AlwaysAble

Body Brace for Seniors

By Jasmine Celia Joaquin

Enhancing Senior Mobility

by

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Abstract

As the medical system struggles to keep up with the aging population, seniors are encouraged to take preventative healthcare measures by being more physically active. Engaging in physical activities not only promotes physical fitness, but also contributes to mental health and can reduce loneliness if physical activities are conducted in group settings. Unfortunately, many seniors struggle to be physically active, which can have detrimental health outcomes and further burden the medical system. The goal of this thesis project was to develop a product that enhances seniors' mobility to make exercise more appealing and accessible. Interviews, surveys, and user observations were used to study seniors' lifestyles, physical abilities, and interests. The most prominent themes were used to develop a design solution. Once a preliminary concept was developed, the feasibility and ergonomics of the design were evaluated. Initially, this project focused on enhancing outdoor physical activities for seniors and began with research on outdoor products, but it slowly transitioned into an effort to enhance senior mobility in general to encourage seniors to participate in a variety of physical activities. The resulting product has the potential to revolutionize seniors' exercise, improve the quality of life of seniors', and significantly reduce the current burden on the healthcare industry.

Keywords: Seniors, physical activity, health, ergonomics, body brace

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CHAPTER # 1:
INTRODUCTION

1.1 Problem Definition

Engaging in physical activities not only promotes physical fitness, but also improves mental health (Centers for Disease Control and Prevention [CDC], 2022; Kiran & Singh, 2014). Unfortunately, many seniors fail to meet the recommended levels of physical activity, which can have detrimental health outcomes (CDC, 2022; Wang, 2014). There is a need to enhance senior mobility to make exercise more enjoyable, engaging, accessible, and convenient. This transformation holds the potential to not only improve senior physical and mental well-being, but also elevate overall quality of life. Furthermore, by promoting preventive healthcare through regular exercise, this project could contribute to alleviating challenges in the healthcare industry that have developed due to the aging population and reduce the burden on medical workers. Research for this project will involve reviewing scholarly articles and then conducting interviews, surveys, user observations, benchmarking, and ergonomic studies.

1.2 Rationale & Significance

This study will provide a deeper understanding of the barriers that hold seniors back from being physically active and will provide a solution that enhances seniors' mobility to encourage them to be more physically active. When conducting research for this project, the goal will be to answer the below key questions.

Key Questions.

- What does the daily life of a senior look like?
- What struggles do seniors experience?
- What motivates seniors to participate in physical activities?
- What are the physical capabilities of seniors?
- What are the limitations of seniors?
- Why are seniors held back from being physically active?
- What active activities do seniors enjoy?
- What active activities do seniors currently participate in?
- Where do seniors enjoy participating in physical activities?
- What can be improved to enhance active activities for seniors?
- How can these things be improved?

Planned Investigative Approach

Both primary and secondary research will be used to answer the above key questions. For the secondary research, existing research will be reviewed and benchmarked. For the primary research, data will be collected from surveys, interviews, and user observations. After the data is collected, various analysis techniques will be employed. These will consist of coding, empathy mapping, journey mapping, benchmarking, and ergonomic evaluations. These analysis techniques will pull out key themes and provide insights into potential design solutions. The breakdown of the planned approach can be seen below:

Primary Research

- Surveys
- Interviews
- User Observations

Secondary Research

- Benchmarking
- Literature review

Analysis

- Coding
- Empathy mapping
- Journey mapping
- Benchmarking (benefits, features, and functionality of existing products)
- Ergonomic Study

1.3 Background/ History/ Social Context

Demographic Trends

The medical advances of the last century have doubled the life expectancy of seniors and created an aging population (Harris, 2007; Statistics Canada, 2022a). The number of seniors above 85 has more than doubled since the 2001 Canadian Census and is expected to triple by 2046 (Statistics Canada, 2022a). Of the senior population, most are female, due to their longer life expectancy (Statistics Canada, 2022b). The senior population is becoming more ethically and culturally diverse as people immigrate between countries more frequently

(Scommegna, 2018). Most seniors have health problems. Minority groups, particularly African Americans, Hispanics, and Native Americans, tend to have worse health than Caucasians and Asians (Scommegna, 2018). Due to recent declines in successful marriages and lower fertility rates, many seniors do not have children who can care for them when they are in poor health (Scommegna, 2018). Seniors with significant health problems are moving to nursing care facilities, long-term care facilities, or seniors' residences. Seniors who are still independent enough to live on their own are choosing to urbanize so that they are closer to the resources they need as they age further (Statistics Canada, 2022a). The government is experiencing increased pressure to supply seniors with adequate healthcare, housing, and transportation (Statistics Canada, 2022a).

Lifestyle Trends

Seniors are increasingly more aware of the importance of health and are choosing to make health-conscious decisions (Kuo & Lin, 2019). Seniors are therefore trying to be more physically active to maintain their health (Harris, 2007). An increasing number of seniors are becoming tech-savvy and are choosing to use technology for medical and personal use (Faverio, 2022; Mace et al., 2022). Seniors who are not well-versed in technology are expressing an interest in learning how to use technology (Ambrens et al. 2021).

Media Trends

The media shares the importance of maintaining positive physical and mental health for senior independence and quality of life (Harris, 2007). Community groups and healthcare workers strive to promote staying active in senior years to stay healthy (Centers for Disease Control and Prevention, 2021.). Many groups also promote socialization to improve mental health, or as something to be done to motivate physical activity participation. This push for socialization comes with a push for inclusivity in physical activities so that all feel welcome to participate.

Product Trends

With the increased population size of seniors and the increased awareness amongst seniors of the importance of physical activity, there is a greater demand for physical activity products for seniors (Harris, 2007). Improved technology has produced physical activity products that have made participation in sports easier for seniors, increased play time, and prevented injury. There has also been sports equipment specifically designed for senior use (Harris, 2007).

CHAPTER #2:
RESEARCH

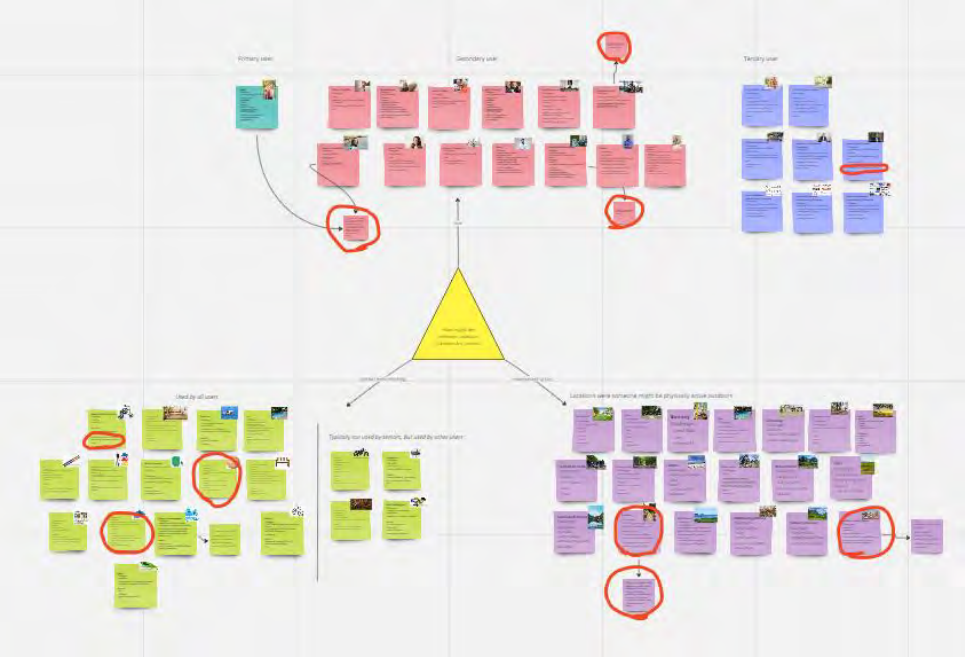
2.1 User Research

In-depth user research was conducted on seniors, defined as people over the age of 65 years old. Amongst many reasons, this was done to determine why seniors participate in physical activities, the types of challenges seniors face when participating in physical activities, and the methods seniors use to improve their physical activities that could be beneficial to include in the product design solution.

2.1.1 User Profile - Persona

Before seniors were chosen as the focus for this thesis project, primary, secondary, and tertiary users were brainstormed using a product, user, and environment triangulation map. This is shown in Figure 1.

Figure 1 *Product, User, and Environment Triangulation*



In this triangulation diagram, the primary users are seniors over the age of 65 who live in Ontario, Canada. The secondary users are caregivers or family members of the seniors. Tertiary users consist of companies that produce products for senior physical activities. The products brainstormed here were outdoor physical activity products, since this study initially focused on enhancing outdoor physical activity products for seniors. After comparing the significant challenges that primary users (seniors) had with the listed products to the minor challenges secondary and tertiary users had with the products, seniors were chosen as the focus for this project due to the obvious need for more products that are suited for seniors.

Based on secondary research on seniors, a persona of Roxanne Smith was developed as a generic example of the typical life of a female senior. This helped to understand the life of a senior before proceeding with interviews so that when interviews were conducted seniors were asked relevant questions.

Figure 2 *Primary User Persona*

Name: Roxanne Smith
Age: 80
Occupation: Retired
Income: Pension of $40,000 annually
Prior Occupation: Part-time receptionist
Education: Some secondary school
Relationship: Married
Location: Guelph, ON
Interests: Plants, health, knitting, and crafts
Physical Activities: Walking and gardening
Health challenges: Had a stroke 10 years ago, has high blood pressure and back pains
Group/Independent Physical Activity: Independent
Prior Relationship with Physical Activity: Anne never plays sports but always goes for long walks.

(Patel, 2019)

User Behavior
When Roxanne wakes up at 6 am she prepares herself and her husband breakfast. Roxanne takes her medications with her breakfast daily to control her high blood pressure, prevent further heart problems, and reduce her back pain. After eating, Roxanne spends her days with her husband gardening, knitting, watching TV, playing sudoku, cooking, and doing health research. When she gets bored of her home, she goes for a walk or travels to a nearby store to window shop. When she goes for an outing, she needs to make sure that she does not travel too far and hurt her back. To avoid back pain, she walks with a cane.

Interviews

Interviews were conducted by phone call and took place from September 29th to October 8th, 2023. There were ten interviews conducted. Of these ten interviews, nine were with seniors, and one was with a nurse who cares for seniors. The interview transcripts can be found in Appendix B. Important parts of the transcripts were highlighted, and then key recurring themes were derived from the highlighted sections. The key takeaways are listed below.

Top Ten Interview Takeaways

1) Seniors know of the importance of physical health, and they want to be physically active to stay healthy.
2) Seniors enjoy participating in outdoor physical activities because of the exposure to nature and because they enjoy the activities they perform outdoors.
3) Most seniors enjoy exercising with a partner or group.
4) Most seniors have health problems.
5) Income determines what physical activities seniors participate in, and where seniors participate in physical activities.
6) Walking and gardening are the most popular outdoor activities that seniors participate in.

7) There is a social stigma around using walkers.
8) Seniors struggle to get up from the ground.
9) Seniors prefer physical activities that are convenient and can be done at home.
10) Seniors need to be mindful of their abilities and take breaks from physical activities as needed.

Surveys

To further understand how to best go about enhancing senior mobility, a qualitative survey was conducted using Google Surveys. Survey answers were collected from September 29th to November 8th, 2023. The survey aimed to understand seniors' experiences by asking them questions about (a) their physical limitations and abilities, (b) the types of outdoor physical activities that they participate in, (c) how they participate in those physical activities, (d) the areas where they are physically active, and (e) what would do the most to enhance their physical activities. This survey was sent to the advisor for this project, who distributed the survey to her friends and family. It was also sent to three senior groups located in Ontario. Of these senior groups, some members sent surveys to other local senior groups. This combined effort resulted in many survey responses, approximately 80. Some seniors who answered the survey said that they were under the age of 65. These responses were removed to ensure that the survey was only representative of seniors over the age of 65 (the target age group for this study).

Survey Takeaways

Some important conclusions from the surveys are that (a) the most popular outdoor physical activities amongst seniors are gardening, walking, hiking, and jogging, (b) seniors sometimes participate in physical activities with a friend or family member, (c) seniors try to do what physical activities they can, (d) the most popular locations where seniors are physically active are the backyard, garden, balcony, road, sidewalk, and driveway, and (e) seniors believe that making outdoor physical activities more convenient and suited to their physical abilities would do the most to enhance their outdoor physical activities. Detailed survey results can be found in Appendix L.

How This Interview and Survey Data May Inform the Design

It is important that seniors do not hurt themselves by being physically active. As mentioned, most seniors have health problems. They are often more cautious because of their limitations. This is why seniors take frequent breaks from physical activities. The design solution should prevent injury, and/or provide a safe method to rest as needed. The design will need to be stylish and socially acceptable because seniors do not want to be embarrassed if seen using the product.

2.1.2 Current User Practice

Seniors usually participate in some form of physical activity. As mentioned above, both interviews and surveys indicated that the most popular physical activities are walking and gardening. Seniors indicate that these activities are done for entertainment, enjoyment, or health reasons. The physical activities that seniors participate in may be routine or casual. If the senior participates in group physical activities, the activities are typically routine and occur regularly. However, if the activities are casual, they may be carried out sparingly depending on the mood of the senior and the senior's physical abilities that day. Seniors who have a positive view of physical activities will prioritize them and will do them more frequently than those who view physical activities negatively. Additionally, casual activities may be participated in less frequently if they are expensive or inconvenient.

2.1.3 User Observation – Activity Mapping

The task map, journey map, user experience map, and empathy maps on the following pages were developed by observing a senior going for a walk with his walker and talking to him about the experience.

Table 1 *Task Map: Senior Walking with Walker*

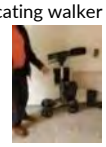
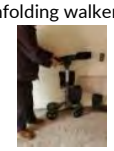
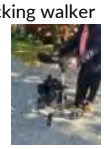
Step	Movement	Challenges	Benefits	User's Thoughts, Feelings & Comments
Locating walker 	• Walks over to the walker • Slides walker away from the wall	• Would have had difficulty accessing the walker if his vehicle had been in there that day	• Walker is foldable • Easy to unfold	• Stores the walker in his garage and barely uses it because it is too large and heavy • Cannot use the walker in his house because it hits everything and scratches the walls • Often walks with a cane because it is less awkward, even though it provides him with less support
Unfolding walker 	• Pulls apart handles to fold walker open	• None	• Walker is ready for use	• None
Walking 	• Walking while holding walker handles • Walker rolls smoothly	• Walker cannot be used on grass • The user has a bad knee and cannot walk far	• Walker's wheels glide smoothly • Seniors can walk for a longer time and can walk greater distances using walker • Walker removes strain	• When compared to walking without anything, or walking with a cane, the walker allows him to walk greater distances and for a longer period
Locking walker 	• Squeezes the walker's lower handles to lock the walker in place and prevent it from rolling	• None	• Lock mechanism prevents rolling • A lighter squeeze on the handles can slow the walker (helps prevent the walker from sliding out from the user while walking)	• He likes the lock mechanisms and their placement • Thinks the lock mechanisms are important for walkers to have
Sitting in walker 	• Checks that the walker is locked in place and that the seat is clean • Holds onto the handle of the walker for stability as he turned to sit in the walker	• Rotates body • Ensures that the walker was completely stable before sitting	• Allows the user to rest as needed	• Likes having a spot to sit when needed • Sometimes seniors go too far for a walk and then realize that they will have difficulty getting back
Walking back home 	• Walks smoothly with walker	• None	• Takes strain off the body	• Many seniors like walkers because they keep them balanced. • Balance is not a problem for this user
Storing walker 	• Pulls up the handle on the seat that folds the walker flat for storage	• None • Would have had difficulty putting the walker away if his car had been in the garage that day	• Foldable • The folding mechanism is easy	• The user mentions that the only reason he has the heavy walker he does is because it was a free hand-me-down

Figure 3 *Journey Map - Senior Walking with Walker*

JOURNEY MAP - SENIOR WALKING WITH WALKER

Stage of Journey	Locating Walker	Unfolding Walker	Walking	Locking Walker	Sitting in Walker	Walking Back Home	Storing Walker
User Goals	- To find walker	- To easily reach walker - To find enough room to open walker	- To get exercise - To get fresh air - To improve physical and mental health - To meet new people	- To successfully lock the walker's wheels	- To not fall - To rest	- Getting back home successfully without experiencing pain	- To fold the walker flat to store it in a small space
User Actions	- Looking for walker - Walking over to walker - Reaching for walker	- Bending over - Grabbing handles and pulling them apart - Folding down walker seating	- Walking while holding walker handles	- Squeezes the walker's handles to lock the walker in place and prevent it from rolling	- Holds onto the handle of the walker for stability as he turns around and sits in the walker	- Walking while holding walker handles	- Grabbing seat handle to fold seat up - Pulling arms together
							
