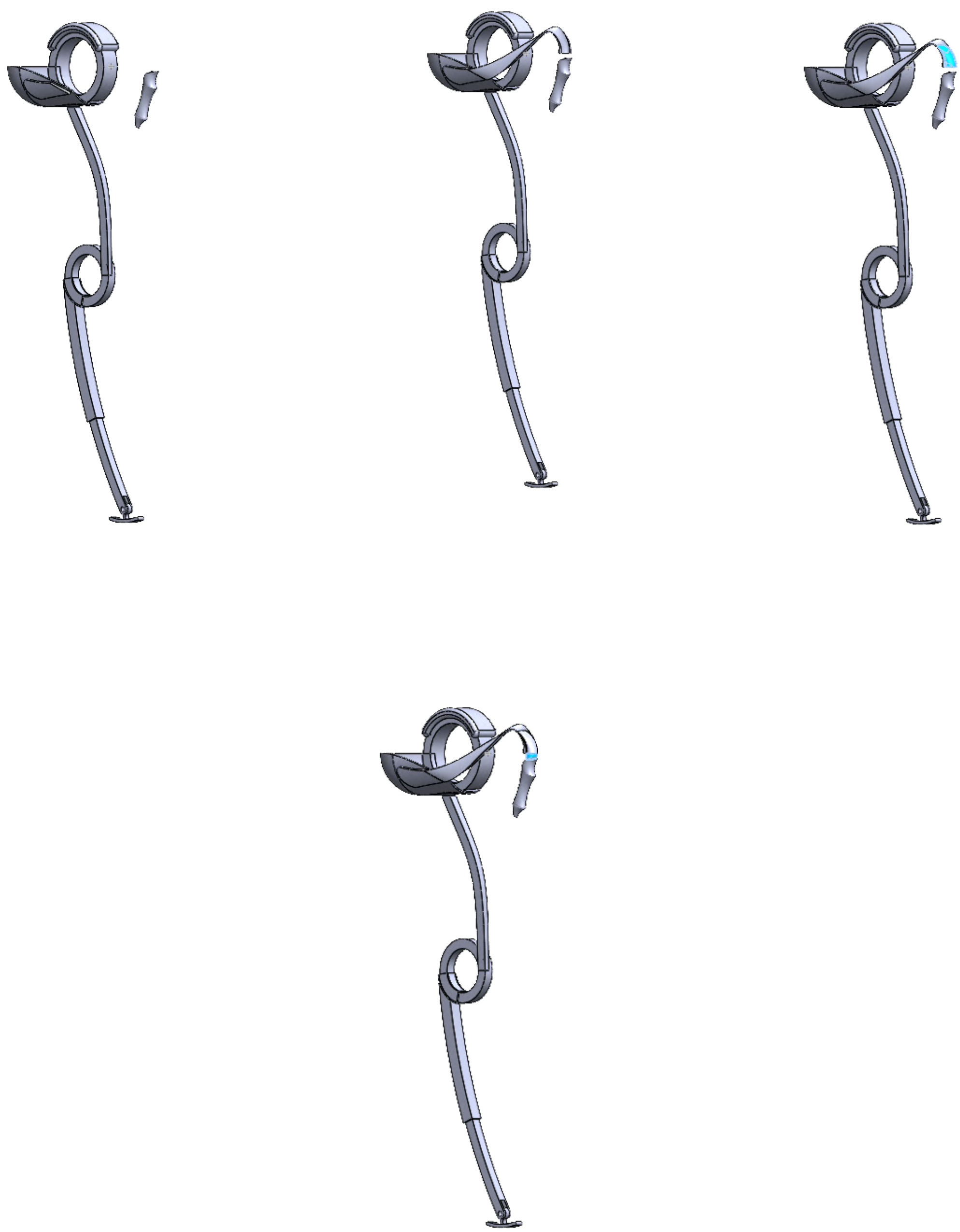


Figure 55- CAD Walking Pole

The CAD modeling process took a couple weeks to complete at most. The software that was used was Solidworks, erosion (2021-2022). The exoskeleton had the least concern as it followed the drawings with few extra detailing add-ons. The walking pole, however, was modified several times as it did not fit the design language. After taking a break and finding solace from a picture of a flamingo as inspiration, this prompted the structure which induced inspiration from bones and from aerial animals. Both CAD models were constructed in one file and later split for animations. To follow the simplicity of the design, few parts were constructed to ensure the product was simple enough to be approached by the targeted age range. Many planes were constructed to make the product look organic and free flowing.

4.8 Physical Model Fabrication

The thesis' final model was made at home with a personal 3D printer. The model was trimmed down with a dremel to account for large imperfections and smeared with modeling putty to fill in any other small print lines, followed by a variety of sandpaper grades ranging from 180 grit to 800 grit to smooth out the surface. To have a clean finish, a coat of krylon gray primer was put on to fill smaller lines from the 3D print. Bright nylon straps were purchased to simulate the straps for the exoskeleton in order to save time and increase realism. A hair dryer was used to speed up the amount of time it took for the primer coat to dry. Any minor cracks were patched up using Gorilla super glue. The final product was a third of a scale model that took a total of 47 hours of printing with the help of two 3-D printers.