User Experience Very happy Very sad							
User Thoughts	- I hope the car isn't in the way	- Walker is heavy	- Walker wheels roll smoothly - If he was to use the walker on grass, the wheels may not roll as smoothly - Walkers are great for seniors who struggle with balance	- He likes the bike brake locks	- He is tired - He hopes the lock is secure - Glad to have a place to rest	- Walker rolls smoothly - He was able to walk a lot farther with a walker than with a cane or nothing - Despite recently having knee surgery, he could still walk outdoors with a walker - Happy that he was able to take a break from his walk before heading back	- Walker folds nicely - Walker is heavy
User Feelings	- He doesn't like his walker because it is big and heavy	- Feels that there must be lighter walkers	- Likes that the walker is easy to walk with - He doesn't want to become dependent on a walker	- Feels satisfied with the bike locks and how easy they are to use and understand	- Tried but gradually regaining energy	- Feels a little tired and sore	- He doesn't like his walker because it is so large a bulky - He doesn't want to bring the walker in his home because there isn't enough room in his home for it and the walker could scratch the walls
Problems/Challenges	- He barely uses his walker so he stores it in his garage, which makes it challenging to access when needed	- The walker is quite large - There are other things around him that he needs to watch out for when unfolding the walker	- Walkers are embarrassing	- None	- Uncertain if the locker wheels are locked - Uncertain if the seat is clean	- His knee is a little sore	- Walker is big and heavy
Ideas/Takeaways	- Walkers are too heavy and large - Walker brakes are necessary - Walker bike brakes are easy to use - Walkers are great for helping seniors be more physically active outdoors						

Figure 4 *User Experience Map - Senior Walking with Walker*

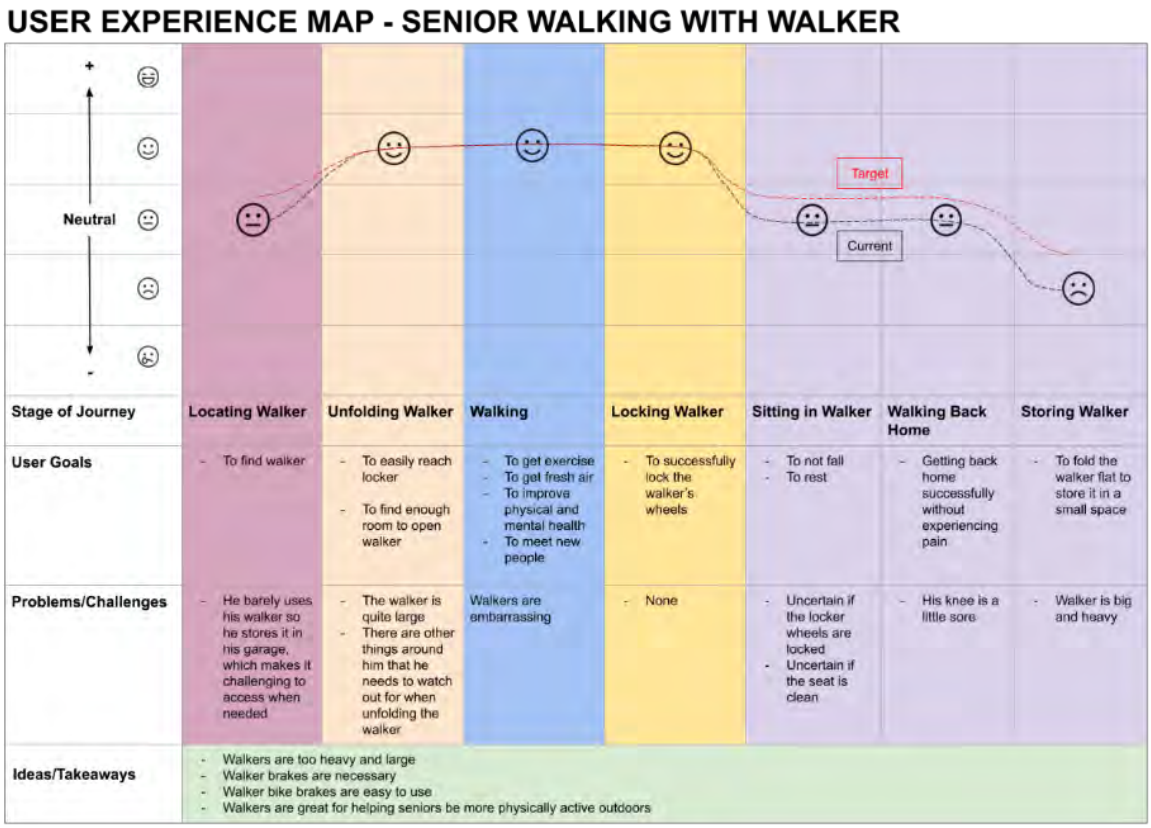
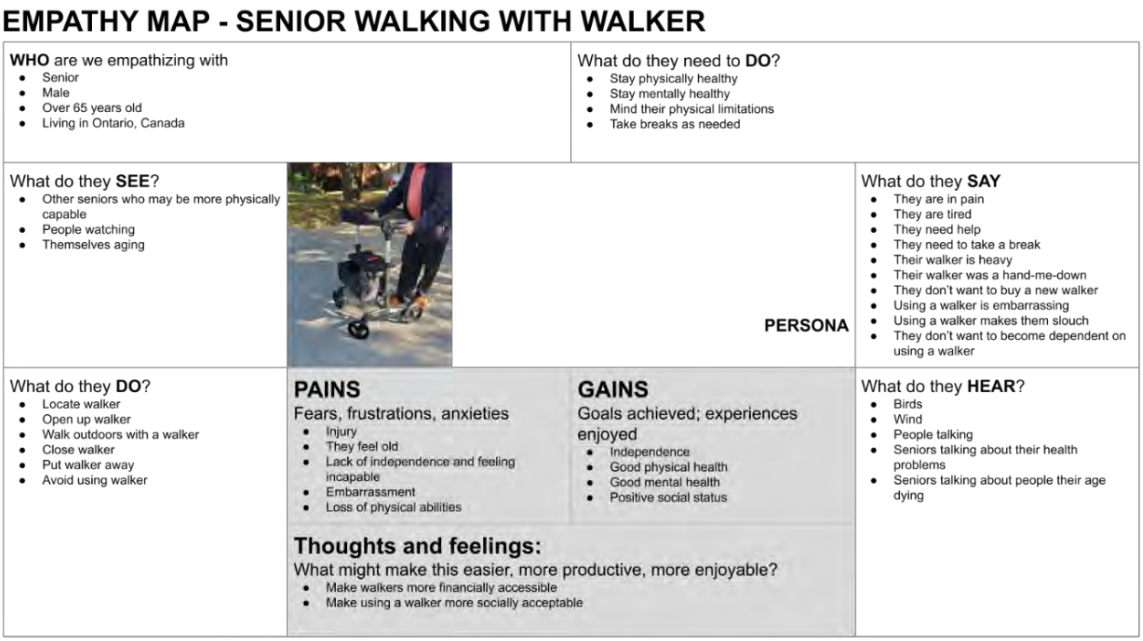


Figure 5 *Empathy Map Senior Walking with Walker*



Reflection on Usability Challenges

Before displaying his walker, the user clarifies that the reason it is stored in his garage is due to its rare use owing to its heaviness. Despite the potential benefits from using a walker in his state of post-knee surgery, he says that he opts for a cane due to its reduced size and weight. With his car usually parked in the garage, removing the walker is challenging. Luckily, on the day of the study, the car was not in the garage. If the walker's design were smaller and lighter, he might consider storing it in his home and using it more regularly. The unfolded walker effectively eases the strain on the user's knee. The user finds the walker helpful for longer distances compared to using nothing or a cane. The brake system activated by squeezing a pair of caliper bike-type handle breaks is easy to use and prevents falls. The user likes the option to sit and rest, and thinks it is especially useful for seniors who might overstrain themselves. Incorporating a resting option in the final design could be beneficial. The user noted his heavy walker was a free hand-me-down. Affordability is crucial for seniors' physical activity products, considering their limited incomes.

2.1.4 User Observation – Human Factors of Existing Products

In addition to the walker study, a study of a wearable chair/brace was also conducted since this device also has the potential to enhance senior mobility by providing seniors with a place to rest so they do not overstrain themselves and can continue being active. A video of a user putting on a wearable chair/brace was observed and notes on how the user interacted with the product and its touchpoints were taken. The results are summarized in the table below.

Table 2 *Usability - Wearable Chair/Brace (Touchpoints)*

Touchpoint		Explanation	Comments
Thighs		• Back of thigh (for resting) • Front of thigh (for connecting)	• Velcro fastening is adjustable and easy to use
Feet		• Strap around circumference of foot	• Velcro fastening is adjustable and easy to use • Orange strap that runs from the Velcro strap keeps the harder skeleton of the structure away from the user's calf to prevent rubbing
Waist		• Strap around waist	• Velcro fastening is adjustable and easy to use • Fastens from right to left (may be hard to pull tighter with non-dominant hand)
Shoulders		• Wide strap that rests on shoulders	• Velcro fastening is adjustable and easy to use • Shoulder strap can be tightened at the front with a buckle (like backpack) • Sholder piece is wider at the top (to prevent strap from digging into shoulders) • Strap narrows at the front (to prevent arms from rubbing against strap)

(Insider Tech, 2017)

2.1.5 User Observation – Safety and Health of Existing Products

Products for seniors typically have ergonomic handles, slip guards such as brakes, and are strong. To increase comfort, the materials used in senior physical activity products are typically padded with durable materials that will not become worn with regular use. Effectively designed mobility enhancing products for seniors require little effort to use; whether this is physical effort or the mental effort that goes into understanding how to use a product. ASTM F2276-10(2015) outlines the guidelines for manufacturing exercise equipment for all individuals above the age of twelve (ASTM, 2023). This specification provides the requirements for the design and manufacturing of the following areas of senior physical activity products: "stability,...support,...edges, corners, and tube ends,...moving parts in accessible areas such as rotating and reciprocating points...[,]squeeze, shear, and crush points,...adjustment and locking means,...handgrips...[,] foot support,...load development and transmitting components such as ropes, belts, chains,...chain or gear drives,...intrinsic, extrinsic, and endurance loading" (ASTM, 2023). The final proposed design solution should adhere to these specifications.

2.2 Product Research

After existing braces on the market were researched, they were benchmarked. Benchmarking is an evaluation method that compares products to determine things such as their similarities, differences, and successful and unsuccessful characteristics. First, the benefits of the braces were benchmarked. Then, the features were benchmarked. Next, size and adjustability ranges were examined to see how they influenced the functionality of body braces. Afterwards, the aesthetics and forms of various braces were benchmarked. Finally, the material and manufacturing methods used in various products related to body braces were examined, and sustainable materials and manufacturing methods used in current products were examined. This benchmarking process helped determine what should and should not be included in a brace design.

2.2.1 Benchmarking - Benefits and Features of Existing Products

The table below displays a range of existing body braces along the x-axis and benchmarks them according to their benefits.

Table 3 *Benchmarking – Benefits of Existing Products*

 (Orthomed, n.d.-a)	 (Orthomed, n.d.-d)	 (Orthomed, n.d.-e)	 (Ober, n.d.)	 (Roxofit Store, n.d.).	 (PAZAPO, n.d.)	 Orthomed. (n.d.-b)	 Ondaring. (n.d.)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Bauerfeind Spinova Osteo Back Brace	Orliman Jewett Hyperextension Brace	Push Med Back Brace	HKAFO Knee Ankle Foot Orthosis Braces	Hip Brace for Sciatica Pain Relief	Posture Corrector for Men & Women	DonJoy X-Act ROM Knee	Ondaring Posture Corrector Women & Men
Benefits							
Straightens the spine and stabilizes the pelvis Activates the back muscles Adjustable Lightweight Unobtrusive	Pain relief Lightweight Stabilisation and restriction of spinal movements Snug fit (better control) 3-axis movement	Improves the position of the lumbar vertebral column and reduces pain Adjustable Comfortable to wear when performing activities Brace is not noticeable under clothing Washable	Adjustable angle Can help with knee pain, ankle pain, foot fracture, or post-injury fixation Comfortable and breathable Shock absorption Non-slip	Eases pain from sciatic nerve, pulled thigh, hip flexor strain, groin injury, hamstring pull, sacroiliac joint, labral tear, arthritis, or bursitis Quick to put on Easy to adjust Provides stability and support Stays in place	Fully fits the spine, providing full back support Improves posture Strong Easy to wear and take off	Can swivel and snap Precise protection and range of motion All four sliders telescope independently to allow strap placement away from surgical site	Improves pain and bad posture Made from high quality material Adjustable Fits under clothes Easy to move freely in Comfortable

The Top Benefits that Can Be Incorporated in The Design Solution.

- Pain relief
- Support
- Adjustable
- Comfortable
- Snug fit

The table below shows various existing body braces and benchmarks them according to their features.

Table 4 *Benchmarking - Features of Existing Products*

	 (Orthomed, n.d.-a)	 (Orthomed, n.d.-d)	 (Orthomed, n.d.-e)	 (Ober, n.d.)	 (Roxofit Store, n.d.).	 (PAZAPO, n.d.)	 Orthomed. (n.d.-b)	 Ondaring. (n.d.)
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Bauerfeind Spinova Osteo Back Brace	Orliman Jewett Hyperextension Brace	Push Med Back Brace	HKAFO Knee Ankle Foot Orthosis Braces	Hip Brace for Sciatica Pain Relief	Posture Corrector for Men & Women	DonJoy X-Act ROM Knee	Ondaring Posture Corrector Women & Men
	Features							
Back Length	Multiple size options ranging from 50-76 cm	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pelvic Circumference	Multiple size options ranging from 80-110 cm	N/A	Multiple size options ranging from 65cm to 145cm	N/A	One size fits up to 109cm	Multiple size options ranging from 60cm to 122cm	N/A	N/A
Chest Circumference	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25" to 44"
Thigh Circumference	N/A	N/A	N/A	N/A	One size fits up to 24"	N/A	Universal fit	N/A
Foot Size	N/A	N/A	N/A	Multiple size options ranging from 5.5 to 10	N/A	N/A	N/A	N/A
Number of Support Points	N/A	3	1	N/A	2	2	4	2
Material(s)	Elastic mesh	Lightweight alloy aluminium Foam fabric	Sympress (a microfiber)	Nylon Aluminum alloy	Latex-free neoprene	ABS Elastic	Nylon Aluminum ABS	Nylon
Manufacturing Method	Cut and stitched	Foam thermoformed	Foam thermoformed Cut and stitched	Cut and stitched Bent and formed	Cut and stitched	Cut and stitched	Cut and stitched Stamping Fattening Injection molding	Cut and stitched
Adjustment Mechanism	Tension of the straps	Velcro	Elastic band	Elastic band Buckle straps	Velcro	Velcro	Swivel action buckles	Buckle

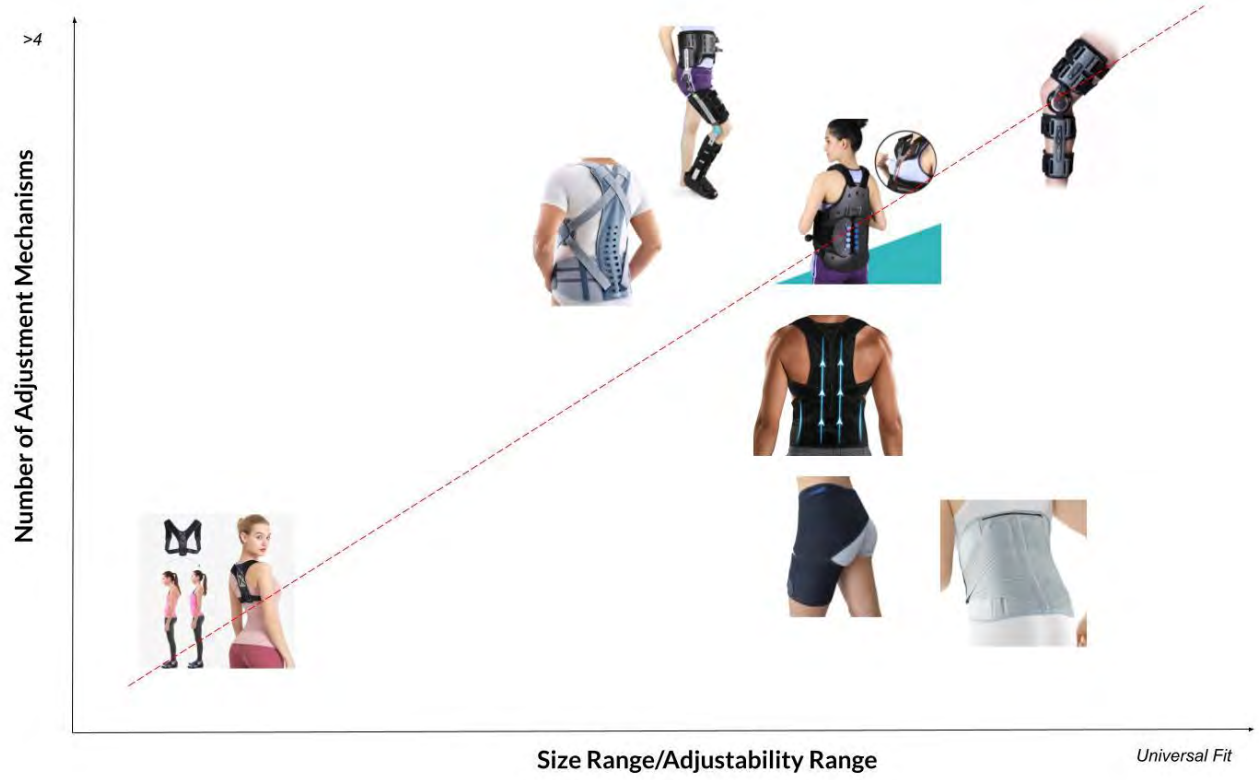
The Top Features That Can Be Incorporated in The Design Solution.