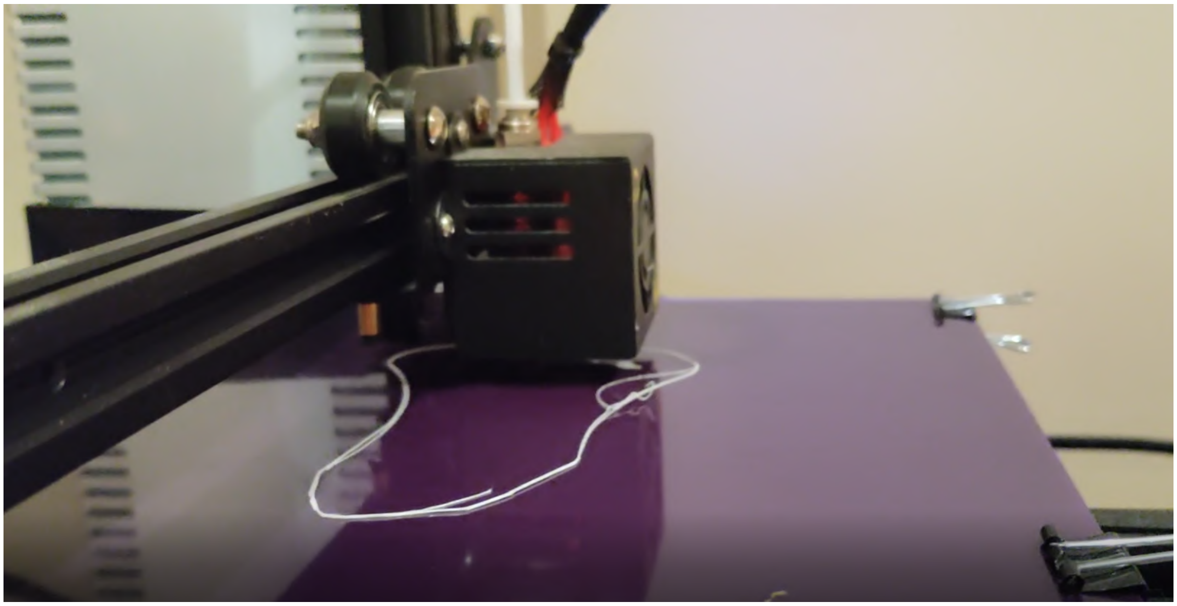


Figure 56 - Personal Printing Bed

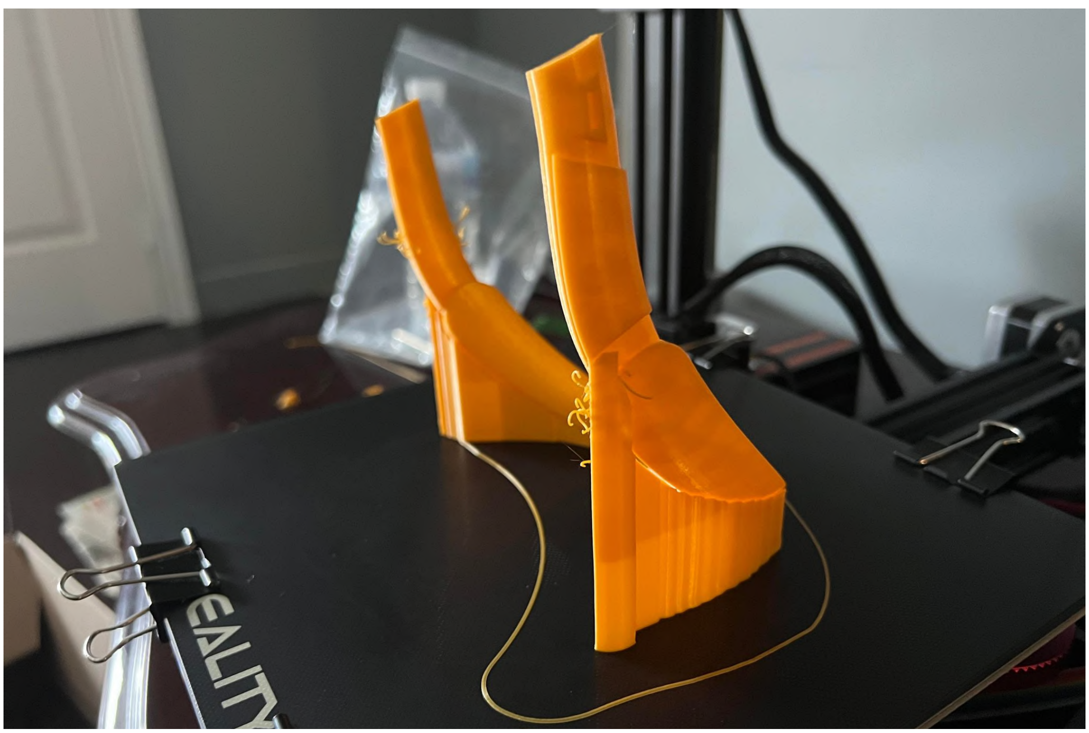


Figure 57 - Mahjub's Printing Bed

Figure 58- Laid Out Pieces

Figure 59- Imperfections

Figure 60 - Dremel Sanding

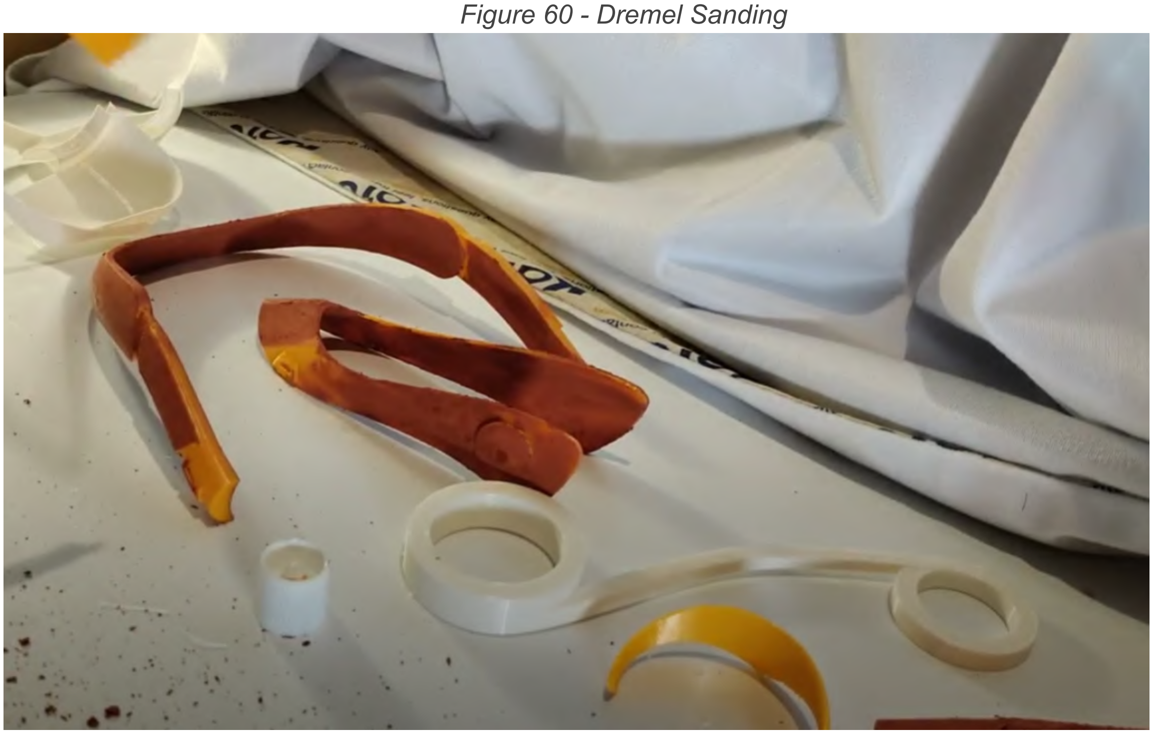


Figure 61- Bondo Putty Applied

Figure 62- Super Glue Cracked Pieces

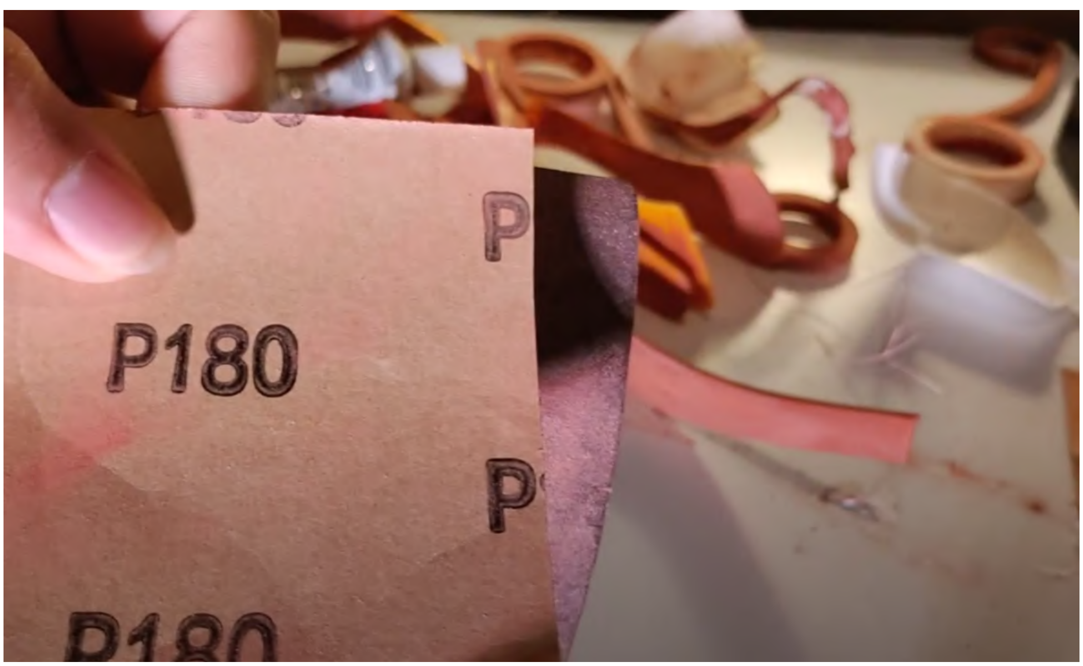


Figure 63 - 180 Grit

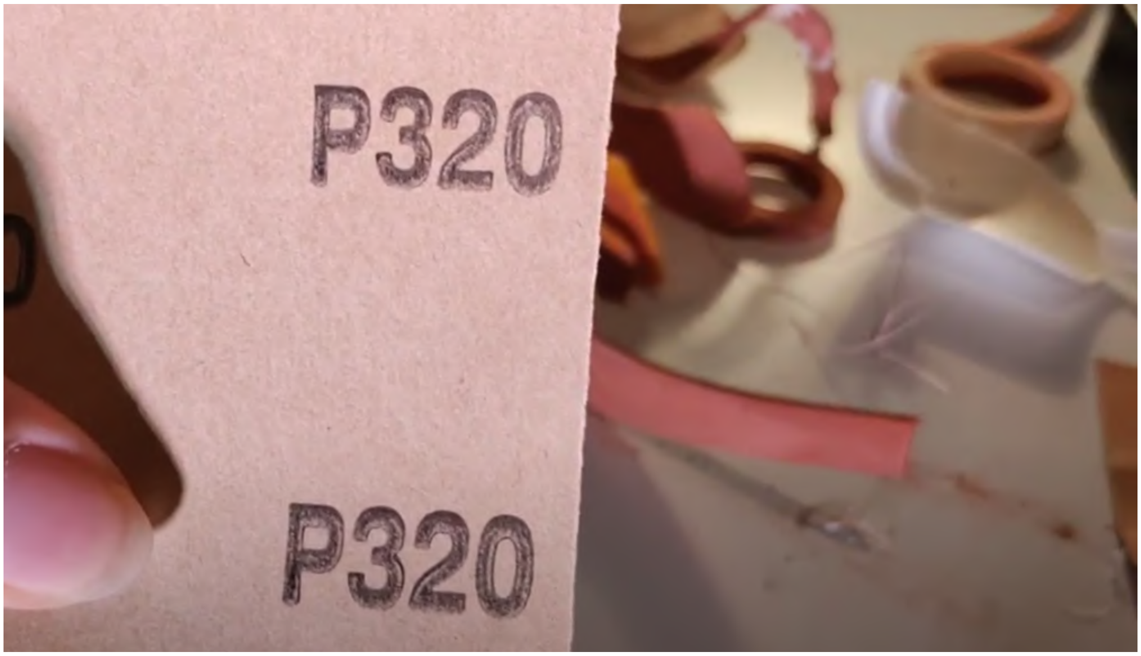


Figure 64 - 320Grit

Figure 63 - 800 Grit

Figure 64 - Spraying Primer

Figure 65- Drying Pieces

Chapter 5 Final Design

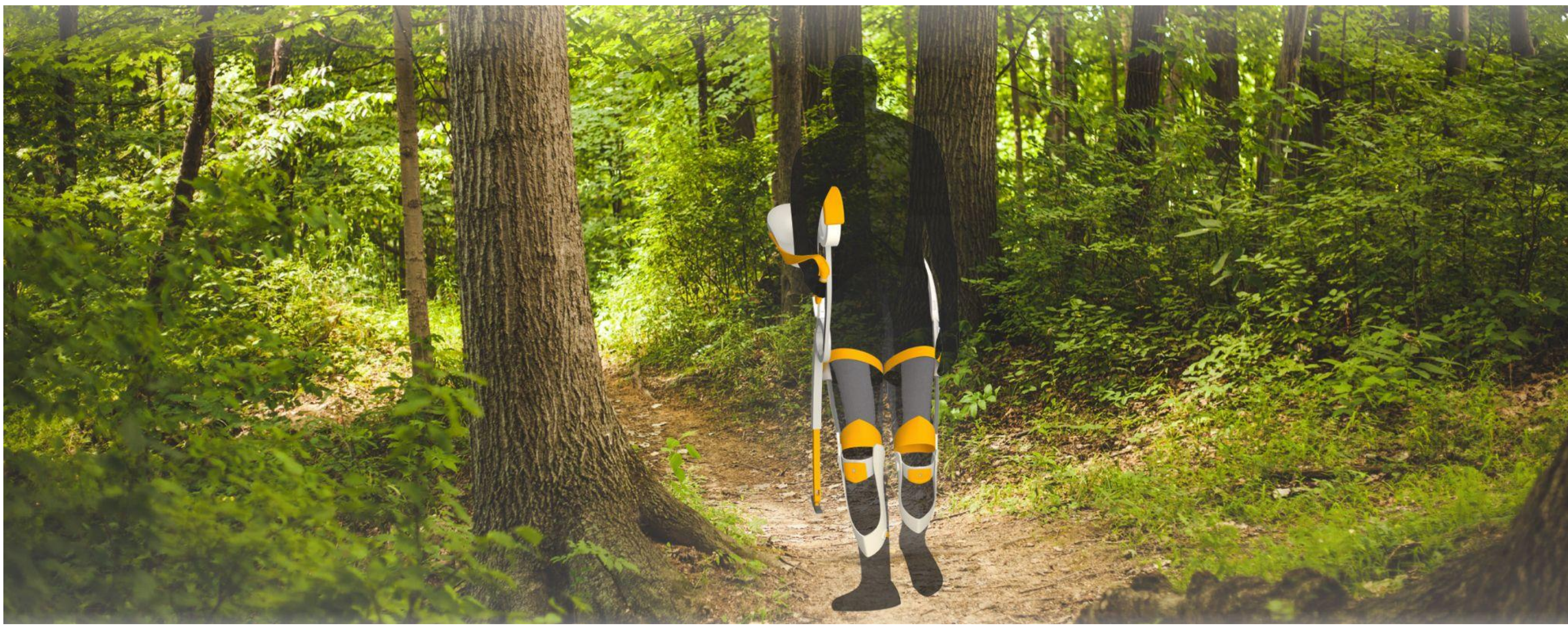


Figure 85. Product in Situation

5.1. Summary

5.1.1 Description

FLINGO is a stabilizing walk-assisted exoskeleton that was designed to improve balance, gait, and speed for uneven terrain on nature trails.

5.1.2 Explanation

Current walking-support apparatuses, particularly those that are accessible on the market, struggle to take everything that users need and want into consideration. These instruments offer little movement and maneuverability in favor of balance and structure, which can be detrimental as it leads to a dependency on the instrument to conduct walks. Walkers tend to limit the user to flat terrain. Issues with walkers include their large size and inability to become compact for vehicles, lack of suspension, and potential for wheels to become dirty and stunted, slowing a person down until they are cleaned. The goal of the thesis is to create a solution to improve mobility, gait, and balance for Parkinson's disease patients to empower them to walk with confidence and maintain a healthy lifestyle. The proposed concept will be human-centric to the user after collecting research and developing for the targeted user's ergonomics when they are walking. This concept will incorporate unparalleled technology that has been proven to be effective for the targeted user. This includes laser guiding systems, HD rumbling motors, and high torque density motors.

5.1.3 Benefit Statement

FLINGO is a walking-assist support solution that combines a high torque motor with haptic and visual guidance for uneven outside environments. This allows the environment to become approachable to users by guiding their steps and promotes a design language that does not draw too much attention from other individuals. This device allows the user to feel empowered and confident when traversing through rough outdoor terrain, which will in turn lead a healthier lifestyle.