- Adjustment mechanisms
- Adjustable back length
- Adjustable pelvic circumference
- Adjustable thigh circumference
- Comfortable and durable materials

2.2.2 Benchmarking – Functionality of Existing Products

The table below shows how braces become bulkier and less aesthetically pleasing the more geometric in shape they become.

Figure 10 *Functionality and Convenience of Existing Braces Based on Adjustability*



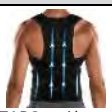
Functionality Design Takeaways.

- Generally, the body brace can fit a greater range of users when it has more adjustment mechanisms.
- Elastic straps with Velcro tend to provide additional adjustability while requiring fewer adjustment mechanisms.

2.2.3 Benchmarking – Aesthetics and Semantic Profile of Existing Products

A comprehensive evaluation was carried out to identify common styles of body braces. This involved benchmarking various existing body braces and applying the elements of design to analyze them, followed by a comparative representation of these features in a table, and a comparison of their forms on a graph. At the end, a summary of the current aesthetics, symbolics and semantics of body braces was generated.

Table 5 *Styling and Aesthetics of Body Brace Designs*

TABLE: Styling and Aesthetics of Body Brace Designs								
	 (Orthomed, n.d.-a)	 (Orthomed, n.d.-d)	 (Orthomed, n.d.-e)	 (Ober, n.d.)	 (Roxofit Store, n.d.).	 (PAZAPO, n.d.)	 Orthomed. (n.d.-b)	 Ondaring. (n.d.)
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Overall Form							
	Bauerfeind Spinova Osteo Back Brace	Orliman Jewett Hyperextension Brace	Push Med Back Brace	HKAFO Knee Ankle Foot Orthosis Braces	Hip Brace for Sciatica Pain Relief	Posture Corrector for Men & Women	DonJoy X-Act ROM Knee	Ondaring Posture Corrector Women & Men
Colour	Light blue	Black	Light grey	Black	Black	Black	Black	Black
Shape/Form	Rectilinear	Rectilinear	Rectilinear & organic	Cylindrical (when on user) with rectilinear components	Cylindrical (when on user)/organic	Cylindrical (when on user) with rectilinear components	Cylindrical (when on user) with rectilinear components	Cylindrical (when on user) with rectilinear and organic components
Size	Large	Medium	Small	Large	Small	Medium	Large	Small
Texture/ Materials	Soft fabric	Hard plastic and soft fabric	Soft fabric	Soft fabric and hard plastic	Soft fabric	Soft fabric	Soft fabric and hard plastic	Soft fabric
Repetition	Arrays of slots Arrays of holes on mesh body	Repeated adjustment slot style Repeated colour use	Rectilinear pattern on straps	Repeated straps Repeated holes	Repeated stitching style throughout Repeated Velcro handle style	Arrays of holes on mesh body	Repeated buckles Repeated forms (4 main sections that are all similar)	Repeated stitch pattern on back
Pattern	Rectilinear pattern on straps	Small honeycomb fabric pattern	Stripes	Slot patten by hip	N/A	N/A	Repeated set of three rectangular forms connect each of the buckles to the main product form	N/A
Balance	Left and right sides symmetric	Left and right sides symmetric	Left and right sides symmetric	Brightly coloured angle control placed at the smaller end of the product to balance out the large size of the other end	Main Velcro connection is placed on the side of the body that the brace is not on	Left and right sides symmetric	An array of pieces of varying sizes – the larger number of small pieces balances the smaller number of large pieces Symmetric about the y axis (when brace is vertical)	Left and right sides symmetric

The table below shows how as braces become more geometric in shape, they also become bulkier and less aesthetically pleasing. Organically shaped products are more compact and stylish.

Figure 6 *Form Graph*

The table below breaks down the aesthetic findings into categories of “product familiarity”, “product differentiation” and “product perception”.

Table 6 *Product Familiarity, Differentiation and Perception*

	Product Familiarity	Product Differentiation	Product Perception
Colour	• Most braces are black • Some are light blue/grey	• The light blue brace stands out from the others	• The light blue brace can be perceived as not too drastically different because it is close to the colour grey
Shape	• Most braces are tubular or wraps shaped to the body of the user • Body braces combine organic and geometric features	• Shapes that are not symmetrical stand out	• The more geometrically shaped forms tend to be interpreted as bulky • The organic forms tend to look more stylish and comfortable
Size	• Most body braces are very or somewhat compact	• Product number nine is quite small but can do a lot for its user – it stands out from the others who require larger forms to achieve their desired outcomes	• Compact forms look more comfortable • Compact forms look more stylish • Larger braces are perceived as robotic/intimidating
Texture/Materials	• Most braces have a fabric or hard plastic texture	N/A	• Fabric texture looks more welcoming and comfortable than hard plastic texture
Repetition	Many braces have: • Arrays of hole patterns (vents) • Arrays of slots (typically for some sort of connection) • Repeated colours	N/A	• Mimic the support systems of the body to be perceived as more ergonomic
Pattern	Many braces have: • Stripes (fabric details) • Honeycomb (fabric details) • Random rectilinear patterns • Slot patterns • Circle patterns	• Honeycomb pattern is unique and fun	• Honeycomb pattern can be perceived as technological
Balance	• Generally, braces are Symmetric about the y-axis (if not designed for use on only one limb)	• Braces that are not symmetrical stand out	• Generally Smaller details are balanced with larger details (appears more balanced and easier to wear)

Key Takeaways.

- Users value braces that are fabric, slim, and avoid chunky plastic components.
- This is likely because fabric braces look sportier because they are seen worn by athletes.
- The chunkier plastic braces look like medical devices and are more intimidating to be seen wearing.
- Braces that are slim and conform to the shape of the body look more ergonomic and comfortable.

2.2.4 Benchmarking – Materials and Manufacturing of Existing Products

Materials and Manufacturing. This section provides an overview of the materials and manufacturing methods used to make two products related to fabric body braces, (a) braces, and (b) sports clothing. The various materials and manufacturing methods of each product are then benchmarked.

Braces. Braces are typically worn on the body to protect or recover from injury, or to reduce pain. They usually form around the shape of the wearer's body and are flexible, semi-ridged, or a combination of the two. Common materials that braces are made from include nylon, cotton, and synthetic foams.

Table 7 *Benchmarking Materials and Manufacturing Methods of Braces*

Product	 Push Med Back Brace (Orthomed, n.d.-e)	 Hip Brace for Sciatica Pain Relief (Roxofit Store, n.d.)	 Posture Corrector for Men & Women (PAZAPO, n.d.)	 Ondaring Posture Corrector Women & Men (Ondaring, n.d.)	 Cleanprene Knee Support (CleanPrene, n.d.)	 FIIXIT Orthotic Lab 3D printed splint (World Intellectual Property Organization, n.d.)	 M-Brace 10" Abdominal Binder (OrthoMed, n.d.-c)
Material(s)	Sympress (microfiber)	Latex-free neoprene	ABS Elastic	Nylon	Sugar cane Oyster shells Recycled plastics	PLA filament	Cotton
Manufacturing Method(s)	Thermoformed Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn	3D printed	Cut and sewn
Cost (CAD)	$417	$60	$23	$11	$30	$147-$368	$86

Table 8 *Comparing Brace Materials*

	Weight (relative to items in comparison)	**Durability (relative to items in comparison)**	**Sustainability (relative to items in comparison)**	**Cost (relative to items in comparison)**
Lightweight Alloy Aluminum	Heavy	High	High	High
Thermoformed foam	Light	Low	Low	Low
Nylon	Light	High	Low	High
ABS	Medium	High	Low	High
Neoprene	Light	Medium	Low	High
Sugar Cane	Light	Medium	High	High
Oyster Shells	Light	Medium	High	High
Recycled Plastic	Light	Medium	Medium	Medium
PLA Filament	Light	Medium	Medium	Medium
Cotton	Light	Low	Medium – High (organic)	Low

(OpenAI, 2024)

Sports Clothing. Sports clothing is worn when partaking in active activities, or for comfort. It is comfortable, lightweight, breathable, supportive, and stretchy. Common materials seen in sports clothing are polyester, elastane/spandex, nylon, bamboo, and cotton. The most common manufacturing method is cutting and sewing. The tables below compare different materials and manufacturing methods for sports clothing.

Table 9 *Benchmarking Materials and Manufacturing Methods of Sports Clothing*

Product	 Everyday Seamless Sports Bra (Gymshark, n.d.)	 Men's HeatGear® Long Sleeve (Underarmour, n.d.)	 Momentum Seamless Top (Athleta, n.d.)	 (Artilect, n.d.)	 Black Dylan Tank Bra (Girlfriend Collective, n.d.)	 Live Wire Sports Bra (PublicMyth, n.d.)	 Active High-Waisted 5" Short with Pockets (Boody, n.d.)
Material(s)	86% nylon 14% elastane	Body: 84% Polyester 16% Elastane Mesh: 92% polyester 8% elastane Imported	Solid colors & shine: 100% nylon Heathered: 65% nylon 35% recycled nylon	85% superfine Nuyarn® merino wool 15% nylon	79% recycled plastic bottles (RPET) 21% spandex (recyclable)	70% bamboo 25% cotton 5% spandex	Content: 61% bamboo viscose 27% organic cotton 12% spandex
Manufacturing Method(s)	Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn
Cost (CAD)	$51	$40	$40-$79	$155	$62	$68	$89

Table 10 *Comparing Sports Clothing Materials*

	Weight (relative to items in comparison)	**Durability (relative to items in comparison)**	**Sustainability (relative to items in comparison)**	**Cost (relative to items in comparison)**
Nylon	Medium	High	Low	Medium
Elastane (spandex)	Light	Medium	Low	Medium
Polyester	Medium	High	Low	Low
Nuyarn® merino wool	Heavy	Medium	High	High
Recycled PET	Medium	Medium	Medium	Medium
Bamboo	Medium	Low	High	Medium
Cotton	Heavy	Low	Medium – High (organic)	Medium

(OpenAI, 2024)

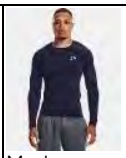
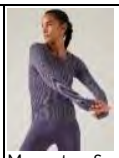
2.2.5 Benchmarking – Sustainability of Existing Products

Some current braces and sports clothes are made using sustainable materials and manufacturing methods. The previously benchmarked products are listed below with their materials and manufacturing methods. They are each evaluated based on the impact that their materials and manufacturing processes have on (a) user health and safety, and (b) the environment.

Table 11 *Benchmarking Sustainability of Braces*

Product	 Push Med Back Brace (Orthomed, n.d.-e)	 Hip Brace for Sciatica Pain Relief (Roxofit Store, n.d.).	 Posture Corrector for Men & Women (PAZAPO, n.d.)	 Ondaring Posture Corrector Women & Men (Ondaring, n.d.)	 Cleanprene Knee Support (CleanPrene, n.d.)	 FIIXIT Orthotic Lab 3D printed splint (World Intellectual Property Organization, n.d.)	 M-Brace 10" Abdominal Binder (OrthoMed, n.d.-c)
Material(s)	Sympress (microfiber) ABS	Latex-free neoprene	ABS Elastic	Nylon	Sugar cane Oyster shells Recycled plastics	PLA filament	Cotton
Manufacturing Method(s)	Thermoformed Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn	3D printed	Cut and sewn
User Health and Safety	Emissions and pollutants released manufacturing petroleum product	Emissions and pollutants released manufacturing petroleum product Allergic contact dermatitis & miliaria rubra (Callinan, Hank, Lewis, Schousboe, Stern, & Ytterberg, 1998)	Emissions and pollutants released manufacturing petroleum product	Emissions and pollutants released manufacturing petroleum product	Recycling plastic releases pollutants	PLA lets off gasses when melted that can be harmful to humans in the following ways: Increase in DNA damage Cellular injury and inflammation (DE Staff, 2022)	Pesticides and herbicides used to grow cotton are harmful to humans
Environmental Impact	Petroleum product Not sustainable	Petroleum product Not sustainable	Petroleum product Not sustainable	Petroleum product Not sustainable	Sugar cane and oyster shells - biodegradable and sustainable Recycled plastics prevent virgin plastics from being produced Hard to dispose of biodegradable materials mixed with recyclable materials	Biodegradable through special processes	Cotton = biodegradable Cotton = monoculture crop (not good) Organic cotton is better than traditional

Table 12 *Benchmarking Sustainability of Sports Clothing*

Product	 Everyday Seamless Sports Bra (Gymshark, n.d.)	 Men's HeatGear® Long Sleeve (Underarmour, n.d.)	 Momentum Seamless Top (Athleta, n.d.)	 (Artilect, n.d.)	 Black Dylan Tank Bra (Girlfriend Collective, n.d.)	 Live Wire Sports Bra (PublicMyth, n.d.)	 Active High-Waisted 5" Short with Pockets (Boody, n.d.)
Material(s)	86% nylon 14% elastane	Body: 84% polyester 16% elastane Mesh: 92% polyester 8% elastane Imported	Solid colors & shine: 100% nylon Heathered: 65% nylon 35% recycled nylon	85% superfine Nuyarn® merino wool 15% nylon	79% recycled plastic bottles (RPET) 21% spandex Recyclable	70% bamboo 25% cotton 5% spandex	61% viscose made from bamboo (lightweight and breathable) 27% organic cotton (comfort) 12% spandex
Manufacturing Method(s)	Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn	Cut and sewn
User Health and Safety	Petroleum pollutants = harmful	Petroleum pollutants = harmful	Petroleum pollutants = harmful	Petroleum pollutants = harmful	Petroleum pollutants = harmful	Petroleum pollutants = harmful	Petroleum pollutants = harmful
Environmental Impact	Petroleum product Unsustainable	Petroleum product Unsustainable Imported materials produce emissions during shipping	Petroleum product Unsustainable	Wool = biodegradable Nylon = petroleum product Hard to dispose of biodegradable products mixed with non-biodegradable	Recycled – prevents virgin plastics from being produced. Spandex = petroleum product Recyclable	Bamboo and cotton = biodegradable Cotton = monoculture crop Non-organic cotton = heavy pesticide and herbicide use Spandex = petroleum product	Bamboo and cotton = biodegradable Cotton = monoculture crop Non-organic cotton = heavy pesticide and herbicide use Spandex = petroleum product

2.3 Summary of Chapter 2 – Topic Understanding

After brainstorming primary, secondary, and tertiary users, seniors above the age of 65 were selected as the primary focus for this project. To gain a deeper understanding of the life of a senior, primary and secondary research was conducted. This data provided a deeper understanding of the challenges seniors experience. Next, the human factors of existing products were reviewed. Through these efforts, it became clear that seniors require products with different ergonomics than younger adults. Finally, existing products used to enhance senior mobility were benchmarked according to their benefits and features, aesthetics, materials, manufacturing methods, and sustainability. The braces that were most appealing were slim and unobtrusive, which is something to keep in mind for continuing to design a brace. Research gathered in this chapter made evident that there are many different physical activities that seniors participate in, many different products that seniors use to enhance their active experiences, and that seniors experience physical limitations. Further analysis of the wants and needs of seniors is required to create an impactful solution. An overarching solution that improves senior mobility in general could address multiple physical activity challenges at once.

CHAPTER #3:
ANALYSIS

3.1 Analysis – Needs

This section provides an analysis of the data collected from interviewing seniors and people who work with seniors. It discusses the needs not met by seniors' current physical activity products and the latent needs of seniors. It provides a categorization of senior needs, an analysis of the usability of their current physical activity products, and a journey map and user experience map for a user wearing a wearable chair/body brace and completing an activity.

3.1.1 Needs/Benefits Not Met by Current Products

The chart below shows various physical activity products, and products that assist in physical activities, used by seniors. It outlines the various needs that these products do not meet and the opportunities for improvement that can be drawn from these needs.