5.2. Design Criteria Met

5.2.1 Full Bodied Interaction Design

FLINGO is a walking-assist support solution that combines a high torque motor with haptic and visual guidance for the uneven outside environment. This allows walking to be an approachable exercise for those who are physically impaired. The design solution reflects the openness by keeping the design sleek and minimal while still being ergonomically close to the body to ensure it does not appear bulky and heavy. To ensure that this does not feel like a medical device, a bright and fruitful color palette was selected instead of a cool tone; this colour was taken into consideration to draw enough attention to the beauty of the device rather than the disorder of the user.

Admittedly, the initial design of the exoskeleton was sporadic, but after focusing on the specific needs of the user, it was evident to stick with a simplistic design, which ended up being an organic bone-like structure. This resulted in an approachable project that makes the user feel comfortable and empowered. The device is able to squat with the user and follow the user's movement without limiting their range. The device is secured with straps that use magnets as latches. This is a great way to wear and attach the exoskeleton to the body due to the lack of motor functions. The exoskeleton is able to extend to accompany the user's leg length at the thigh region, the shins fit both the 99th percentile male and 1st percentile female.

Attached throughout the body are HD rumble motors that signal the user when to step. Depending how well the user steps, vibration from the motors act as haptic feedback and indicate to the user if their strides in each step are long enough. The laser guide in the shins projects a line on the ground to indicate where the user should step. In the shins, one will find an Arduino Nano 33 IOT, which acts as a gyroscope, goniometer, and accelerator to check the user's movements.

The walking pole was inspired by the flamingo; this is evident through the similarity between the shape of the exoskeleton and the bird's organic shape. It also borrowed a bone-like style and implemented an extension on the handle to assure that the two pieces looked symbotic. The arm rotates in different positions when walking, and it also includes a detachable handle if the user damages the handle or chooses a different design. The leg of the walking pole is able to extend to the user's height and is loaded with a mini spring for suspension. Like the arm, the leg also has the ability to rotate for a different walking position. The foot can also be swapped out for a different walking style to ensure that the user is able to walk on any terrain. Both the arm and leg are able to fold in for easy transport and storage space.

5.2.2 Materials, Processes and Technology

In Section 2.2.4, an analysis of materials used in current market products was made in order to decide what material should be considered if the product is manufactured. Materials such as light metal alloys, rubbers, resin molded composites, and other materials were all deconstructed to be examined. Aluminum will be used for the main body of the walking pole and the inside chassis of the exoskeleton. The other parts of the build will be made of machine-molded resin, and bright nylon straps. All materials mentioned are sourced from eco-friendly materials that have been approved by the Cradle to Cradle organization.

The study of the nervous system and our knowledge of how it affects the movement and balance of the legs will always be growing as more people try to find ways to foster independence in those who are physically impaire. With that insight, there are always going to be new, emerging technologies that are being refined and tested in order to modernize these walking support solutions. The following technologies that are incorporated into the final design are as follows:

- Lithium Ion Batteries
- Laser Diode
- High Torque Density Motors
- HD Rumble Motors
- Arduino Nano 33 IOT
- Custom 3D Printed Handles

5.2.3 Design Implementation

Manufacturing expenses are very different from what is on the current market. The majority of the walk assists of this caliber mirror the SPORTSMATE 5. With only one piece of information in terms of price, pricing estimates for this product are difficult to determine. After deducing the competitor and comparing corresponding production costs, an estimate was established.

While these two products differ with regard to aesthetic and features, the overall function of the product will be accounted for. The table showcasing the components used and their corresponding price estimates based on similar products in the current market are as follows:

Cost of Items		
Item	Quantity	Material
Exoskeleton		
Lithium Ion Batteries	1	Sourced
HD Rumble Motors	12	Sourced
High torque density motors	2	Sourced
Laser Diode	2	Sourced
Arduino Nano 33 IOT	2	Sourced
Nylon Straps	4	Nylon
Shin cushions	2	Sourced
Hip Component	1	bio-copolyester
Thigh Component	2	bio-copolyester

Hip Cushion	1	Sourced
Chassis	1	Aluminum Pressed
Shin guards	2	bio-copolyester
Trekking Pole		
Foot	2	Sourced
Handles	2	bio-copolyester molded
Leg Extension	2	bio-copolyester
Leg	2	Aluminum Tubing
Pole Body	2	Aluminum Tubing
Fasteners		
Bolts	4	Steel
Screws	20	Steel
Nuts	4	Steel

Table 12 . Bill of Materials

5.3 Final CAD Render

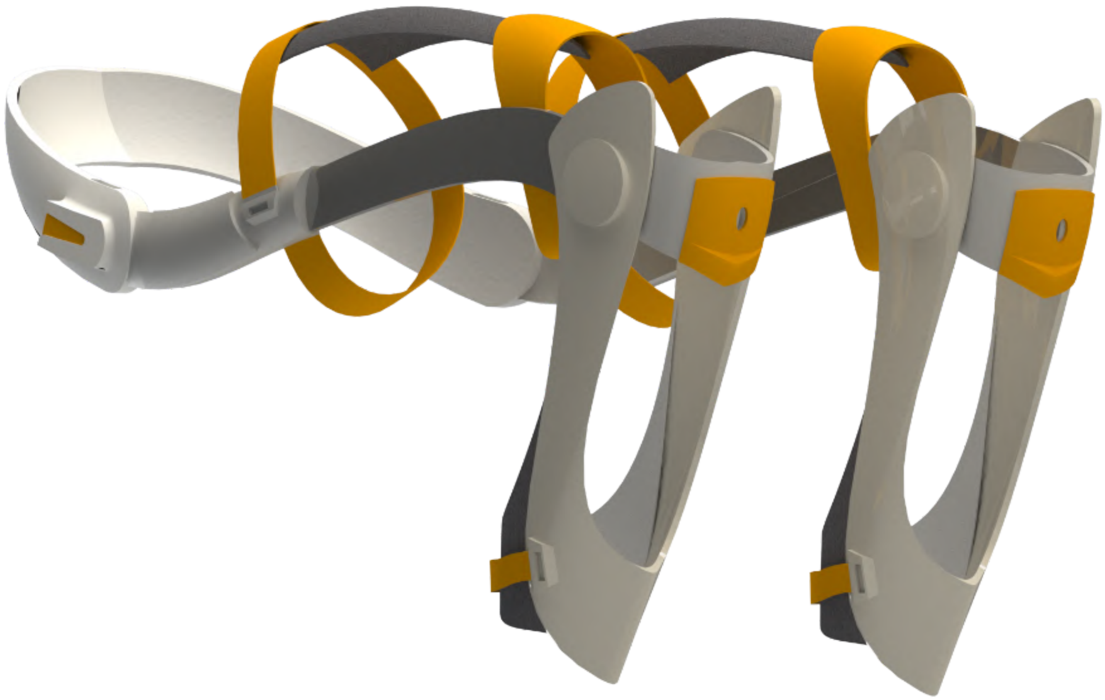


Figure 66- Exoskeleton ¾ View

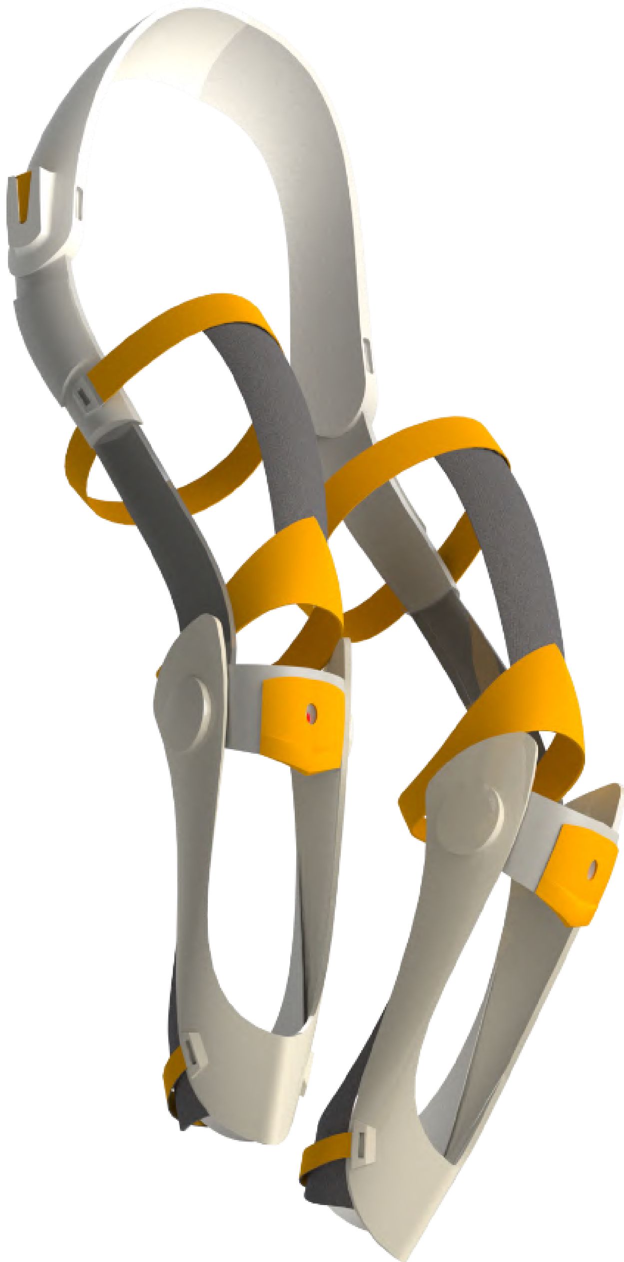


Figure 67- Exoskeleton Standing Position

Figure 68- Exoskeleton Knee Close-up

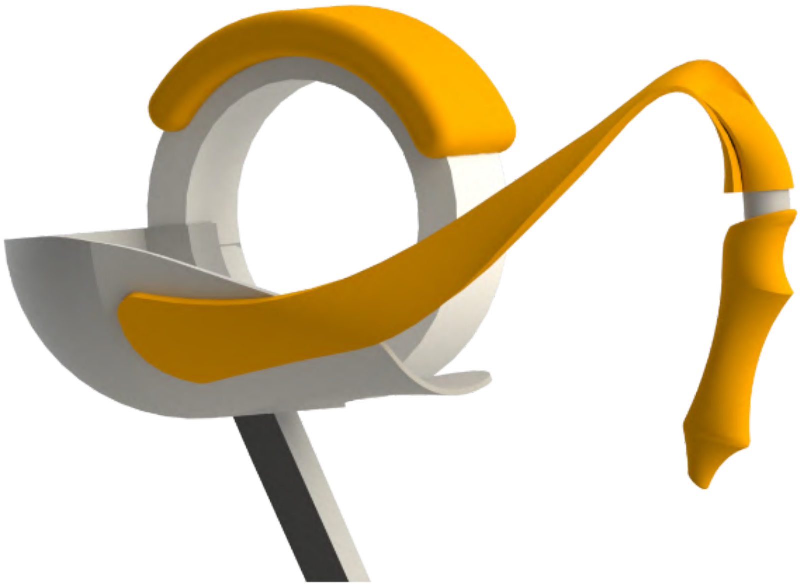


Figure 69- Walking Pole Close-up

Figure 70 - Wrist Position

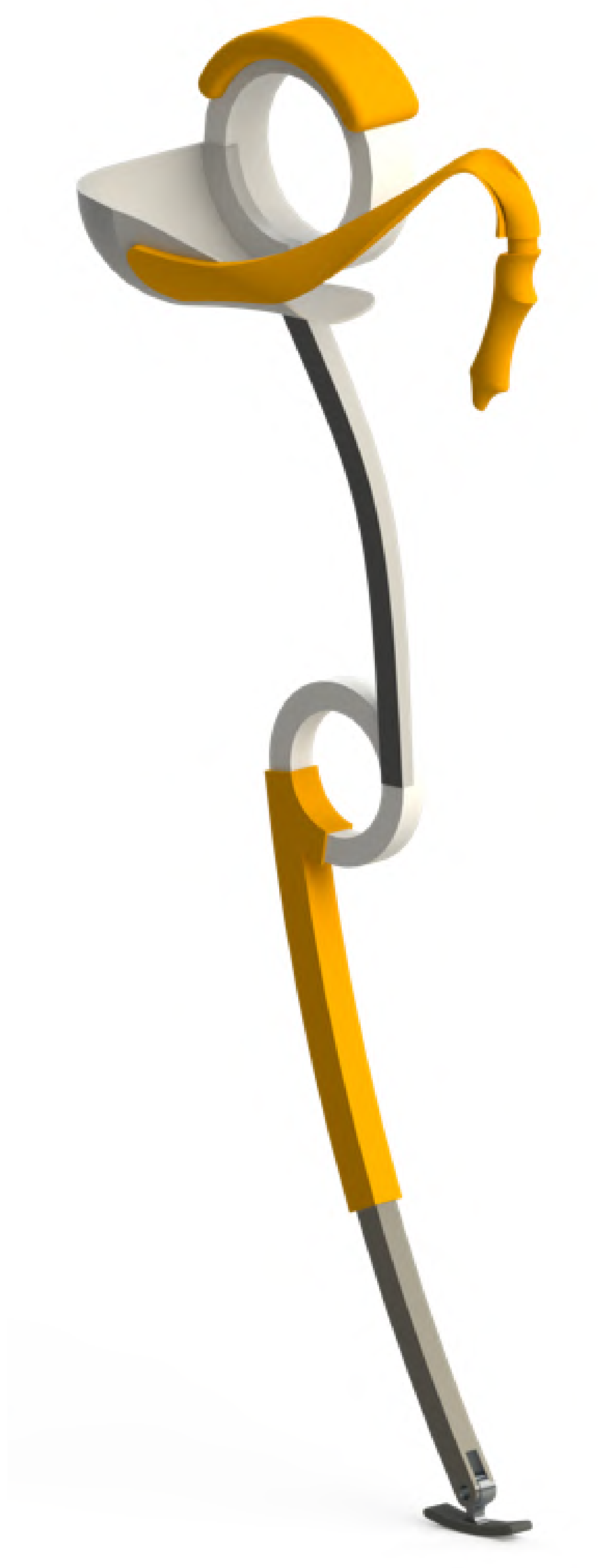


Figure 71- ¾ View

5.4 Physical Model

5.4.2 Exoskeleton

Figure 72 - Exoskeleton Front View

Figure 73 - Exoskeleton Top View

Figure 74 - Exoskeleton Side View

Figure 75- Exoskeleton ¾ View

5.4.2 Trekking pole

Figure 76 - Walking Pole Front View

Figure 77 - Walking Pole Top View

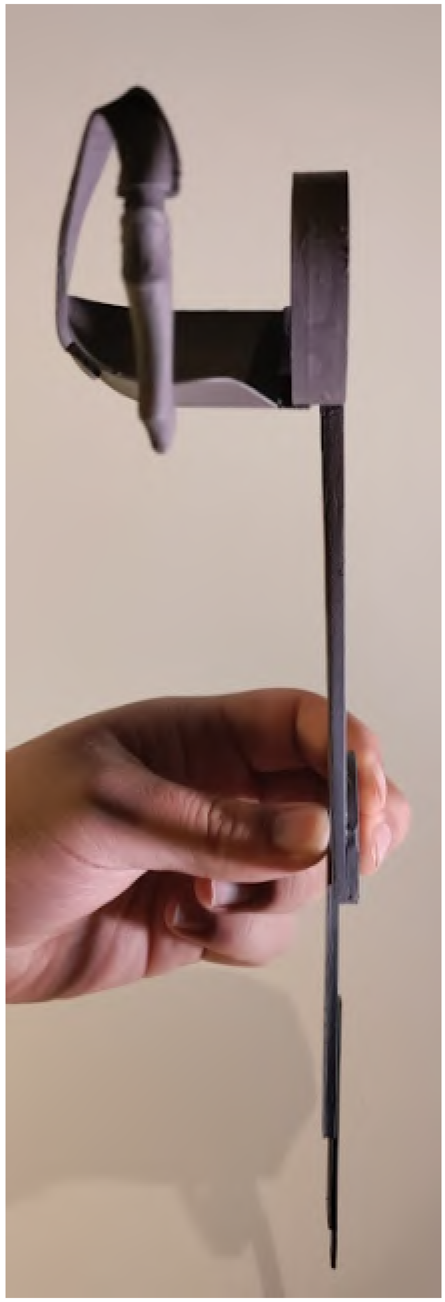


Figure 78- Walking Pole Side View

Figure 79 - Walking Pole ¾ View

5.5 Technical Drawings

5.4.1 Exoskeleton

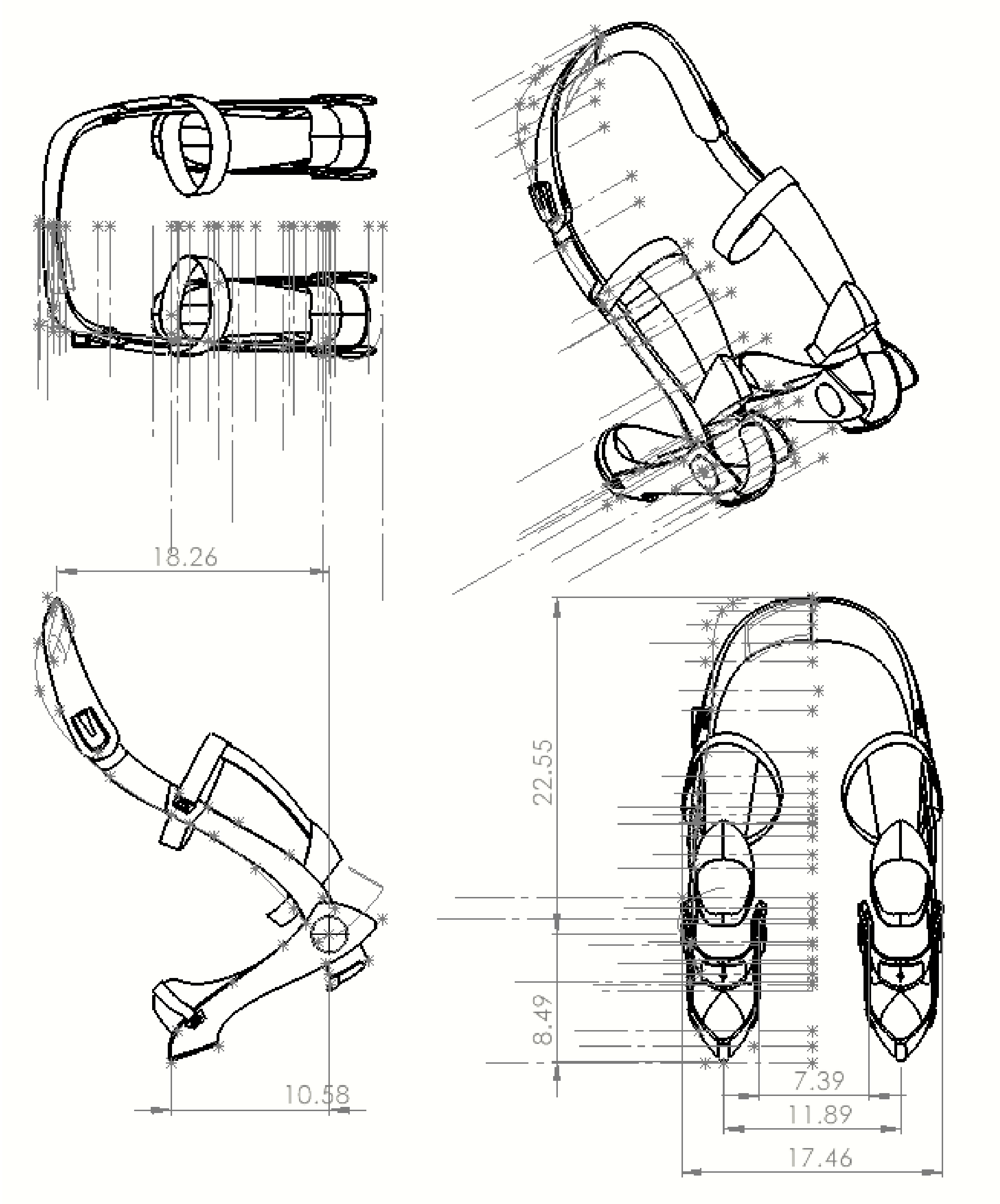


Figure 80- Technical Drawing Exoskeleton

5.4.2 Trekking pole

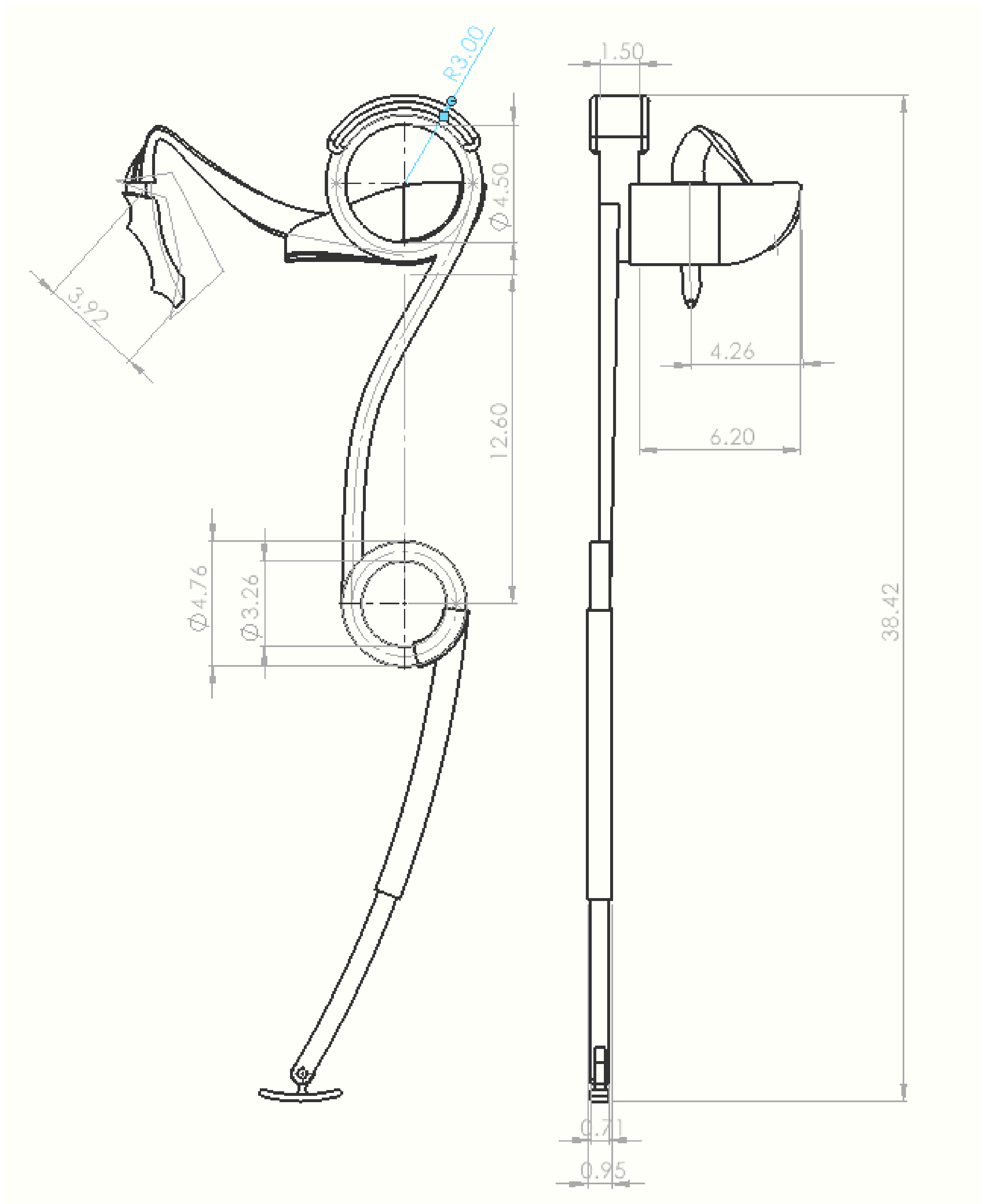


Figure 81 - Technical Drawing Walking Pole

5.6 Sustainability

For long term success, it is critical for FLINGO to be sustainable for the environment and for the people who use the product. The planet is on the path to recover from years of unsustainable practices; being able to ensure the sustainability of every design produced will bring a positive effect to a resource-depleted ecosystem. This project would be able to meet these environmental expectations if it were constructed. It is able to contribute to the environment and the community of people who support it.