Table 13 *Unmet Needs & Opportunities*

Product	Challenges/Unmet Needs	Opportunities for Improvement
Walker	• Not fun • Not stylish • Social stigma around use • Encourages user to slouch	• Reduce social stigma associated with walkers • Make walkers more stylish • Reduce tendency to slouch while using a walker
Cane	• Confusing to understand how to properly use • Social stigma around use	• Make canes easier to understand how to use • Make canes less stigmatized
Rowboat	• Only strengthens arms • Expensive • Consumes much space • Need access to a large body of water	• Make rowing a full-body workout • Reduce the cost of rowboats • Make rowing easier for small spaces • Make an indoor option for rowing exercises (ex. an existing solution is a rowing machine)
Tai Chi Ball	• Difficult to master • Unique hobby • Limited teachers	• Make learning tai chi easier and provide more opportunities to learn it (maybe online resources can help) • Make tai chi more popular amongst seniors
Yoga Mat	• Seniors find it difficult to get up from a yoga mat when doing floor exercises • May be challenging to do yoga properly without an instructor • Mat gets dirty/muddy/wet when used outdoors • Mat may slide on uneven ground	• Have the yoga mat aid the user in getting up (maybe the user could pull themselves up using a built-in pole) • Make yoga easier for seniors to learn without an instructor • Make yoga mats more suited to the outdoors • Make yoga mats easier to clean • Make yoga mats more sturdy and less slippery
Water Exercise Equipment	• Need access to water • Need to know how to swim for safety • Possibility of drowning if a health problem occurs while exercising (ex. cardiac arrest) • Seasonal	• Make water exercise equipment incorporate water into them so users don't need access to water • Make water exercise equipment possible to use indoors so it is not seasonal
Bicycle	• Risk of bike slipping, or user falling off bike (injury) • Users may need to bike on the road which can be dangerous • Exhausting • Seasonal	• Make bikes better balanced to prevent falls • Make biking in safer areas easier (ex. indoor biking machine) • Make biking less exhausting • Make biking easier to do during the winter months (ex. indoor biking machine)
Skis	• May be difficult for a beginner to learn how to use • Expensive to purchase • Need land to use • Seasonal • May be too strenuous for some seniors	• Make skiing easier for beginners to learn • Make skis more affordable • Make skiing easier to do without access to land • Make skiing possible in non-winter months • Make skiing less strenuous

3.1.2 Latent Needs

Based on research, a list of the needs of seniors was generated and organized according to Maslow's hierarchy of needs. Organizing the needs helped determine which needs should be addressed when creating the product design brief, which can be found in section 3.7.

Table 14 *Fundamental Human Needs Chart*

Fundamental Human Need	Benefits and Underlying Needs	Importance
Basic Needs	Allows seniors to be more mobile to improve physical health	High
	Increases physical confidence (this improves senior mental health)	High
	Makes exercise less strenuous and/or painful for seniors, and therefore makes seniors more likely to be physically active	High
Security	Protects users from overstrain and injury	High
	Product feels comfortable	High
	Is affordable to seniors who have lower incomes from pensions	High
	Reliability (the product needs to be affordable but should also be durable enough to be reliable - unreliable products can result in injury)	High
	Enhances user abilities	High
	Adjustability (allows users to make precise movements without obstruction to their movements)	High
	Caring for body, ensuring that no muscles are overstrained, and not causing long-term injury	High
	Improving long-term physical and mental health through continuous use	High
Social Belonging	Looking less able-bodied	High
	Friends/relatives' recommendations	Moderate
	Seniors are less physically capable than younger adults and may require mobility aids	Moderate
Esteem	Seniors want to use products used by popular people	Slight
	Seniors want to find unique tricks to solve problems and share with their friends	Slight
Self-Actualization	Newfound freedom of movement without discomfort	High
	The creative endeavors that the product enables the user to do that they would not have been able to do previously	Moderate
	More mobile and can go to places they could not before	Moderate
	Being able to enjoy living in the moment	High

3.1.3 Categorization of Needs

The needs of seniors were then categorized according to whether they were wishes, wants, latent needs, or immediate needs.

Table 15 *Categorization of Needs*

Categorization of Needs	
Immediate Needs	• Positive physical health • Positive mental health • Regular exercise • Food security • Safe housing • Help making movements (walking, bending, etc.) • Ease & comfort • Reduced pain • Support
Latent Needs	• Belongingness • Emotional security • That they are improving • Posture correcting clothing • Body braces with built-in motors that act as artificial muscles • Robotic leg attachments to provide additional leg strength • Sensor technology that vibrates the user's back when their posture needs to be corrected
Wishes	• To have better physical health • To have better mental health • To have more money • To have friends • To be more motivated to exercise • Exercising was easier • Outdoor activities were more comfortable • Outdoor activities were not seasonal • To be more mobile • To have better balance
Wants	• Happiness • Health • Independence • Friends • Relationships • Physical fitness • Fun activities to do • To have new experiences • Equipment that reduces pain • Equipment that enhances mobility • A socially acceptable solution • A stylish solution

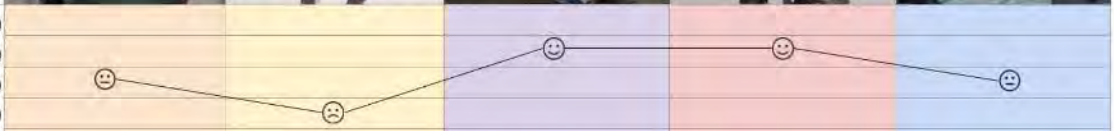
3.2 Analysis – Usability

Design maps were developed from observing a video of a user putting on a wearable chair/brace and doing an activity. The first map created was a journey map. This helped understand the steps involved in using a wearable chair/brace. The second map made was a user experience map. This map helped explain the positive and negative experiences of putting on a brace, using it for an activity, and taking it off. These maps helped to better understand the user and their challenges with wearables.

3.2.1 Journey Mapping

Figure 7 *Journey Map: Using a Wearable Chair/Brace and Doing an Activity*

JOURNEY MAP - USING A WEARABLE CHAIR/BRACE

Stage of Journey	Connecting Straps	Locking & Sitting	Doing Activity	Standing back Up	Taking off
User Goals	• To connect the shoulder, waist, shoe, and thigh straps without injury	• To successfully lock the leg pieces • To sit in a balanced seated position	• To work on their project • To rest legs while doing so	• To stand up from a seated position	• To remove the wearable chair/brace
User Actions	• Pulling straps • Pushing velcro parts of strap together	• Pressing button to lock legs • Squatting down into a seated position	• Moving wires • Connecting components • Maneuvering around the product	• Standing up (releases the lock mechanism immediately)	• Pulling apart velcro straps on the shoulders, waist, shoes, and thighs
					
User Experience					
User Thoughts	• This is a lot of work • There are so many straps • At Least the straps are Velcro so they aren't too difficult to do up	• I hope I locked it properly • I hope I don't fall • I hope my feet are correctly positioned for this to work	• It is nice not having to stand and do this • It's nice that I can easily move and go back to a sitting position as needed • It's a little awkward to have to keep pressing the button every time I walk and sit down again	• Standing up was easier than I anticipated…I didn't need to unlock the legs	• There are many straps to undo • I just want to be done with this activity • At least because the straps are velcro it isn't too difficult
User Feelings	• A little frustrated about how many straps there are	• Anxious about potentially injuring themselves by not using the product properly	Generally: • Relieved • Comfortable • Calm • Satisfied • Happy Occasionally: • Frustrated with need to constantly press button to lock	• Happy • Satisfied	• A little frustrated about how long the product takes to take off • Tired after their long activity
Problems/Challenges	• Straps move as user goes to grab them • User's hands/arms aren't strong enough to fasten straps tightly	• User is unsure of if they have successfully locked the product	• Every time the user stands up to move to a new position and sit down again, they have to press the button and go through the experience of sitting down with the uncertainty of if the product is locked properly.	• None	• Product takes a long time to take off because there are so many straps • At the end of their activity, the user doesn't have the patience to undo all the straps

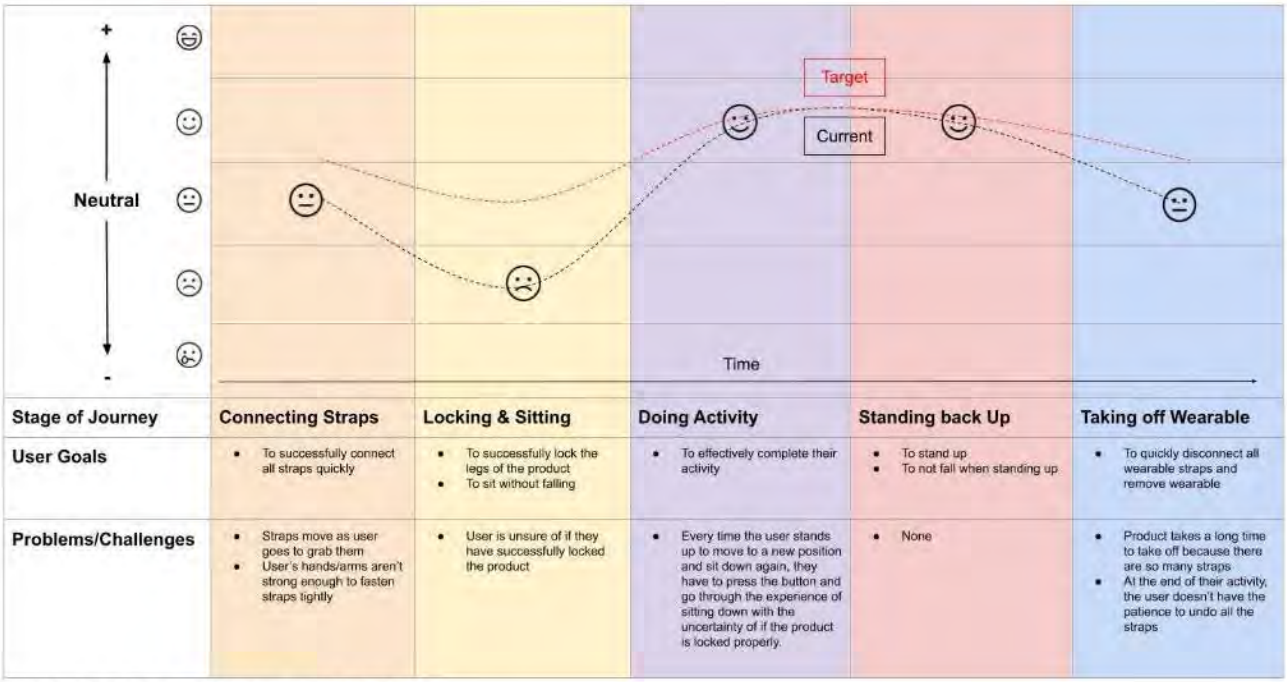
(Freepik, n.d.-d, n.d.-e, n.d.-l; Iconjam, n.d.; Insider Tech, 2017; Th studio, n.d.)

Findings That May Assist in Product Development

- Straps can be time-consuming and exhausting to do up and undo (pain point).
- Velcro straps can reduce the time needed to do up and undo straps (point of delight).
- User needs reassurance that the lock mechanisms are working (pain point that could turn into a point of delight)

3.2.2 User Experience

Figure 8 *User Experience Map: Using a Wearable Chair/Brace and Doing an Activity*



Stage of Journey	Connecting Straps	Locking & Sitting	Doing Activity	Standing back Up	Taking off Wearable
User Goals	• To successfully connect all straps quickly	• To successfully lock the legs of the product • To sit without falling	• To effectively complete their activity	• To stand up • To not fall when standing up	• To quickly disconnect all wearable straps and remove wearable
Problems/Challenges	• Straps move as user goes to grab them • User's hands/arms aren't strong enough to fasten straps tightly	• User is unsure of if they have successfully locked the product	• Every time the user stands up to move to a new position and sit down again, they have to press the button and go through the experience of sitting down with the uncertainty of if the product is locked properly.	• None	• Product takes a long time to take off because there are so many straps • At the end of their activity, the user doesn't have the patience to undo all the straps

(Freepik, n.d.-d, n.d.-e, n.d.-l; Iconjam, n.d.; Th studio, n.d.)

Findings That May Assist in Product Development.

- The most important user experiences to improve are putting on and taking off the wearable and locking and sitting.

3.3 Analysis – Human Factors

The human factors analysis consisted of making a product schematic configuration diagram and a one-to-one scale physical study model of the proposed product design solution, a mobility enhancing body brace. It investigates the ergonomics of the product to determine the correct dimensions and positionings of features to provide ease of interaction and use. The study helped identify the challenges and pain points of putting on, wearing, and taking off a body brace, primarily with a focus on the following parts of the body:

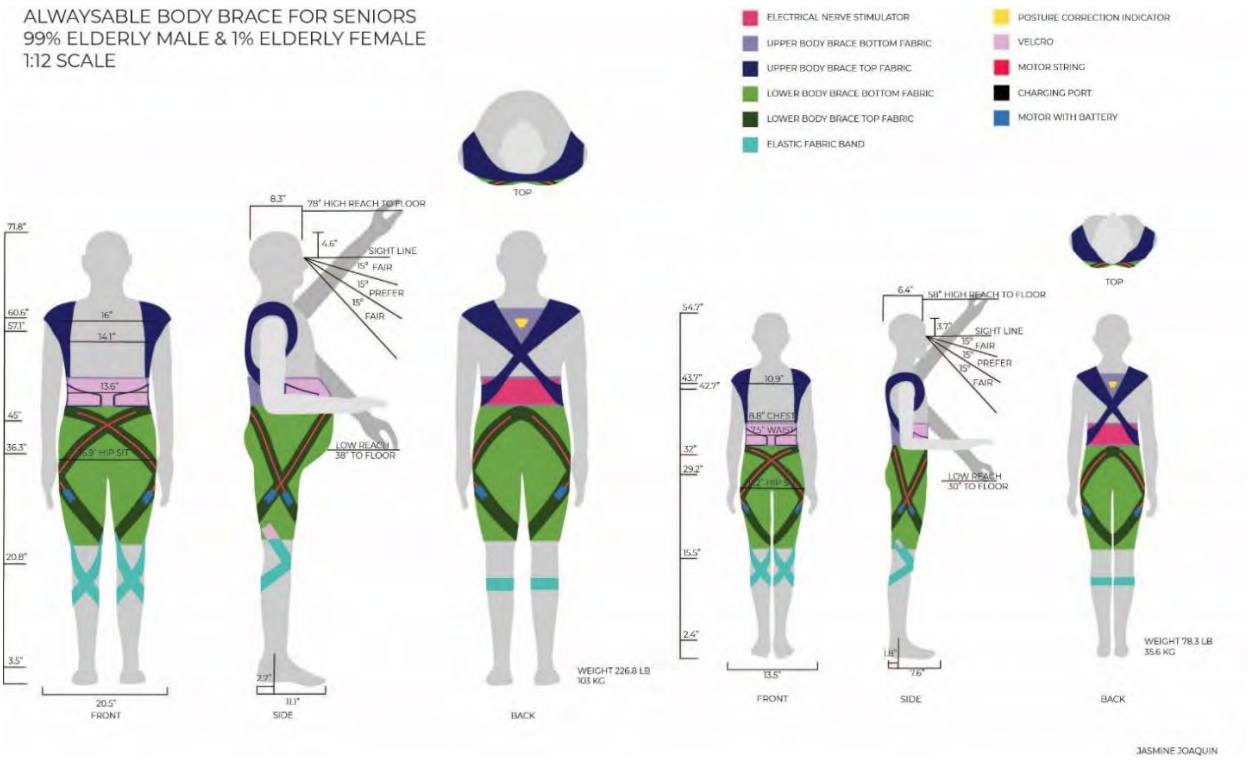
- waist/lower back
- knees
- hips
- thighs
- and shoulders.

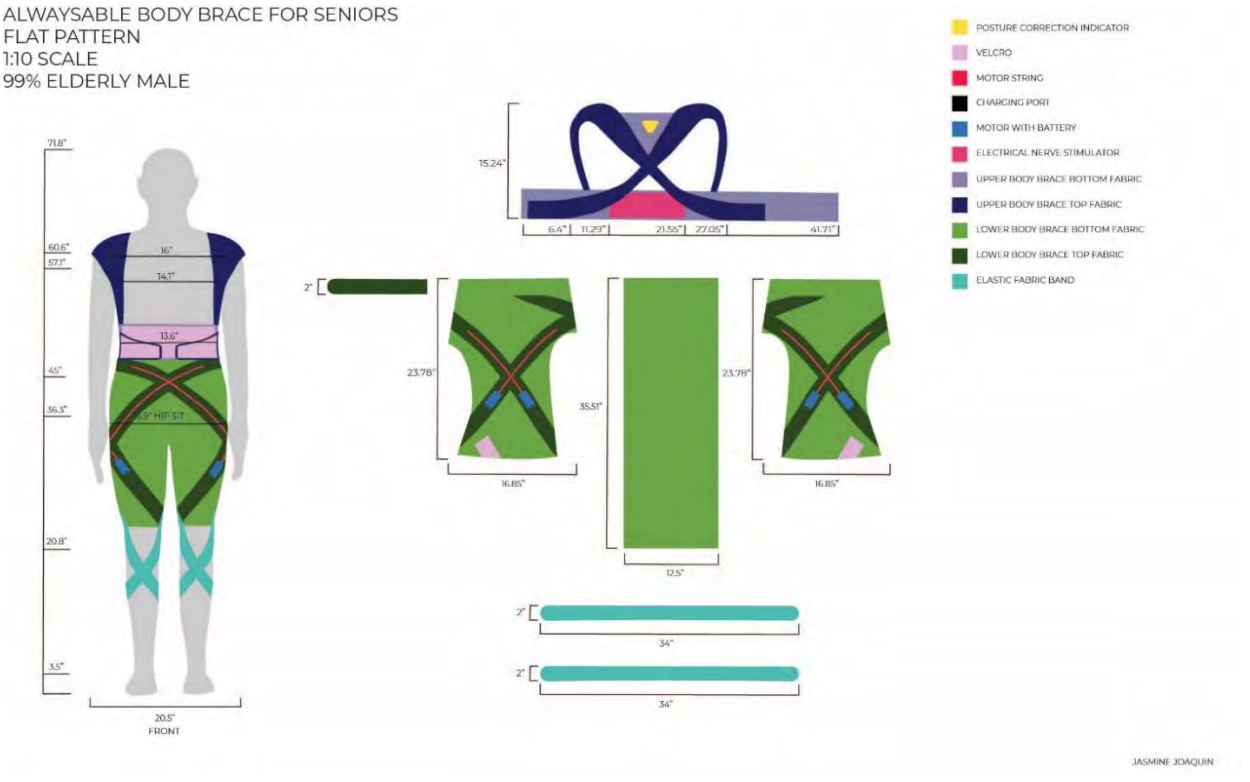
The study established the convenience of use of the body brace and the pain alleviation possibilities that it offered users. The results of this study will help develop a user-centric design brief for this thesis project.

This study was completed with the 99% elderly male senior and the 1% elderly female senior from Dreyfuss' *The Measure of Man* (1993). These users were selected as references because designing a wearable for young adults is different from designing a wearable for seniors. Elderly men between the ages of 65 and 79 are on average 5% shorter than they were when they were twenty (Dreyfuss, 1993, p. 33). Their cartilage has also shrunk, mostly in their spine, meaning that they are less able to resist compressive forces (Chang et al., 2022; Dreyfuss, 1993, p. 33). Seniors are smaller and more brittle. Male seniors' hand strength is reduced by up to 40% and arm and leg strength is reduced by 50% (Dreyfuss, 1993, p. 33). Seniors cannot use the same products as younger adults who can handle larger products that put greater strain on their bodies.

3.3.1 Product Schematic – Configuration Diagram

The product schematic configuration diagram below shows the two users wearing the proposed brace design in its earlier stage of development.





3.3.2 Ergonomic – 1:1 Human Scale Study

The next section shows the results of the ergonomic study conducted on the 99% elderly man and the 1% elderly women using the second physical study model. It explains ergonomic challenges encountered during the study, and how they were solved to refine the design. This study provided many insights and some of these insights were brought into the refined final product schematic configuration diagram.

Table 16 *Waist/Lower Back*

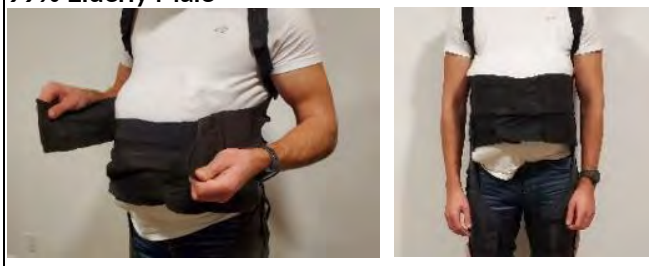
99% Elderly Male	**1% Elderly Female**
	
Both the 99% elderly man and the 1% elderly women found it easy to do up the waist strap. This was likely because the strap used a hook and loop fastening system (Velcro), which is familiar and easy to fasten and undo. The strap was designed to Velcro from the left to the right so that most users could pull the strap tight using their dominant hand. At first, the strap was too short to fit the stomach of the 99% elderly man, so the strap was extended.	

Table 17 *Hips*

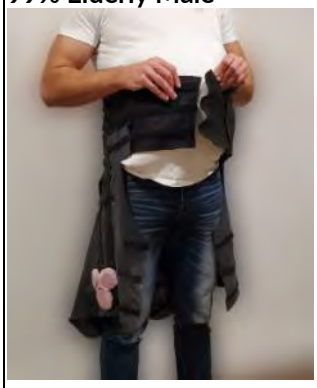
99% Elderly Male	1% Elderly Female
 	
Both user percentiles found the hip support piece comfortable, likely because the size of this area could be controlled by the thigh and waist adjustments. Initially, the motor strings ran up to a point just below the hips, but after looking at where the motor strings sat on the users and further analyzing Yves Béhar's Aura Power Clothing concept, it was discovered that the strings needed to run higher above the hips to properly facilitate the user's movements (Morby, 2017). The motor strings were then moved upward. This meant that the waist on the bottom brace piece needed to be moved up too so that the endpoint of the string had a fixed fastening point.	

Table 18 *Knees*

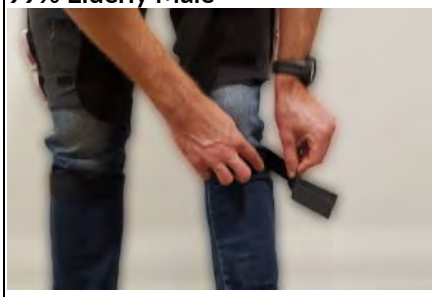
99% Elderly Male	1% Elderly Female
 	
The knee support braces were easy for the users to put on and take off because they were also Velcro-adjustable. At first, the upper tabs on the knee braces were too short, so the knee braces could not be moved up enough to correctly reach the knee of the 1% elderly women. The tab length was extended to solve this problem.	

Table 19 *Thighs*

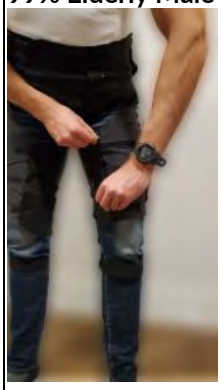
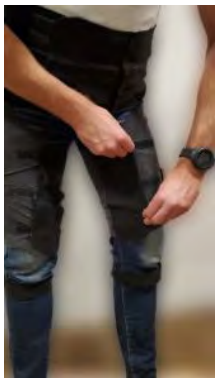
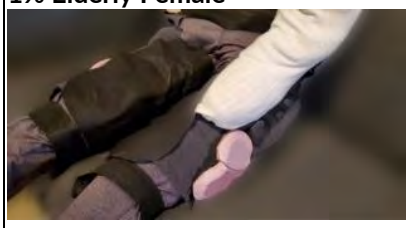
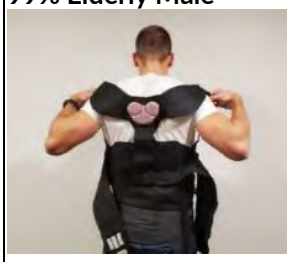
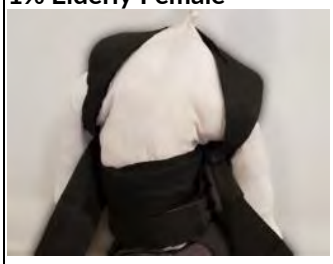
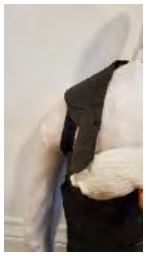
99% Elderly Male	1% Elderly Female
 	 
Neither percentile had problems with the Velcro adjustments on the thighs. They were well positioned so they were effective for adjusting the size and taking the brace on and off.	

Table 20 *Shoulders*

99% Elderly Male	1% Elderly Female
 	 
The shoulder straps were repeatedly adjusted as the one-to-one scale study model was built. First, they were extended to fit the large upper body height of the largest user. Next, it was realized that the straps could become uncomfortable if they were sitting on the users' shoulders for long periods, so the straps were widened and moved to sit on the shoulder bone, rather than close to the neck. The place where the upper strap connected to the lower strap was slimmed so that it did not rub on the user's arm as they moved. The angle that the straps came out from was also tweaked repeatedly so that the brace was easy to put on, but the shoulder straps did not fall off.	

Significance and How This May Influence Design Decision Making

The results from this study indicated that (a) the large size difference between users meant that nearly every part of the upper body brace needed to be adjustable; (b) the knee supports needed to be able to move up and down to accommodate for the different knee positions of users; (c) the motor strings needed to be moved upwards to properly support the user's hip movements; (d) hook and loop (Velcro) adjustments were effective for adjusting the thigh size of the brace; and (e) the shoulder straps needed to be adjustable, wider at the top, and at a particular angle so that the brace was easy to put on but the shoulder straps did not fall down. The study also indicated that Velcro was a beneficial fastening method since it was familiar to users and easy to use. The brace was redesigned as ergonomic evaluations were conducted to help improve the human interaction design aspects of the body brace.

3.4 Analysis – Aesthetics & Semantic Profile

Aesthetics

Current body braces are (a) tubular and shaped to the body of the user, (b) have repeated features, (c) are lightweight, (d) are symmetrical, and (e) are mainly one color (usually black). The final design will incorporate these aesthetic trends. The design will also be slim and organically shaped so it is comfortable and can be hidden under clothing. Additionally, the design will look minimalist, so it does not look challenging or intimidating to understand how to use, and so it is more welcoming to seniors.

Semantics

Mobility enhancing products are generally becoming more simplistic and modern looking. This has made them easier to understand. Unfortunately for seniors who are often not very tech-savvy, physical activity products are being sold with fewer instructions due to the simpler designs and the increased number of individuals who can access manuals online, which can result in user injury. The final product design will be simplistic, modern, and ergonomic. However, this product will also go against the trend to include fewer instructions and instead include a paper copy of the instructions for seniors who may not be tech-savvy enough to find a manual online.

3.5 Analysis – Sustainability: Safety, Health, and Environment

Sustainable materials and manufacturing methods were selected for the design to lower carbon and toxic pollutants and promote responsible production amid the planet's environmental challenges. This approach prioritized biodegradable and rapidly renewable materials, along with low-emission manufacturing methods. Emissions contribute to climate change, and pollutants harm both the environment and human health. Opting for biodegradable materials was favored over recyclables, as plants used in production can sequester carbon and purify the air, whereas plastic recycling releases emissions and pollutants and does not align with the goal of phasing out harmful petroleum products for a sustainable future.

Based on the above insights and findings, the approach to sustainability initiatives, health, and safety in this project was as follows:

Sustainable Initiatives.

- Utilize biodegradable materials that are rapidly renewable.
- Where biodegradable options are not available, utilize recycled materials that are recyclable.

Health.

- Choose materials and manufacturing methods that release fewer emissions and pollutants.
- Avoid using materials from plants that require many pesticides and/or herbicides to grow.

Safety.

- Choose materials and manufacturing methods commonly used on the market that have been approved as safe to use for clothing.
- Avoid materials that are prone to allergic reaction or skin irritation.

3.6 Analysis – Innovation Opportunity

To understand the innovation opportunity, a needs analysis diagram, and a desirability, feasibility and viability chart were created.

3.6.1 Needs Analysis Diagram

Table 21 *Needs Analysis Diagram*

Needs Analysis Diagram	
Problem	Seniors do not get enough exercise, which can have detrimental health outcomes, reduce quality of life, and burden the healthcare system
Why	Seniors find exercise painful
Why	Seniors find exercise exhausting
Why	Seniors are afraid they will injure themselves if they exercise
Why	Seniors do not want to be embarrassed

Based on the chart above, there appears to be many opportunities to help seniors get more exercise. This can be achieved by making a product that (a) reduces pain, (b) makes exercise less exhausting, (c) protects seniors from injury, and (d) is not embarrassing to be seen using.

3.6.2 Desirability, Feasibility & Viability

Table 22 *Desirability, Feasibility and Viability*

Desirability	Seniors want: a) To stay active and healthy b) To have social interaction c) To spend more time in nature to receive the various benefits it offers d) To live pain-free e) To have new experiences f) To have fun g) Enjoyment h) Mental engagement i) Holistic experiences in nature j) An accessible solution k) An affordable solution l) A convenient solution m) A socially acceptable solution
Viability	These desires can be achieved by making a product for seniors that is: a) More comfortable b) More convenient c) More affordable d) More fun e) Social f) From natural materials g) Less intimidating h) More socially acceptable
Feasibility	• It is possible to design a product to achieve these outcomes because the technology and materials used to manufacture products that enhance senior mobility already exist and are widely accessible • Additionally, seniors are becoming increasingly more health conscious, so a product that enables them to exercise will be well accepted by them (Harris, 2007)

The above desirability, feasibility, and viability table helped determine what seniors want from a product solution and what would make the product solution successful.

3.7 Summary of Chapter 3 – Defining Design Brief

Based on the above research, ten points detailing the key guidelines that the design needs to meet were generated:

1) **Reduces pain:** Both primary and secondary research indicated that pain was a reason why seniors do not exercise. Pain should be alleviated so that they feel motivated to exercise.
2) **Is safe:** Many seniors said that they were afraid of exercising because they could injure themselves. The design solution will be safe and ensure seniors that they will not be injured by the product.

3) **Is comfortable:** Seniors have frail bodies and sore joints and muscles. Therefore, comfort is important. By making the product comfortable, it becomes more likely to be used regularly.
4) **Provides independence:** Seniors want to be viewed as independent adults. They do not want to be seen as less capable. The design should enable them to do more activities without assistance.
5) **Enables seniors to participate in physical activities:** Seniors have many active hobbies that they enjoy participating in, or that they used to participate in and are unable to do now due to physical limitations. They also find deep gratification from the personal accomplishments of activities. The proposed product solution should make it easier for seniors to participate in the physical activities that they enjoy.
6) **Is affordable:** Research indicates that seniors often struggle to live on their pension incomes. Therefore, seniors are generally cautious about how much they spend. The product solution must be inexpensive to manufacture so that it is inexpensive for seniors to purchase.
7) **Enhances mobility:** Nearly every senior surveyed indicated that they experienced some level of reduced mobility. Mobility challenges prevent seniors from exercising due to a fear of further injury. Enhancing senior mobility is essential to ensuring that seniors can experience the full benefits of living an active life.
8) **Improves physical and mental health:** Poor health not only reduces the quality of life of the senior, but also burdens the currently exhausted medical system. The product solution will encourage exercise as a preventative healthcare measure.
9) **Is welcoming**: Seniors of different ages have different limitations to different degrees. The designed product must not be intimidating to use so that all seniors feel comfortable using it regardless of their physical limitations.
10) **Is socially acceptable and stylish:** Seniors do not feel comfortable using products that have negative social connotations. For example, research indicated that there was a social stigma around using walkers because it may make seniors look older and less able than they are. Seniors also feared walkers because they were associated with depending on a product. Seniors like to live with the mindset that they are still able and free, and do not like to be thought of as old and incapable. The final designed product must be stylish and not thought of as a product that seniors need, but as a fun product of choice.

CHAPTER #4:
DESIGN DEVELOPMENT

4.1 Initial Idea Generation

With the above ten guidelines in mind (see section 3.7), design development began. A STEEPV trends analysis was conducted before concepts were sketched.

Table 23 *STEEPV Trends Analysis*

Driver	Aesthetic Influence
Social	• Seniors do not want products that make them look old • Seniors do not want products that make them look incapable
Technology	• Seniors are intimidated by technology so the product should not look too technologically advanced • The design aesthetics must be able to be manufactured using the technology of today
Economic	• The design will feature organic and ergonomic shapes that are comfortable for senior use
Environmental	• The design will include natural materials
Political	• The design will be limited to utilizing materials that have been determined to be legal for sale in Canada
Values	• Seniors value comfortable products, so the design will look comfortable • Seniors want to have enriching new experiences, so the design will look fun or interesting

The first mood board for the aesthetic and semantic profile, Figure 9, had a greater focus on having fun outdoors, since enhancing outdoor activities for seniors was the initial focus of this project. The concepts generated from it were bright and colourful. However, when the focus shifted to a body brace to be worn under clothing, the semantic and aesthetic profile changed since seniors wanted different things for a wearable. To create a safe and comfortable body brace, inspiration was drawn from products with fabric housings. Grey was selected as the main colour for the brace because (a) most braces seen in research were a single colour; (b) this brace is intended to be warn under clothing and grey is a popular undergarment colour; (c) grey is a less intimidating neutral colour than, for example, black, but is not prone to staining like white; and (d) grey is a neutral enough colour to hide under most articles of clothing. Both the original and second revised aesthetics and semantic profiles can be seen on the next page. The final concept included mostly light greys, like in the second aesthetic and semantic profile, but with some burnt orange and black and white patterned sections to add interest to the product.