After researching aspects of walking devices and their sustainability, along with discovering eco-friendly materials to provide the project with an environmentally friendly agenda, FLINGO provides an opportunity to surpass industry standards in creating a device that can be reimplemented back into the process after its life cycle. This may include using new materials such as PETG and Econyl, which have been approved by the Cradle to Cradle organization. Both have the same properties as their competitive counterparts, but unlike their counterparts, they are able to be recycled into the system if the product deteriorates. Old Lithium-Ion batteries are being reutilized by adopting old ones and furnishing them back to their basic model, practically creating a new battery that can be used over again.

A singular battery pack is located on the side of the hip, specifically a 6 cell Panasonic NCR18650GA 3450mAh 10A Battery that can be recharged when running low. This battery can also be charged using the exoskeleton itself, using leftover kinetic energy. As the motors lift the legs, energy is regained when the user sets their feet back. The motors then reach a peak height and release its power for the user to press back to its starting position. When the user resets the position, the motor winds up the potential kinetic energy and stores it in the battery bank. This does not make the whole system dependent on the user, but it allows the user to use the battery for a longer period of time on hiking trips.

Chapter 6 Conclusion

Figure 83. *Image by monkeybusinessimages from Getty Images/iStockphoto*

The current market for walking supports meant for those who are diagnosed with hypokinetic disorders are abysmal in that they lack maneuverability and the ability to walk on outdoor terrain. These instruments fall short on agility and favor balance and structure, which results in a complete dependency on the instrument to perform walks. FLINGO provides the user with confidence and determination to complete any hike they may approach on their journey to an active lifestyle.

FLINGO is a stabilizing walk assisted exoskeleton that will feel personally human-centric to the user. This is done after collecting research and determining important targets for a user's ergonomics when walking. The design is sleek and minimal, while still being ergonomically close to the body to ensure it does not look bulky and heavy. This design also shows users that it is a recreational device, not a medical device.

FLINGO brings a sustainable business model that helps the community and the environment around those people by utilizing a clean source of materials without sacrificing the quality to guarantee the user stays safe, light, and strong. The prototype exoskeleton integrates new emerging technologies and practical features that allow for a secure walking gait cycle. Trekking poles allow the user to use the Nordic walk technique, which incorporates the upper body, while still being able to transport to far places that require a vehicle. When both the exoskeleton and walking pole work in tandem, it gives the user the freedom and agility to traverse in natural environments without any external help, thus solving the problem statement.

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van der Kolk, Nicolien M, & King, L. A. (2013). Effects of exercise on mobility in people with Parkinson's disease. Movement Disorders, 28(11), 1587-1596. https://doi.org/10.1002/mds.25658

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Chapter 8 Appendix

Appendix A - Discovery

Key Article 1

A key article for this topic was sourced and selected. Required article content (Abstract, Introduction, and Conclusion sections) was copied and highlighted.

- Search Engine: Humber Library Discover
- Key Words: “exercise in Parkinson's disease”

Findings

van der Kolk, Nicolien M, & King, L. A. (2013). Effects of exercise on mobility in people with parkinson's disease: Exercise in parkinson's disease. Movement Disorders, 28(11), 1587-1596. https://doi.org/10.1002/mds.25658

Key Content: Reproduced below:

Abstract: Parkinson's disease is a prevalent neurodegenerative disorder for which only symptomatic treatment exists. Gait and balance disturbance is common in Parkinson's disease and is a major contributor to increased disability and decreased health-related quality of life and survival. Balance and gait deficits in Parkinson's disease are notoriously difficult to treat and are not significantly helped by pharmacological or surgical treatment. The last two decades have seen a dramatic increase in the research and clinical interest in using exercise as a treatment for mobility problems in people with Parkinson's disease. With exciting advances in basic science research suggesting neurochemical and neuroplastic changes after exercise, an increasing number of high-quality studies are documenting particular aspects of mobility improving after exercise. Exercise has the potential to help both motor (gait, balance, strength) and nonmotor (depression, apathy, fatigue, constipation) aspects of Parkinson's disease as well as secondary complications of immobility (cardiovascular, osteoporosis). This perspective article focuses primarily on recent evidence on the effects of exercise in improving mobility while highlighting the importance of targeted exercise intervention for maximizing the benefits of exercise. Suggestions for exercise guidelines, adherence issues, and directions for future research are provided. © 2013 International Parkinson and Movement Disorder Society

Introduction: Parkinson's disease (PD) is a complex and highly prevalent neurodegenerative disorder characterized by disabling motor abnormalities such as bradykinesia, postural instability, and gait disorders that can lead to falls,1, 2 increased risk of fractures, mobility disability, poor quality of life, and reduced survival.3 Therefore, it is not surprising that gait and balance impairment in PD is a major contributor to decreased quality of life.4 Unfortunately current pharmacologic and surgical treatment options for gait and balance disturbances are limited.5, 6 Therefore, there is a pressing need for other (nonpharmacologic) treatment strategies such as exercise to treat mobility impairments in PD. The number of publications addressing exercise for PD has more than tripled in the past decade. Furthermore, several comprehensive meta-analyses, Cochrane reviews, and perspective articles7-17 have been published on this topic in the past several years. Yet important obstacles remain with regard to methodology and definition of exercise that prevent clear guidelines and conclusions to be drawn from the literature.

The types of exercise strategies studied in PD patients are numerous, and there is overlap in the definition of exercise versus physical therapy, terms often used interchangeably. The American College of Sports Medicine (ACSM) defines exercise as a subcategory of physical activity involving planned, structured, and repetitive body movements that are performed to improve or maintain one or more components of physical activity.18 Physical activity, on the other hand, refers to any body movement that is produced by contraction of skeletal muscles that increases energy expenditure and can involve tasks like walking the dog and household chores as well.18 Physical therapy uses exercise as a modality to facilitate more effective movement; however, it also utilizes other elements, such as cognitive strategies, that are not traditionally considered exercise. For the scope of this article, we will use the term exercise both for exercise according to the ACSM definition and for physical therapy. It is beyond the scope of this article, however, to discuss physical activity. Mobility is defined as the ability of a person to move around safely in many different conditions and environments, and relies upon good control of balance, gait and the ability to change strategies to task and environment.

Conclusion:
In conclusion, there is great interest in defining best practices for exercise as an intervention for PD that could help both motor and nonmotor complications of PD. There is a growing body of empirical evidence on the beneficial effects of exercise on gait and balance control in PD and several areas of exciting research including exercise-induced changes to the brain. It is important to continue to strive for specific and universally accepted recommendations regarding the frequency, intensity, and type of exercise for people with PD. It is also important for researchers and clinicians to come to a consensus on the most sensitive and meaningful outcome measures in trials to achieve larger power. We strongly suggest an increased role for exercise and rehabilitation at all stages of the disease and believe that exercise should use a wide variety of movements and address many different constraints on mobility. When designing an exercise program for a PD patient, several issues should be considered. (1) The intervention should be targeted to address patient-specific key physiological restrictions. (2) The intervention should be feasible. Unrealistic time-consuming regimens will dramatically influence compliance; however, exercise strategies that cover several areas of physiological restrictions simultaneously or combine several exercises into one training session of approximately 1 hour seem a feasible time consumption. (3) Exercise-related risks should be assessed. (4) Barriers to exercise should be decreased by, for instance, group classes, home exercise, monitoring and treatment of NMSs and comorbidities, personal goal setting, and seeking alternative ways to improve exercise participation on a permanent basis.

Summary Statements:

1. Parkinson’s disease decreases qualities of life, but exercise can improve motor skills.
2. There are no surgical treatments for the disease which is why researchers and doctors are pushing to do physiotherapy

3. Mobility can help reach new conditions and environment and therefore improve balance and gaits

Improving gait and balance alters brain chemistry which can alter the user's mind for a better and healthier lifestyle

Key Article 2

Method

A key article for this topic was sourced using Google Scholar and selected. Required article content was copied and highlighted.

- Search Engine: Google Scholar
- Key Words: "parkinson's disease falling injuries"

Findings

Pelicioni, P., Menant, J. C., Latt, M. D., & Lord, S. R. (2019). Falls in Parkinson's Disease Subtypes: Risk Factors, Locations and Circumstances. International journal of environmental research and public health, 16(12), 2216. https://doi.org/10.3390/ijerph16122216

Key Content: Reproduced below:

Abstract: People with Parkinson's disease (PD) can be classified into those with postural instability and gait difficulty (PIGD subtype) and those manifesting tremor as the main symptoms (non-PIGD subtype). In a prospective cohort study of 113 people with PD we aimed to contrast fall rates and circumstances as well as a range of disease-related, clinical, and functional measures between the PD subtypes. Compared with non-PIGD participants, PIGD participants were significantly more likely to suffer more falls overall as well as more falls due to freezing of gait, balance-related falls and falls at home. The PIGD group also performed significantly worse in a range of fall-related clinical and functional measures including general cognitive status, executive function, quadriceps muscle strength, postural sway and the timed up and go test. These findings document the extent to which people with the PIGD subtype are at increased risk of falls, the circumstances in which they fall and their disease-related, clinical and functional impairments.

Introduction. Falls are a significant cause of disability, lost independence and reduced quality of life in people with

Parkinson's disease (PD) [1,2]. Prospective studies show that between 45% and 68% of people with PD will fall each year [3,4], with a large proportion (50–86%) falling recurrently [5]. In addition, their risk of falls and fractures rise steadily from 40 years of age, much earlier than in healthy individuals [6]. The consequences of falls are devastating and include restriction of activities of daily living, fear of falling, high levels of caregiver stress and injuries [1]. In fact, the incidence of hip fracture is four times that for older people of the same age without PD [7]. This has significant economic consequences as the costs of fall-related fractures in people with PD are close to double those in healthy older people [2].