4.1.1 Aesthetics Approach & Semantic Profile

Figure 9 *Aesthetic & Semantic Profile - Old*

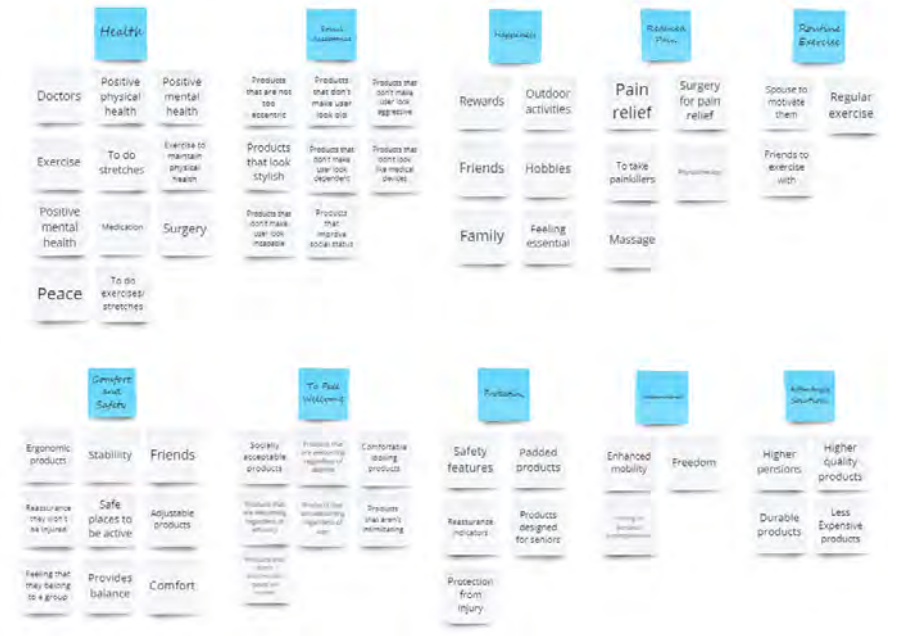
Figure 10 *Aesthetic & Semantic Profile - New*

4.1.2 Mind Mapping

Mind mapping was employed to explore potential solutions to the design problem as the research phase concluded and the idea generation phase commenced. The first mind map was used to understand the general research topic. The second mind map is of user needs.

Figure 11 *Mind Mapping – General Topic*

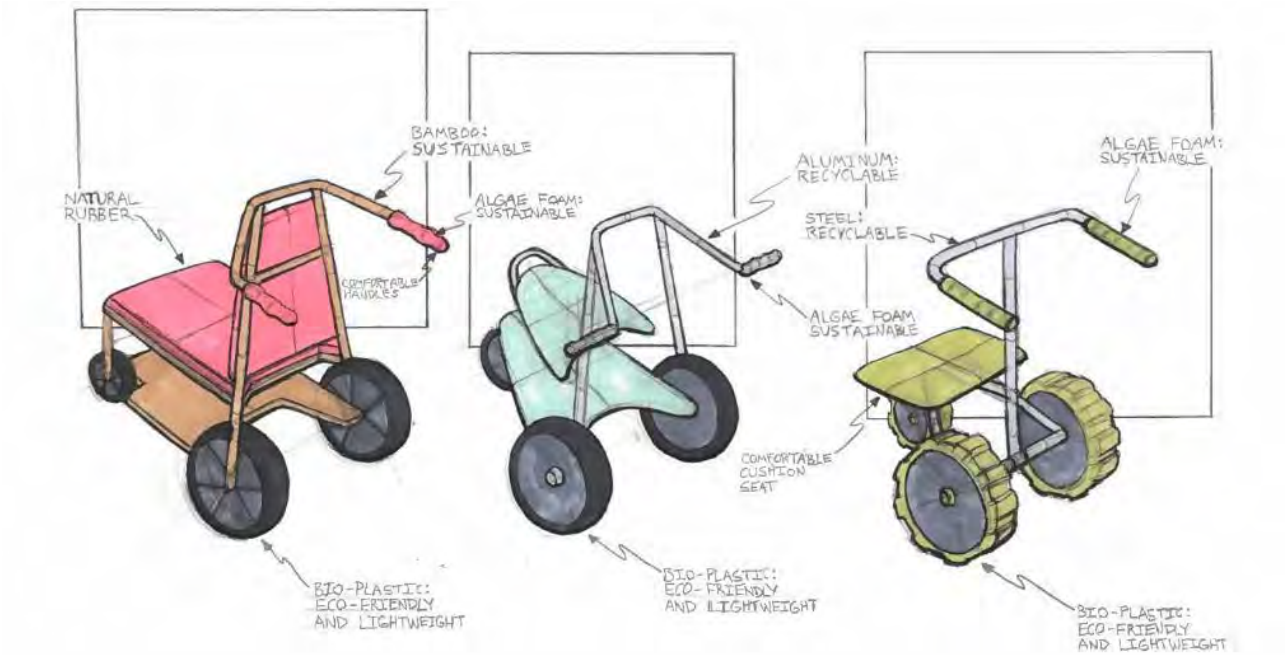
Table 24 *Mind Mapping - User Needs*



4.1.3 Ideation Sketches

Once aesthetic and semantic profiles were developed and mind mapping was completed, concept sketches were generated. As mentioned above, the initial concept sketches were based on the first aesthetic and semantic profile mood board and were focused on developing a physical activity product that enhances outdoor physical activities for seniors, the later concepts used the second aesthetic and semantic profile mood board to develop a wearable for seniors that enhanced seniors' mobility.

Figure 12 *Ideation: Walker/Gardening Stool*



How This Concept Enhances Outdoor Physical Activities for Seniors.

1. Aids with gardening – one of the most popular outdoor activities for seniors
2. Less social stigma around using this product (a traditional walker is embarrassing)
3. Can be conveniently used at home in the backyard (a location where seniors often choose to be physically active)
4. Provides a resting spot for seniors' needed breaks
5. Prevents injury/bruising that may occur when gardening without a garden stool or bench
6. Is easy to travel to and from the garden with (not the case for garden benches without wheels)

Figure 13 *Ideation: Reducing Lower Body Pain & Strain*

How This Concept Enhances Outdoor Physical Activities for Seniors.

1. Aids with walking – one of the most popular outdoor activities for seniors
2. Can help users participate in a variety of outdoor activities rather than being limited to one
3. Is convenient to use at home

Figure 14 *Ideation: Yoga Map with Standing Aid - Page One*

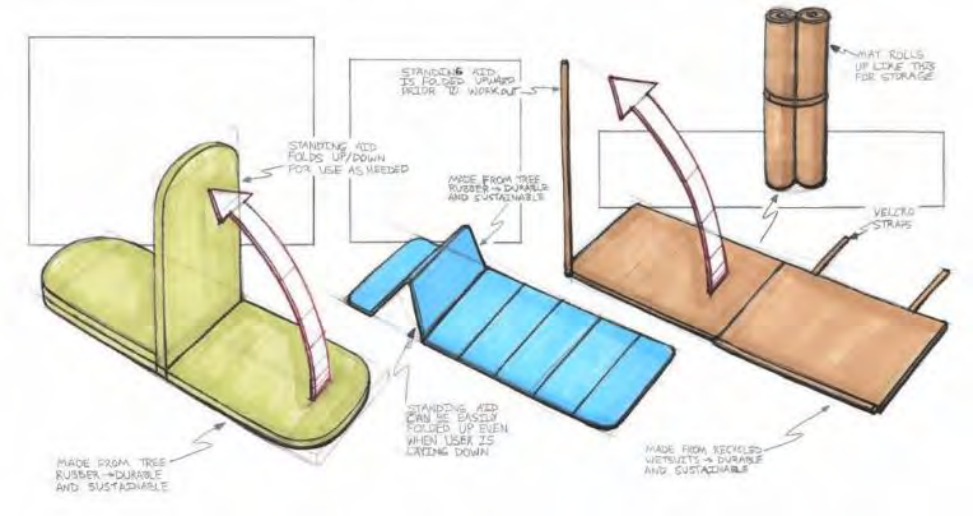
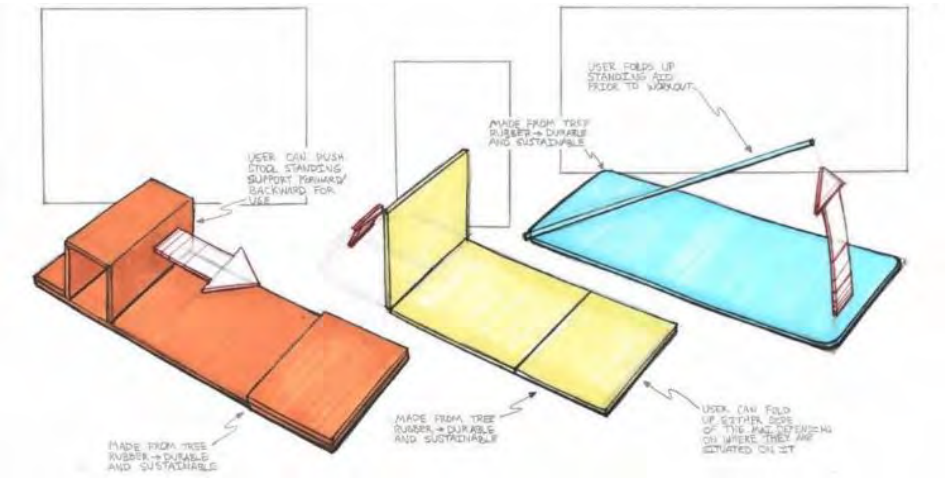


Figure 15 *Ideation: Yoga Map with Standing Aid - Page Two*



How This Concept Enhances Outdoor Physical Activities for Seniors.

1. Aids with yoga – a popular outdoor activity for seniors
2. Enables seniors to do floor exercises without the fear of how they will get up from the ground (a common fear found through interviews)
3. Can prevent yoga injuries
4. May make it easier for seniors to feel more comfortable participating in a group yoga class despite being more physically limited than others in the group
5. Can be used anywhere (and is easy to bring to a group activity)

Figure 16 *Ideation: Raised Garden Bed with Seating - Page One*

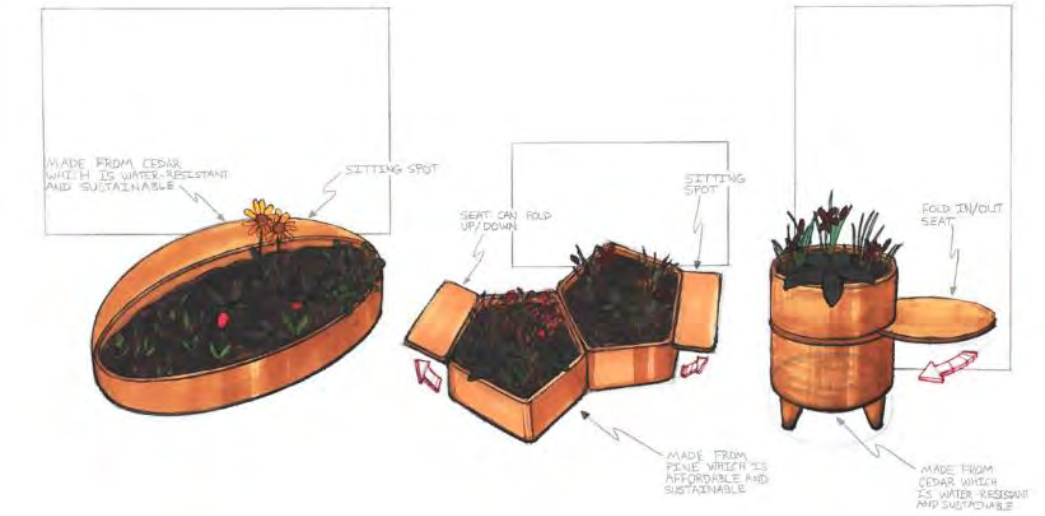
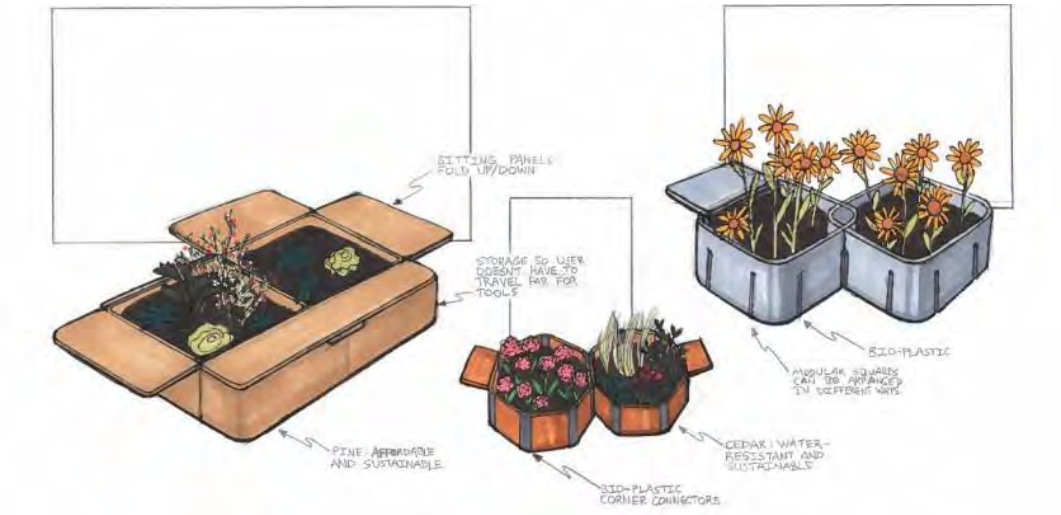


Figure 17 *Ideation: Raised Garden Bed with Seating – Page Two*



How This Concept Enhances Outdoor Physical Activities for Seniors.

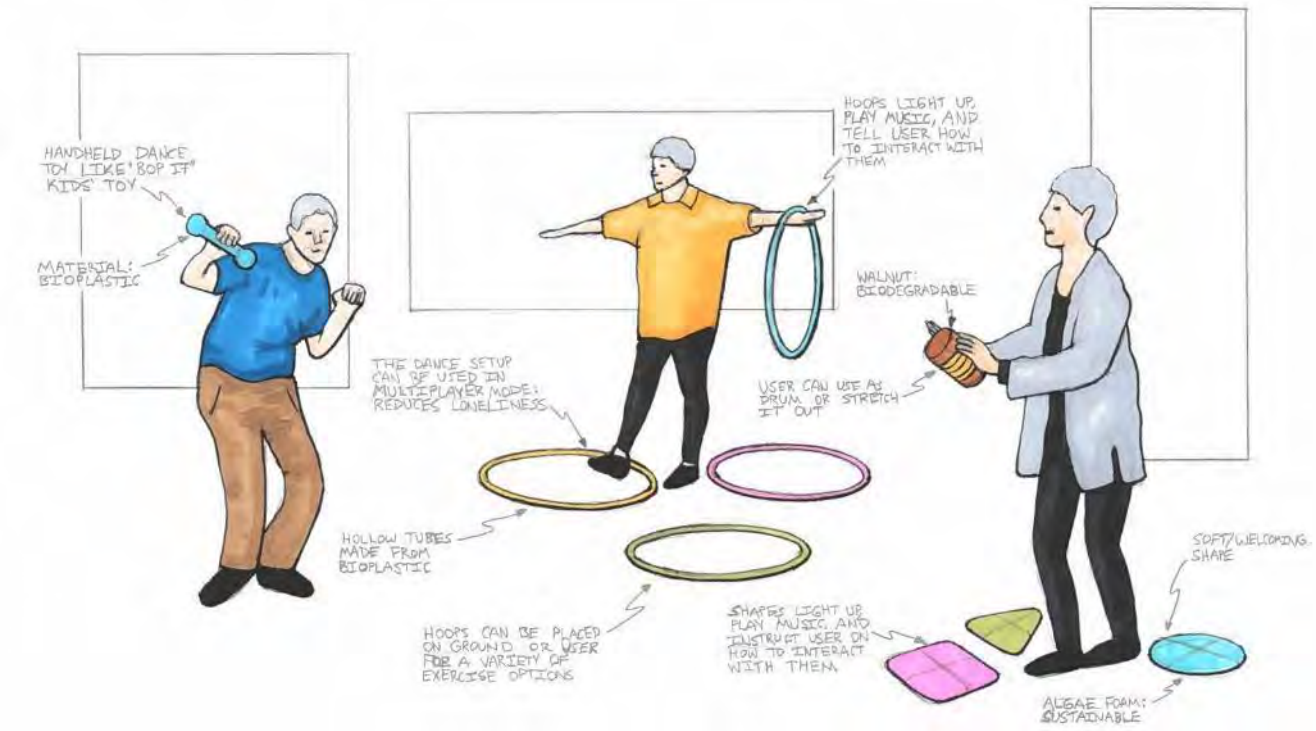
1. Aids with gardening – one of the most popular outdoor activities for seniors
2. No social stigma around using this product
3. Can be conveniently used at home in the backyard (a location where seniors commonly choose to participate in outdoor activities)
4. Helps seniors get up from the ground
5. Provides a resting spot for seniors' needed breaks
6. Prevents injury/bruising that may occur when gardening without a garden stool or bench

Figure 18 *Ideation: Walking Kit with Seat*

How This Concept Enhances Outdoor Physical Activities for Seniors.

1. Aids with walking – one of the most popular outdoor activities for seniors
2. Less social stigma using this product (ex. bringing a walker for a sitting spot would be embarrassing)
3. Allows seniors to walk farther than they may have been able to before due to a fear of walking too far and injuring themselves
4. Provides a resting spot for seniors' needed breaks

Figure 19 *Ideation: Outdoor Interactive Dance Setup*



How This Concept Enhances Outdoor Physical Activities for Seniors.

1. Fun (naturally motivates user to keep using it)
2. Can be used in a group (reducing loneliness)
3. No social stigma around using this product
4. Guided lessons ensure that seniors are only doing movements/activities suited to their age
5. Can easily be used anytime, anywhere, indoors, or outdoors (important for season changes)

4.2 Concepts Exploration

Wearable mobility aids and walkers were the two concepts from the ideation phase that were selected to move forward. These concepts were selected because they had the most potential to create an original design that effectively met the criteria defined in the design brief (see section 3.7).

4.2.1 Concept One

The wearable mobility aid concept enhances senior engagement in physical activities by making participation in physical activities less painful and tiring and providing seniors with additional mobility. Seniors indicated that they had mobility limitations that held them back from being physically active. By providing seniors with a wearable to alleviate some of these restrictions from being physically active, seniors can more regularly participate in physical activities and experience the benefits of living an active life. Some wearable mobility-enhancing concepts are shown on the following pages.

Figure 20 *Pulse therapy Back Support*

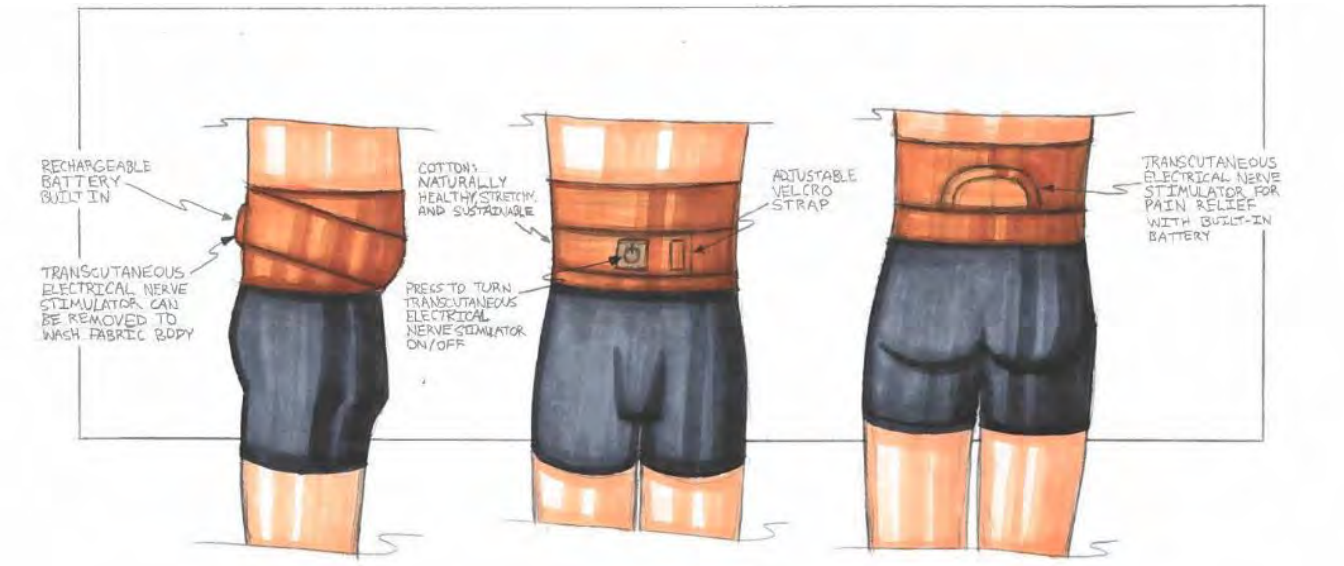


Figure 21 *Walkease Brace*

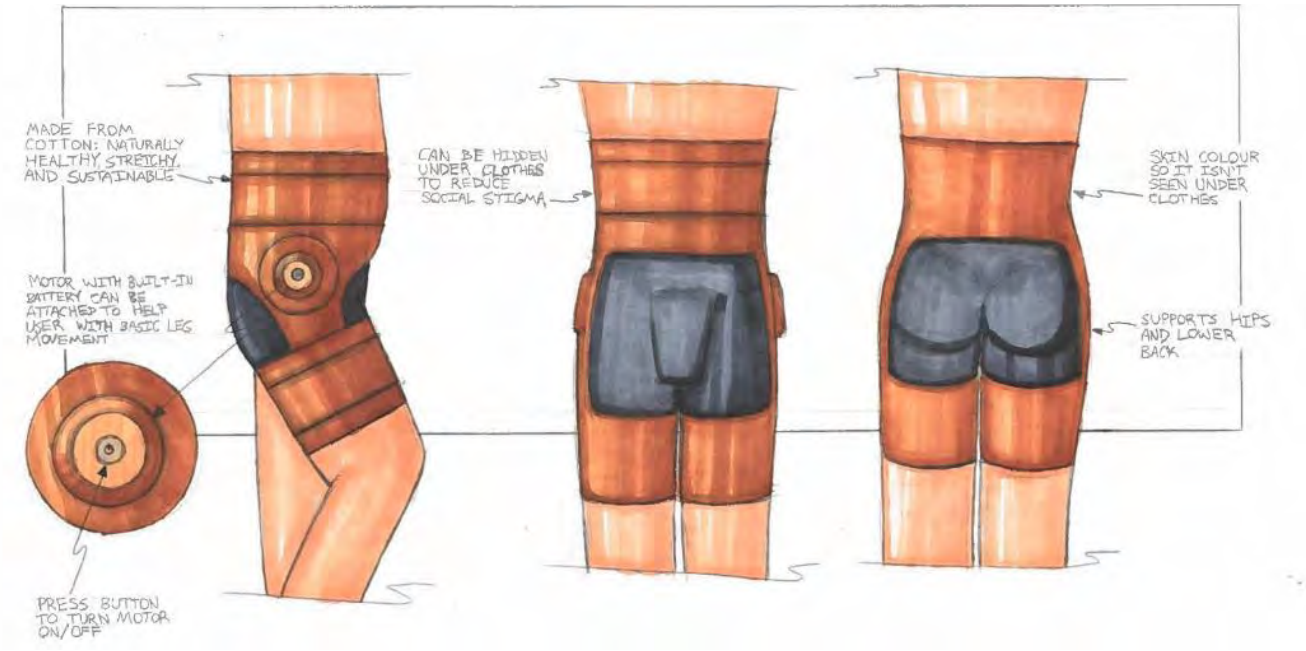
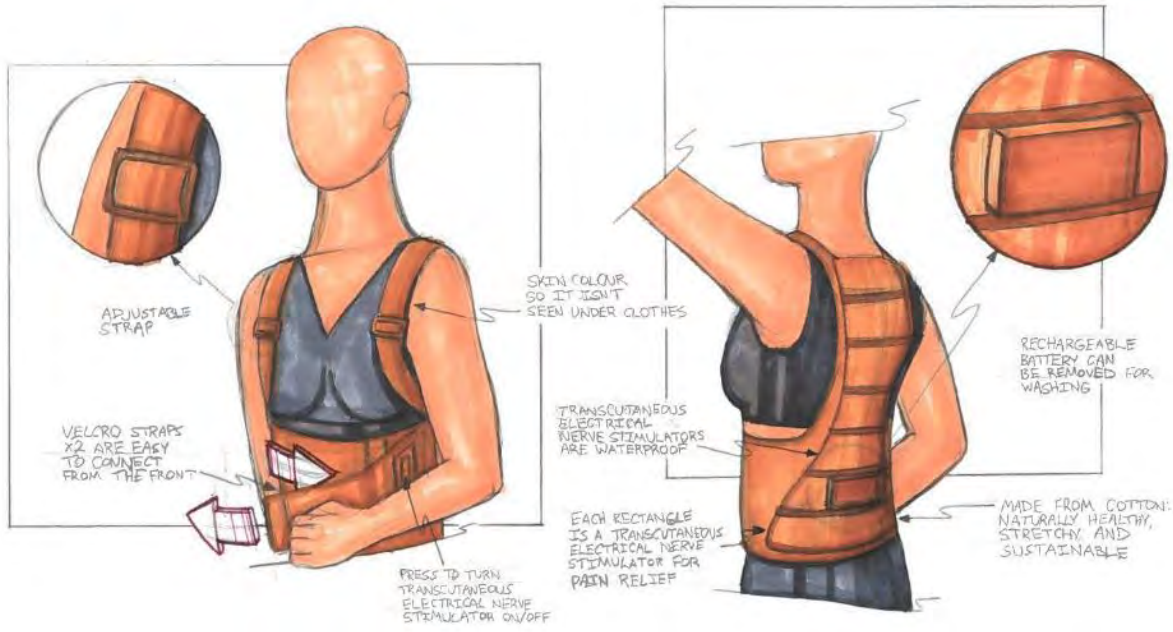


Figure 22 *Pain Relieving Back Brace*



4.2.2 Concept Two

The second concept focuses on providing seniors with a place to rest when participating in active activities. Seniors indicated that they often pushed themselves too far when being physically active, and that they required frequent breaks during physical activities to prevent injury. Walkers were effective at alleviating stress seniors may exert on their bodies when being physically active by providing them with a place to rest extra weight, or a place to sit. Current walker designs were too heavy and large to use regularly and are embarrassing to be seen with because they make the user look older than they are. This concept direction focuses on creating a foldable walker device that is stylish and provides the user with a place to rest as needed. By providing seniors with a place to rest, seniors do not overstrain their bodies and can continue to exercise for longer periods of time. The walker concepts are shown on the following pages.