Many risk factors for falls in PD have been identified. These include freezing of gait (FOG), cognitive impairment, poor leaning balance, previous falls, lower limb weakness and slow gait speed [4,8,9]. In addition, people with PD with the postural instability and gait difficulty (PIGD) subtype have also been identified as having an increased risk of falls. This subtype has a predominance of postural instability and gait impairment as opposed to the tremor dominant (TD) subtype, for which there is a predominance of resting and postural tremor [10]. Only a few studies, however, have investigated whether people with the PIGD subtype fall more frequently [11,12,13], and such work is based solely on retrospective surveys, limited by differential to recall bias.

The circumstances in which falls occur may provide insights into underlying causes of falls and possible fall prevention strategies. For example, in people with PD, falls that occur outdoors are primarily due to slips and trips, whereas falls that occur indoors are related more strongly to lower limb weakness, vertigo and postural instability [14]. However, no studies to date have examined differences between the PIGD and TD subtypes in the circumstances of falls, including fall locations. In addition, only a few studies have contrasted cognitive, functional and mobility measures between the two PD subtypes [10,11,15]. Such between-group comparisons are important to identify key impairments that might be amenable to intervention and hence guide the prescription of evidence-based treatments in clinical practice.

Conclusion:The study findings document the extent to which people with the PIGD subtype are at increased risk of falls, the circumstances in which they fall and their disease-related, clinical and functional impairments. Compared with non-PIGD participants, PIGD participants were significantly more likely to suffer falls, more falls overall, as well as more falls due to FOG, balance-related falls and falls at home. The PIGD group also performed significantly worse in a range of fall-related clinical and functional measures including general cognitive status, executive function, quadriceps muscle strength, postural sway and the TUG test. This information may prove useful for informing cognitive, physical and environmental interventions to prevent falls in this high-risk group.

Summary Statements:

1. Postural instability and gait disorders (PIGD) significant to fall over due to freezing gaits which causes more falls
2. 45% and 68% of people with PD fall each year which increases the risk of fractures
3. Elders are more likely to suffer from a hip fracture with parkinson's disease
4. Lack of strength near the legs causes postural sway and can reduce cognitive abilities

Name	Email	Credentials
Vivian Lo Bachelor of Science	vivianwylo@outlook.com	Honorary neuroscience graduate

An interview was conducted with Vivian Lo, a soon to be Bachelor of Science graduate who excels in neurology and is one of the leads in the science student association in Mcmaster University. She agreed to do a casual online interview to receive her professional input on the matter as Parkinson's disease is a neurodegenerative disorder that falls in the category of neuroscience. Prior to the interview, questions were developed in preparation of the interview.

The transcript is not 100% accurate due to the limitations of the software, minor grammatical changes were made . This transcript was transcribed using Otter.ai.

Brian Pham - 0:07

We got the terms and conditions here. Hi my name is Brian Pham, I'm conducting research on my thesis relating to Parkinson's disease. Please note this interview will be recorded and examined but your personal information will not be used outside of research. If you choose to remain anonymous you are allowed to forfeit and withdraw your consent at any time if you feel uncomfortable if you accept these terms.

Vivian Lo - 0:43

Yes, okay. All right.

Brian Pham - 0:45

If you want to go ahead, I want to ask you about your background education, your name, age, gender, all that stuff.

Vivian Lo - 0:47

Well, I am 22 years old, I identify as female. I am currently an honors neuroscience student at McMaster University and I'm going to get my Bachelor of Science in the coming April.

Brian Pham - 0:56

Are you part of any kind of Science Committee as well?

Vivian Lo - 1:02

Aside from the Student Society, I can't really say that I am

Brian Pham - 1:09

That's still good. So I'm going to ask you a bunch of very questions. So is Parkinson's targeting certain genders, ages, ethnicities more than others? Let's start with that. From what I've seen so far, it affects a lot more males and females.

Vivian Lo - 1:56

Like most neurodegenerative diseases, it affects older individuals. And before it used to be sort of a death sentence where if you were diagnosed with Parkinson's, it was really about palliative care. Making sure you're comfortable until he passes away, but now we're moving on towards more curative treatments. So there's actually hope and the prognosis for individuals with Parkinson's is a lot better. That being said, there seems to be a lot more that's done to take care of these individuals as they grow into their old age.

Brian Pham - 2:28

With being diagnosed with that kind of disease, I'm assuming everything in their daily tasks change as well. Maybe including their dietary, I'm assuming like people usually do. Do people get more inactive and have Parkinson's? I'm assuming that's the case. Right?

Vivian Lo - 2:50

Yeah, it's not just with motor control, but also problems with cognitive control. Yeah. So not only are they losing the ability to be able to move their bodies but in a way, the sort of those losing cognitive functions that are important to them that would, you know, be really important for daily living like, for example, remembering to take medications or remembering to eat a meal. These things sort of become very difficult when you have an array of genetic diseases.

Brian Pham - 3:25

I was actually very curious about that. I honestly thought if people are just not doing as much then they would gain weight and there'll be weight gain to that but suddenly you just lose interest because they feel uninterested in eating as well. Okay, um, I think this is a long shot but you said the detriment of back in the day when you were if you're diagnosed with Parkinson's but are there any preventable steps to get some of these effects of Parkinson's disease? Probably not. Right.

Vivian Lo - 4:00

So far, no, the most you can do is get genetic screening and just sort of be aware that you may have an increased risk of developing Parkinson's disease but there isn't really anything preventative that you can do.

Brian Pham - 4:16

Are there any certain exercises you think that are good to focus on. Would you recommend any exercises or any physical activities that are safe for people with Parkinson's? As you know, I'm already doing a walking apparatus for that but like any other things that should come to mind, or do you think walking is a good exercise?

Vivian Lo - 4:44

The best thing is whatever is in their range and they can do it safely in their own homes. Like it's not really about the specific actions. It's just about being able to do it and being able to stick to a consistent schedule. That's probably the most important thing.

Brian Pham - 5:00

Are you familiar with Nordic tracking or Nordic walking?

Vivian Lo - 5:14

It's when you have the sticks to walk during hikes?

Brian Pham - 5:16

Yes, you have the sticks. What I've seen is multiple articles about people with Parkinson's that say that they thoroughly enjoy walking outdoors and they believe that Nordic walking really helps them. Do you want to have any comments on that?

Vivian Lo - 5:37

Walking outside, it's nice, vitamin D.

Brian Pham - 5:40

Vitamin D and also the natural surroundings. Like that's the whole point of my thesis, being able to go outside and get some fresh air instead of being cooped up, you know? Especially if COVID, you kind of want that feeling of fresh air.

Vivian Lo - 5:55

It's mainly for mental health.

Brian Pham - 5:58

Yeah, that's what I'm thinking of. My mental health is so important. Like you, you want people to be independent. When they're walking outside. They want to have a good feeling. It's really good for mental health, with exercise as well. Anything with exercising works. So the first question I have for you is what are some of the most common walking supports you have seen for people with Parkinson's? Like, canes crutches from your experience? Do you know anyone? Anyone that uses one more than more than the other?

Vivian Lo - 6:37

I don't have any personal experience working with individuals with Parkinson's but in sort of old age homes, where, like a lot of these people tend to have neurodegenerative diseases. I'd say the most common is probably the walker, canes not so much because canes can be quite slippery, especially again, you know, our Canadian winter, and the Walker is a lot more stable. It provides individuals with a place to sit if they get too tired.

Brian Pham - 7:07

Yes. All right. And the last question is, are there any trips and tips you recommend for Parkinson's patients to improve their gait? I think you showed me videos of people just shuffling their feet and I do have some ideas down the line to help with but do you have any ways to improve that?

Vivian Lo - 7:42

To improve? Okay, I haven't looked into those specific papers yet. sorry. I don't know anything. Yeah.

Brian Pham - 7:46

That's alright. Thank you for taking the time to interview me

Appendix B - User Research

PREPARATION/SET-UP The cane has to be maintained and clean in order to deliver a better performance. When stored away in a compact area, keep in mind adjusting the device after it has been used, the user alters the height and measurements to make the product neat.	 Figure 2 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc
STEP 1 The cane is used very heavily, everytime pressure is being applied to the device, the body pushes down on wrist and the posture is now slouched, therefore can lead to a sprained wrist and back after a prolonged use	 Figure 3 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

STEP 2 Moving from the sidewalk to the streets excites/scares the user. Any change in elevation causes the user to spasms and can either stunt the gait or eagerly throw them forward, otherwise it cannot be controlled. This increases anxiety due to increased risk of falls and accidents.	 Figure 4 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc
STEP 3 In times of exhaustion or uncontrollable spasm, stretching the lower limbs can really reduce the tension. Sitting can regain back balance of the gait and reduce the spasms making it manageable to walk again. Stopping is necessary in order to continue walking.	 Figure 5 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

STEP 4

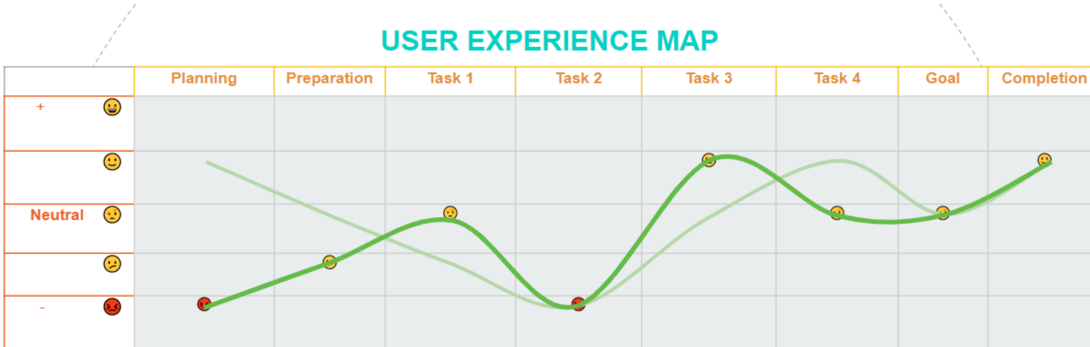
User’s have a better experience when focused on the lines of the sidewalk. The lines guide the user where to step over due to the need of taking long strides to overcome the line. Legs have no problem moving and generate movement. Parkinson's disease patients break up walking into steps, since the lines act as a guide, the user does not have to worry about how far to step forward.

Figure 6 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc

COMPLETION

When walking up the stairs, users have little difficulty lifting their legs. This suggests that vertical movement is not as difficult as forward movement.

Figure 6 - Retrieved from https://www.youtube.com/watch?v=n2qS887jYFc



	Planning	Preparation	Task 1	Task 2	Task 3	Task 4	Goal	Completion
User Goal	Getting Ready	Open door	Walk on pavement	Move to different elevation	Take a break	Walk on sidewalk	Open Door	Back to house
Problems/ Challenges	Sanitize cane with every use Must bend over to put on shoes Where the right clothes	Dangerous is surface is wet One hand is always occupied	Hard to concentrate with no visual guide Shoulder/neck pain from bending to one side Strenuous	Spasms when excited or upset Causes anxiety when changing elevation	Tiresome Waiting for control to set in	Cracks can cause tripping Anxiety for mistaken as drunk Bothered to tell people	Bending over to collapse and store canes Must bend over to take off shoes	
NEW Ideas / Takeaways	Preparation take longer if the device is big	Vertical movement is not a problem Improve traction	Walker seems to have better support Look into improving stance	Incredible anxiety How can I make it better	Stopping is necessary in order to continue.	Movement of feet is separated into steps		

When situating the observation in a natural trail scenario instead of an urban setting, there might be more anxiety with different elevations and terrains. Interesting to see that walking with some sort of rhythm aspect really helps with the pace and stride, something to look into as a feature.

INSIGHT STATEMENTS

1. Additional anxiety generated while walking due to
   - not being able to keep up with others
   - not knowing when they might trip
2. Not being able to find a place to rest and sit
   - Can cause irritations and frustration and fatigue
3. Setting up the device
   - Can loose time time walking

PROBLEM STATEMENT

Problem Statement

Walking in the new terrains and elevations with parkinson’s is frustrating and anxiety inducing

Opportunity

To give an ample reting area while keeping up with other family members

General Solution

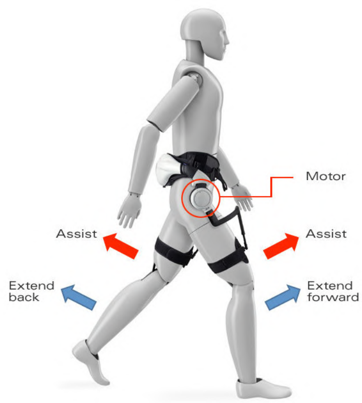
Device that can be transformed in a seat, as well as improve gait with enough stability to guide users


Primary Users
Secondary Users
Tertiary Users
Neurodegenerative Disorder
Huntington's Disease
30-50 years of age and tend to be male 3:2 for Huntington's
Parkinson's D isease
50-60 years of age and tend to be male 3:2
Supranuclear palsy
Problems with balance, movement, vision, speech and swallowing.
Social Worker
Support families in need of assistance
Family Members
Contribute help for the physically challenged
Caregiver
Paid to help with activities
Physical Therapist
Assign exercises regain movement and regain better balance
Technicians
Helps patients and individuals recover regain their mobility
Movement Disorders Specialist
Personalizes care to an individual's symptoms and needs.
Physician
Doctor that knows family history
Kinesiologists
Information of certain muscle groups to reform from diseases
Frame 1

	Challenges			
Parks	This area is enjoyed by many with different activities to do. With many opportunities, there are also different heights and terrain	Primary Users	Secondary Users	
Patient's House	Home requires you to walk up the stairs and clean off your shoes	Primary Users	Secondary Users	
Rocks and Gravel	Even people who aren't physically feel uncomfortable when walking over gravel and rocks since it displaces balance of the foot	Primary Users		
Parking Lot	If trails are further, you're going to need a vehicle to transport no yourself but also your device.	Primary Users	Secondary Users	
Sidewalk	Small cracks can make the experience harder since it can be uneven	Primary Users		
Wooden Bridges	Small gaps between each plank of wood can cause mobility devices to stutter or catch the device in between the cracks	Primary Users		
Forrest	Leaves and dirt are dangerous when slippery. As well as different elevations make it difficult to balance. Can also be stuck in gears	Primary Users		
Dirt Ground	Dirt can crumble and can cause an uneven surface. Devices have a hard time gauging a supported surface	Primary Users		
Hospital	Floor is smooth but can take a while to talk due to exhaustion	Primary Users	Secondary Users	Tertiary Users
Nursing Home	Nursing home requires you to walk up the stairs and clean off your shoes	Primary Users	Secondary Users	Tertiary Users

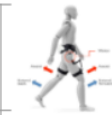
Appendix C - Field Research (Product)

	U-Step Figure 8 - Retrieved from https://attainability.co.uk/u-step/
	ProBasics K2 Standard Hemi Wheelchair Figure 9 - Retrieved from https://www.performancehealth.com/probasics-k2-standard-hemi-wheelchair
	ACTIVATOR Poles for Balance and Rehab Figure 10 - Retrieved from https://walkwithpath.com/products/path-finder-2-0
	GYENNO Figure 11 - Retrieved from https://www.medgadget.com/2018/01/gyenno-gait-aid-helps-avoid-gait-freeze-parkinsons-patients.html

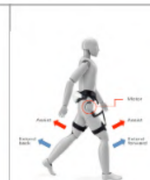
	SPORTSMATE 5 Figure 12 - Retrieved from https://global.honda/innovation/robotics/WalkingAssist.html
	NOTCH Figure 13 - Retrieved from https://wearnotch.com/
	Forearm Crutches Figure 14 - Retrieved from https://www.amazon.ca/Forearm-Crutches-Adjustable-Lightweight-Ergonomic/dp/B07V5HJB6X

	Tango Belt Figure 15 - Retrieved from https://www.tangobelt.com/
	SPORTSMATE 5 https://www.xenhanced.com/pages/sportmate5-prelaunch

Benchmarking - Feature/Function Comparison Table

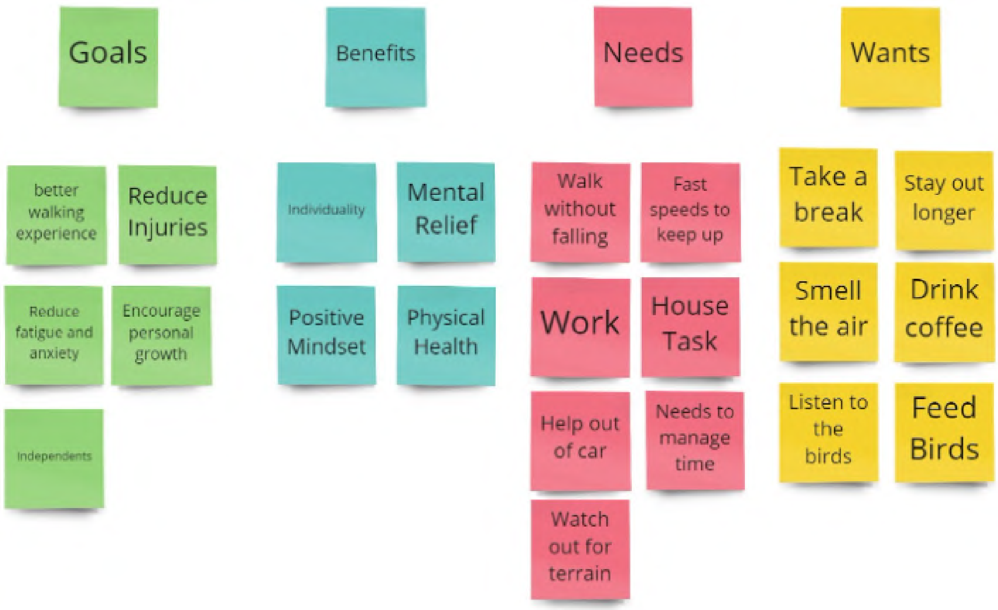
Products								
Dimensions	13.7 x 12.5 x 8.6 cm	Ø 16mm 77 to 107 cm		1.55m to 1.86m x 58cm		430mm - 495mm		78 cm x 83 cm x 93 cm
App compatible	NO	YES	YES	NO	YES	NO	YES	NO
Load Test	3 Sizes for all shoes	150 kg	5 sizes	160kg	Straps around most limbs	Wraps around most limbs	Sticks to all skin surfaces	136 kg
Water Repellent	YES		NO		NO		YES	
Material	Nylon ABS	Carbon Fiber Polyethylene	nylon	Tubular steel aluminium				vinyl powder coated steel
Weight	530 Grams	390 g		8.6kg		2.7kg	10 grams	18kg
Padding	NO		YES	YES	NO	NO	NO	YES

Benchmarking Products

							
1	2	3	4	5	6	7	8
Path Finder	SmartCane	Tango Belt	U-Step	GYENNO Straps	ASIMO	NOTCH	K2 Standard Wheelchair
Benefits							
-Comes in 3 sizes -Rechargeable batteries -2-3 year lifespan	-magnetic charging port -wireless emergency call -built in gyroscope	-Gathers data and sends alerts -5 sizes that fit 5-95 percentile -7 days without charging	-comfy forearm pads -slick caster wheels	-attach to the torso, legs, and/or a cane -rechargable -Small and strapped	-size-adjustable frames - smooth shifting of weight	-capture motion -Tiny and light -Water-resistant	-easy cleaning vinyl -longlasting ball bearings - range of heights

List Of Tables

Appendix D - Result Analysis



ROOT ANALYSIS

Problem: **People with Parkinson's have trouble walking in rough terrain**

Why? Because it's hard to walk and balance

Why? Because they do not have enough support

Why? Because they are meant for pavements

Why? Because they are meant to be transported to urban areas

Why? Because the devices are not meant for rough terrain

POTENTIAL BENEFITS AND FEATURES

NEED STATEMENTS

The User	**needs to**	*Take a rest*	**because**	*they want to regain their strength*
The family member	**needs to**	*find out where their parkinson's family member fell*	**because**	*not knowing creates anxiety*
The User	**needs to**	*able to keep up with family members*	**because**	*they don't want to be left behind*
The User	**needs to**	*support on larger limbs*	**because**	*they don't want to exhaust smaller joints*
The User	**needs to**	*know where to step next*	**because**	*It helps with their steps and concentration*

Appendix E - Approval Forms & Plans

THESIS TOPIC APPROVAL:

Student Name:	Thanh Trung Brian Pham
Topic Title:	How may we improve the nature trail experience for the physically challenged?

TOPIC DESCRIPTIVE SUMMARY (Preliminary Abstract)

Walking on nature trails is a wonderful way to conduct cardio and maintain a healthy lifestyle. However, those who are physically impaired, often patients suffering from hyperkinetic disorders such as Parkinson's, face the risk of falling when approaching the outdoors. This is due to lack of walking equipment that offer little support and suspension made for uneven terrain. Those who have limited mobility rely on external aid in case of any injuries. How can we improve the nature trail experience for the physically challenged? Keeping these patients safe, comfortable and energetic would allow them to experience a better walking experience and promotes healthy living and a healthy mindset. In turn, this would create a productive and active union of healthy people and decrease the number of unhealthy individuals. This thesis evaluates the needs of the physically impaired and improves upon current mobility instruments through innovative thinking, in-depth ergonomic study and analysis of their maneuverability through the help of certain doctors and specialists that concentrate on movements of the lower muscle group. The result of the studies will maximize the impact of better quality living. Interviews and observational studies will provide details for a better understanding of user behaviour. A one-to-one scale model will assist in establishing guidelines of necessary ergonomics and evaluate the correct full-bodied human interaction points. A solution will be developed for the physically impaired to enjoy the simple pleasures of walking.

Student Signature(s):		**Instructor Signature(s):**	
Date:	27/09/2021	**Date:**	08 October 2021

IDSN 4502
SENIOR LEVEL THESIS TWO

Humber ITAL / Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / WINTER 2022
Catherine Chong / Sandro Zaccolo

CRITICAL MILESTONES: APPROVAL FOR CAD DEVELOPMENT & MODEL FABRICATION

Student Name:	Brian Pham
Topic / Thesis Title:	Enhancing Mobility for Parkinson Patients

THESIS PROJECT – DESIGN APPROVAL FORM

Design is reviewed and approved to proceed for the following:	☑ **CAD Design and Development Phase**
Comment:	- Initial CAD started well as of week #7/February 22nd, continue with detailing and refinement. - Refinement CAD for the scooter progress well as of week #8/March 8th. - Still need to develop CAD for the Kiosk, continue with refinement and finishing. - CAD completion in week #12.

Design is reviewed and approved to proceed for the following:	☑ **Model Fabrication Including Rapid Prototyping / 3D Printing and Model Building Phase**
Comment:	- Cannot approve of model fabrication until CAD development at 90% completion of all components > advised completion latest by week #9 (March 17th). - Once CAD is completed can move forward to model fabrication from week #10 onward. - Model fabrication in progress.

Instructor Signature(s):	
Date:	5th April, 2022

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2021 & WINTER 2022

INFORMATION LETTER

Conditions of Participation

- ✔ I understand that I am free to withdraw from the study at any time without any consequences.
- ✔ I understand that my participation in this study is confidential. (i.e. the researcher will know but will not disclose my identity)
- ✔ My identity will be masked.
- ✔ I understand that the data from this study may be published.

☑ **I have read the information presented above and I understand this agreement. I voluntarily agree to take part in this study.**

Vivian Lo

Click or tap here to enter text.	Vivian Lo	April 20, 2022
Participant's Name	Participant's Signature	Date

Project Information

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: 647-918-9936

Email: brian_thanh_pham@yahoo.ca

My supervisors are:

Prof. Catherine Chong, **catherine.chong@humber.ca**

Prof. Sandro Zaccolo, **sandro.zaccolo@humber.ca**

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2021 & WINTER 2022

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: Parkinson's Disease Research Study

Investigator: Brian Pham

Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, Vivian Lo *(First Name/Last Name)*, have carefully read the Information Letter for the project « insert student's thesis topic », led by « insert student Name ». A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact « insert student Name » at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording, photography and/or videotaping; with the proviso that my identity will be blurred in reports and publications.

Consent for Publication: Add a (X) mark in one of the columns for each activity

ACTIVITY		YES	NO
Publication	I give consent for publication in the Humber Library Digital Repository which is an open access portal available to the public	X	☐
Review	I give consent for review by the Professor	X	☐

Privacy

All data gathered is stored anonymously and kept confidential. Only the principle investigator /researcher, Brian Pham and Prof. Catherine Chong or Prof. Sandro Zaccolo may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

I also understand that I may decline or withdraw from participation at any time, without negative consequences.

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca** or « insert student Name /Phone Number /Email Address ».

Verification of having read the Informed Consent Form:

☑ I have read the Informed Consent Form.

My signature below verifies that I have read this document and give consent to the use of the data from questionnaires and interviews in research report, publications (if any) and presentations with the proviso that my identity will not be disclosed. I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Click or tap here to enter text. Vivian Lo	Vivian Lo	Click to enter a date. April 20, 2022
Participant's Name	Participant's Signature	Date

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

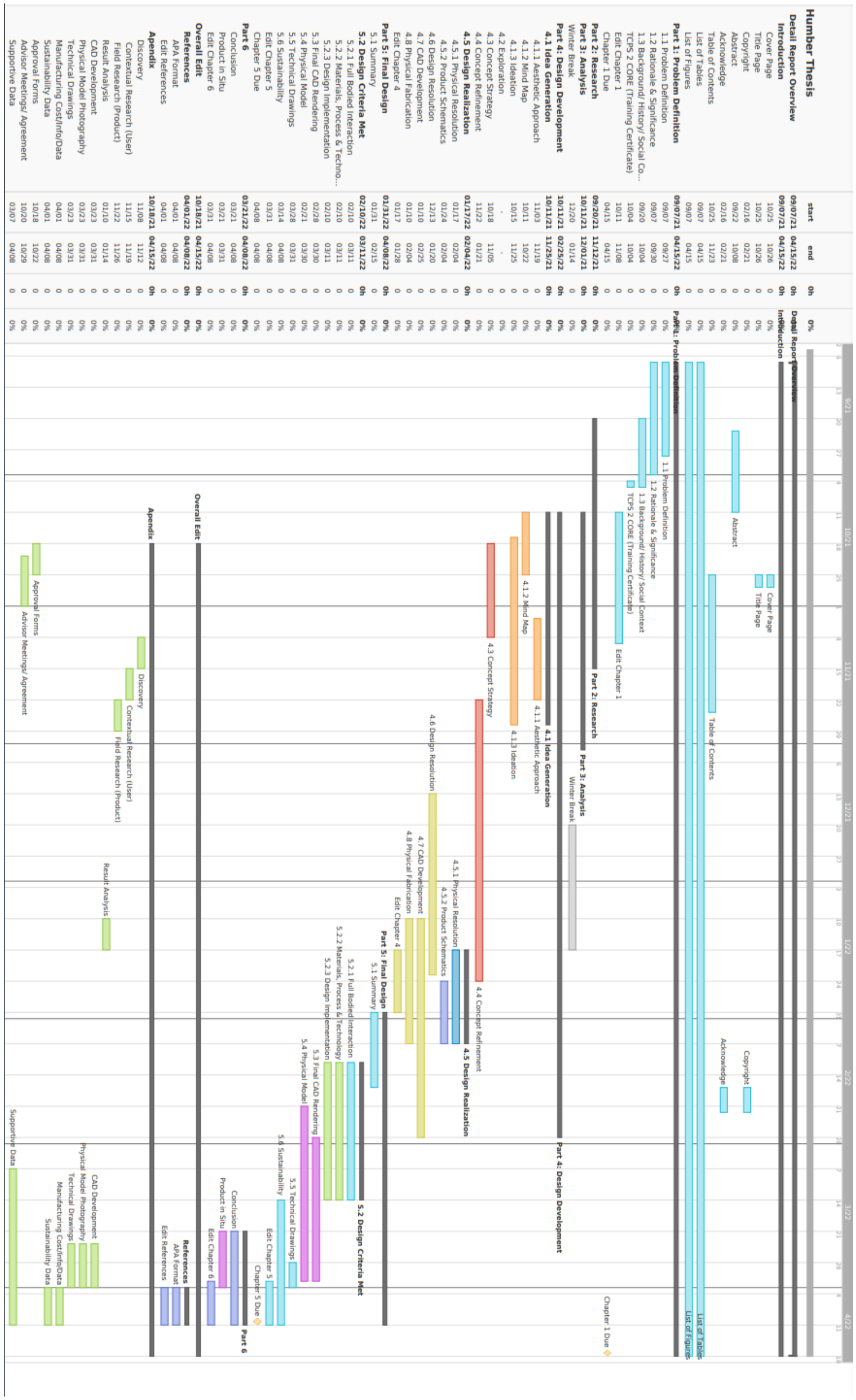
This document certifies that

Thanh Pham

has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)

n01266379

Date of Issue: **25 September, 2021**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List of Tables | 09/07 | 04/15 | 0 | 0%
List of Figures | 09/07 | 04/15 | 0 | 0%
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Part 3: Analysis | 10/11/21 | 12/01/21 | 0h | 0%
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4.1.2 Mind Map | 10/11 | 10/22 | 0 | 0%
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4.3 Concept Strategy | 10/18 | 11/05 | 0 | 0%
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4.5.2 Product Schematics | 01/24 | 02/04 | 0 | 0%
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4.7 CAD Development | 01/10 | 02/25 | 0 | 0%
4.8 Physical Fabrication | 01/10 | 02/04 | 0 | 0%
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Part 5: Final Design | 01/31/22 | 04/08/22 | 0h | 0%
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5.2.1 Full Bodied Interaction | 02/10 | 03/11 | 0 | 0%
5.2.2 Materials, Process & Techno... | 02/10 | 03/11 | 0 | 0%
5.2.3 Design Implementation | 02/10 | 03/11 | 0 | 0%
5.3 Final CAD Rendering | 02/28 | 03/30 | 0 | 0%
5.4 Physical Model | 02/21 | 03/30 | 0 | 0%
5.5 Technical Drawings | 03/28 | 03/31 | 0 | 0%
5.6 Sustainability | 03/14 | 04/08 | 0 | 0%
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Part 6 | 03/21/22 | 04/08/22 | 0h | 0%
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Product in Situ | 03/21 | 03/31 | 0 | 0%
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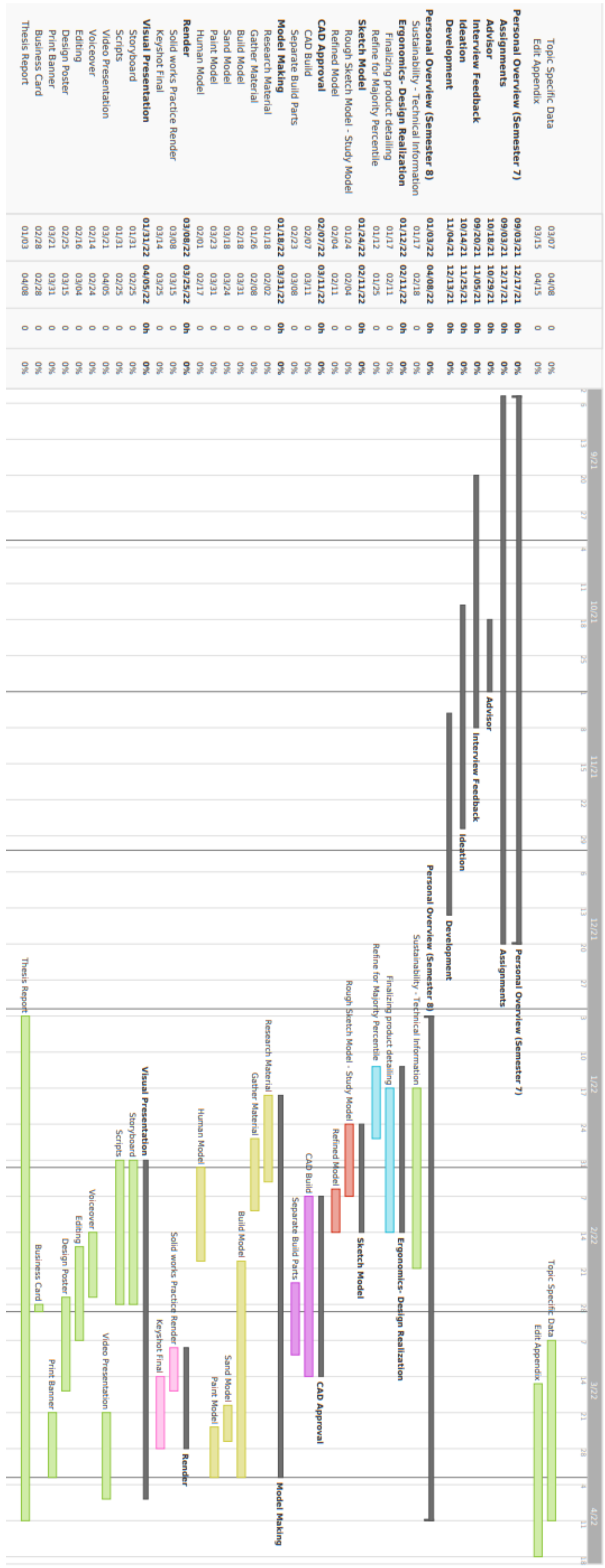
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Finalizing product detailing 01/17 02/11 0 0%
Refine for Majority Percentile 01/12 01/25 0 0%
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Rough Sketch Model - Study Model 01/24 02/04 0 0%
Refined Model 02/04 02/11 0 0%
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CAD Build 02/07 03/11 0 0%
Separate Build Parts 02/23 03/08 0 0%
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Gather Material 01/26 02/08 0 0%
Build Model 02/18 03/31 0 0%
Sand Model 03/18 03/24 0 0%
Paint Model 03/23 03/31 0 0%
Human Model 02/01 02/17 0 0%
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