Figure 23 *Sit-N-Stride Companion Page One*

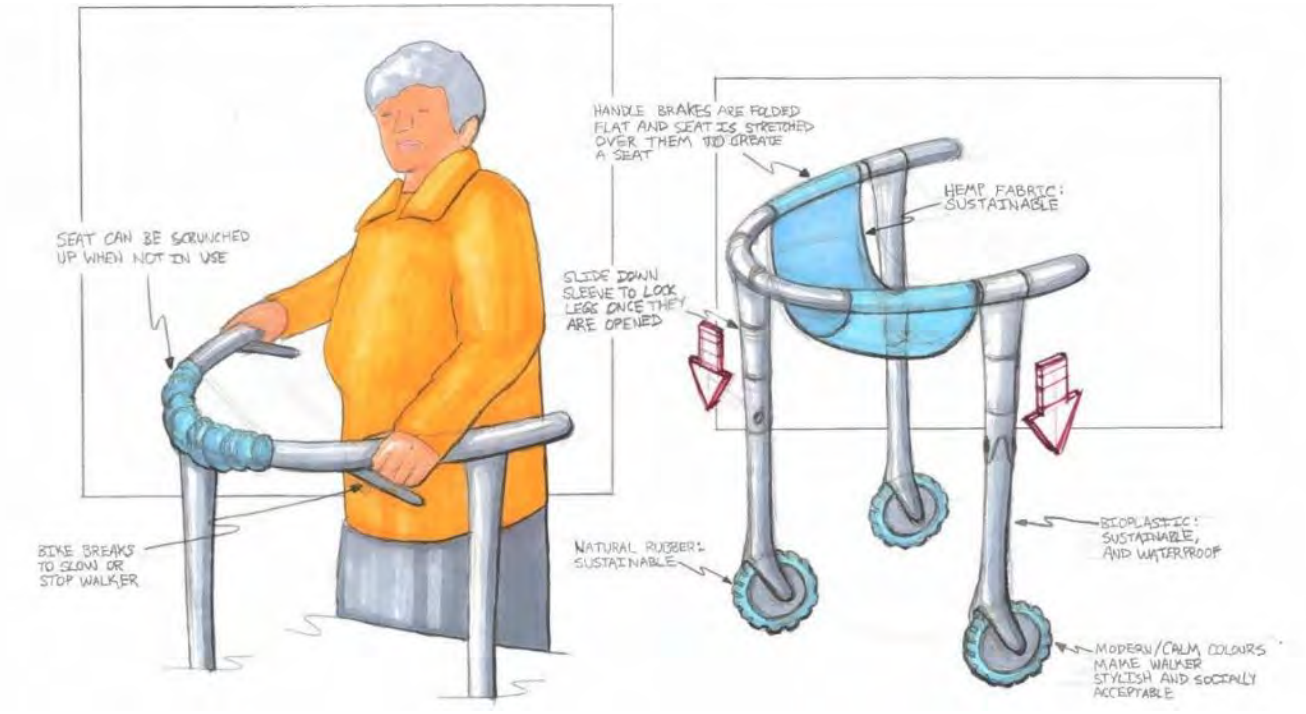


Figure 24 *Sit-N-Stride Companion Page Two*

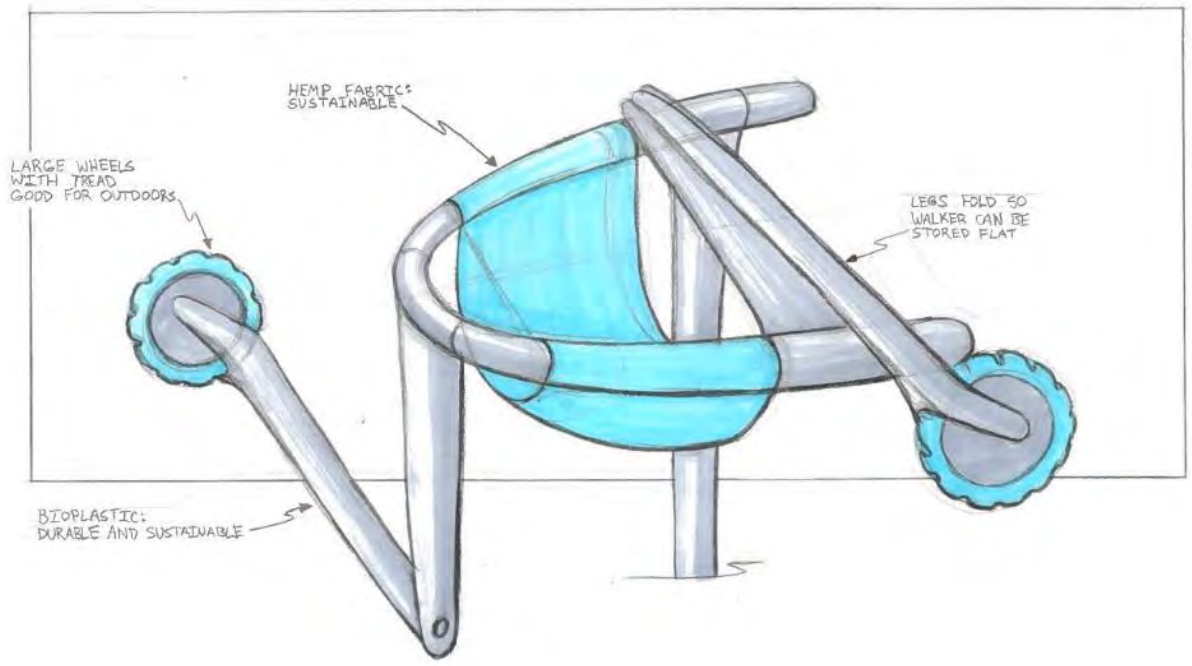


Figure 25 *V-Fold Walker*

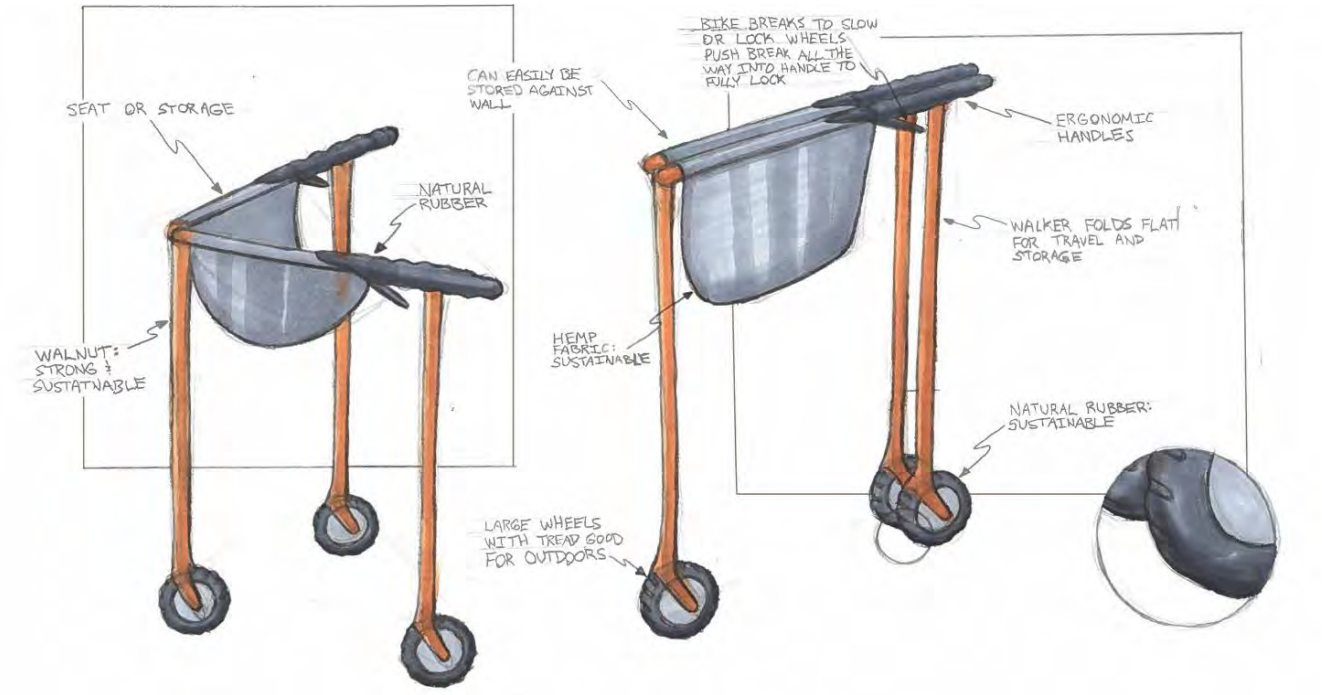
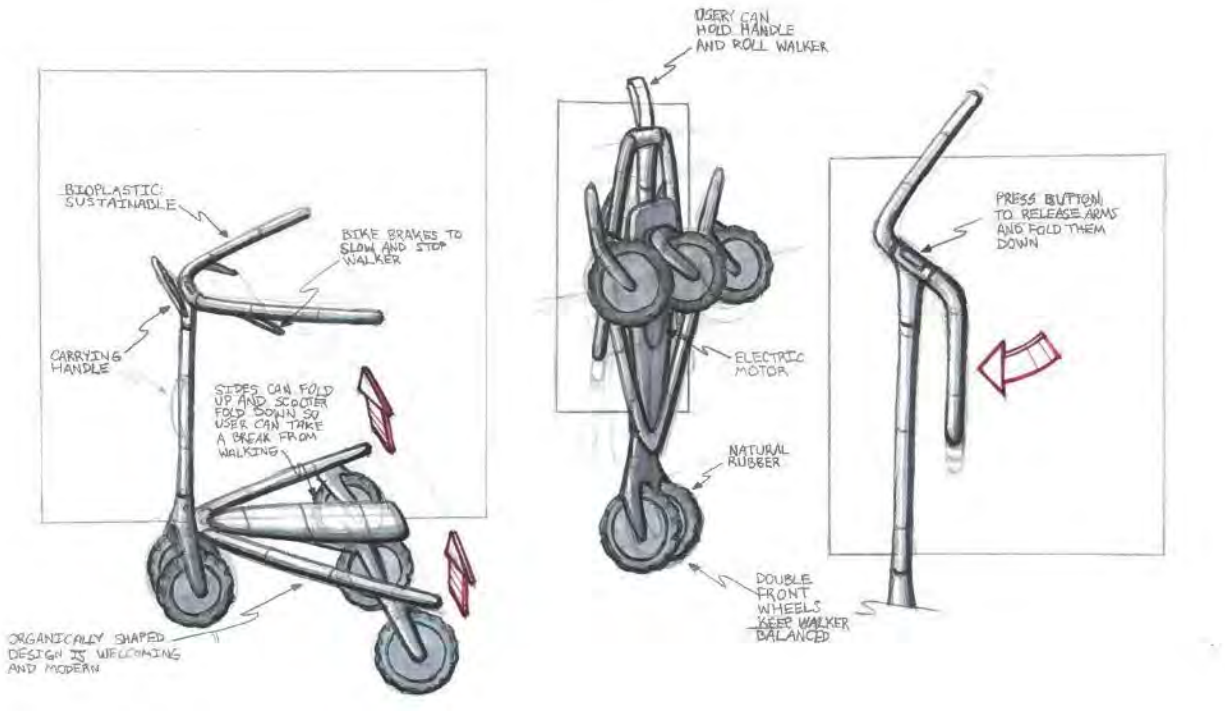


Figure 26 *Scooter-Walker*



4.3 Concept Strategy

From the wearable mobility aid concept, it was decided that the wearable should focus on supporting multiple parts of the user's body instead of just focusing on a section of the body, and that the user should be able to choose which parts of the wearable to use when. For example, the user could just use the back support piece, or they could use the back support piece and the hip support piece. It was also suggested that a design solution be created that can transform between a product that offers only partial mobility support, to a product that can provide full mobility support with the use of robotic legs. For the walker concept, the V-Fold Walker concept was selected to move forward. However, primary focus was placed on the wearable because it seemed to be the most unique design direction of the two. In addition to the concept sketches, configuration diagrams were made for both concepts to determine the required components that needed to be integrated into each product, as well as the proportion, positioning, and scale of the parts relative e to the user. As learnings were drawn from the configuration diagrams, the concept strategy sketches were adjusted. These new designs are shown on the next few pages.

4.3.1 Concept Direction & Product Schematic One

Figure 27 *Exploration*

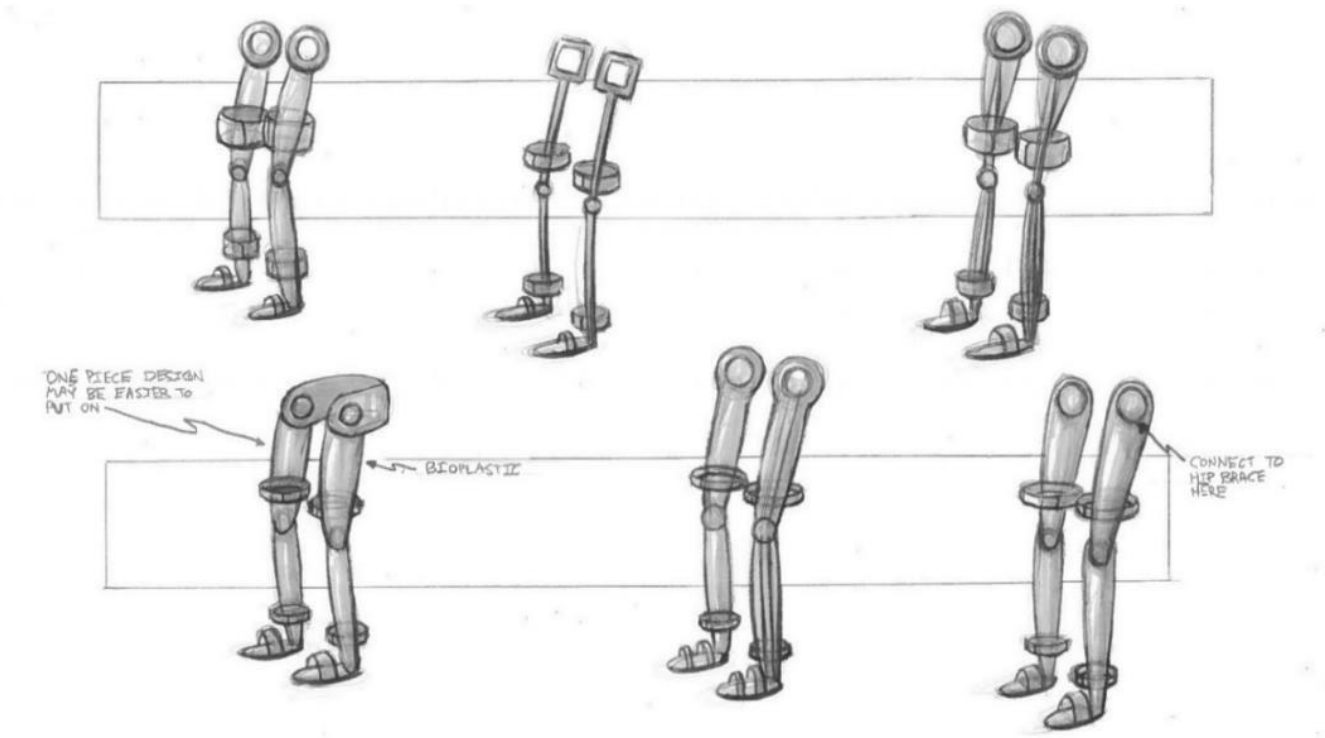


Figure 28 *Walkease Transformer*

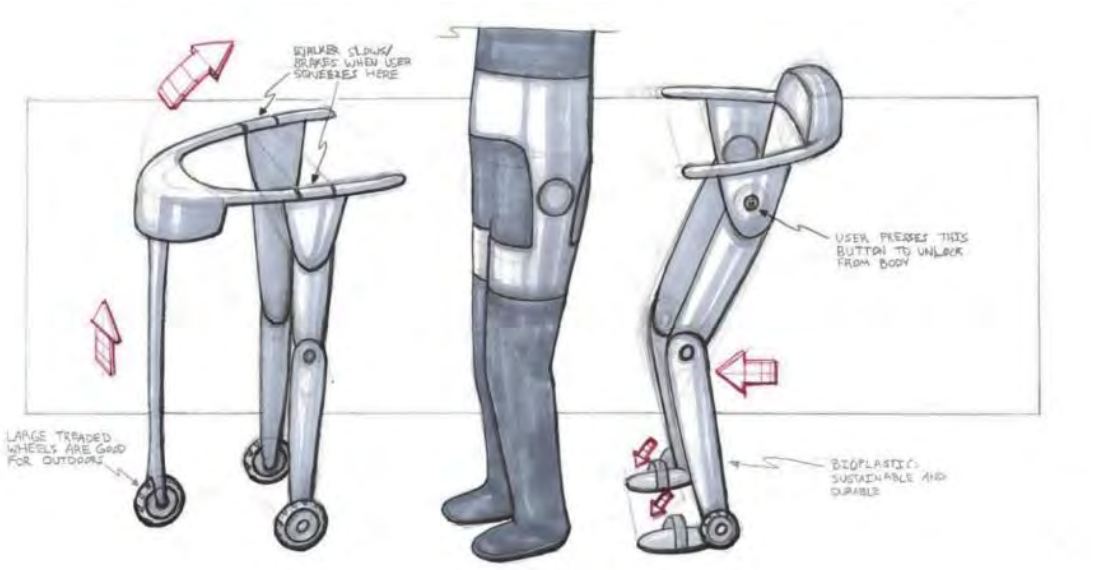


Figure 29 *Walkease Transformer Page Two*

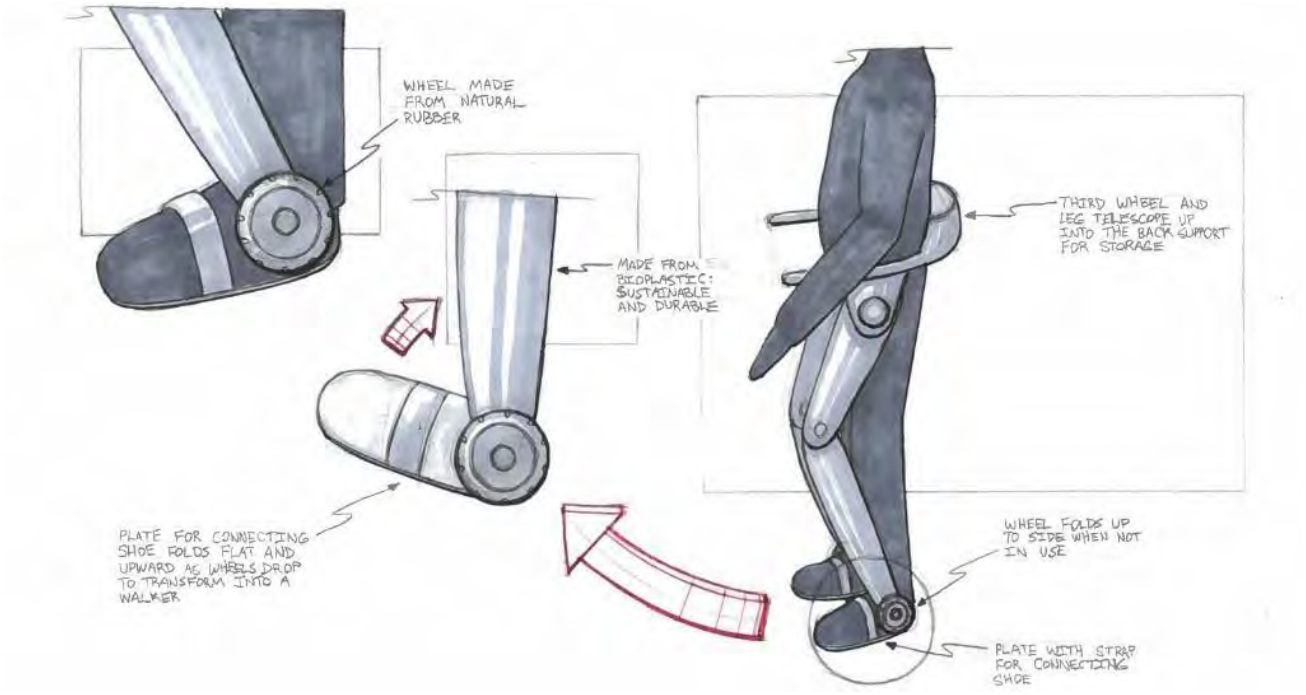


Figure 30 *Mobile Seat Page One*

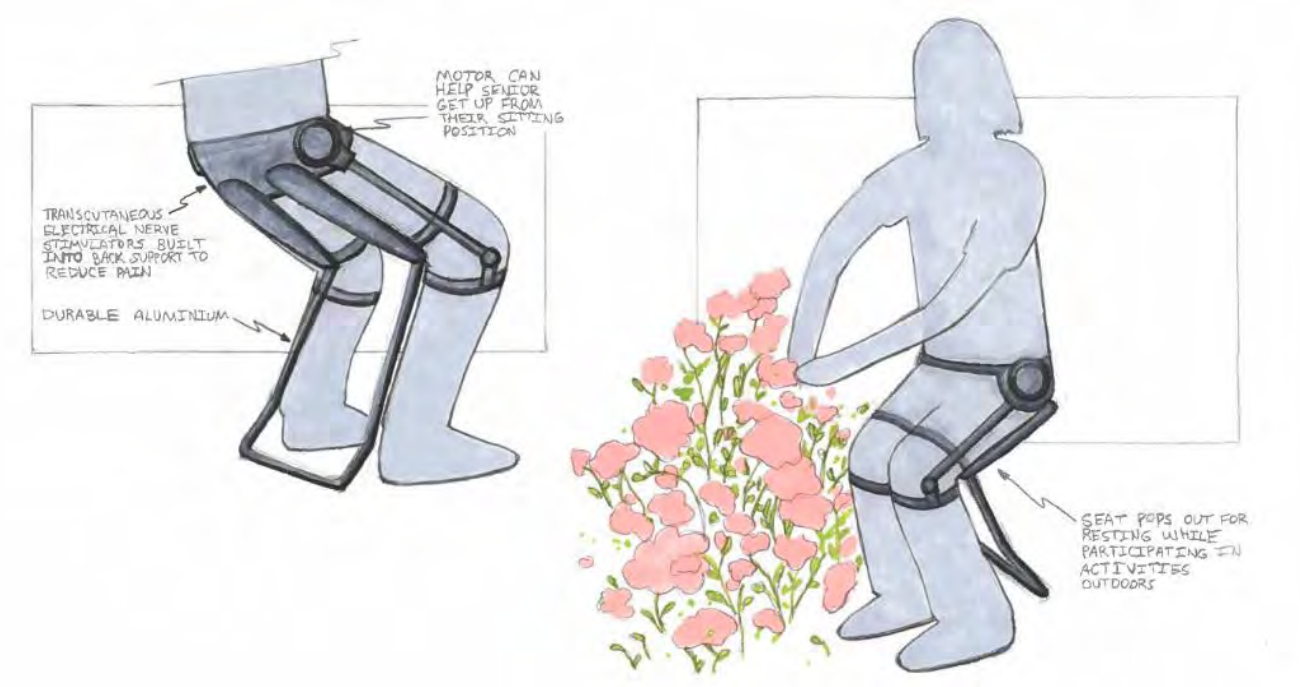


Figure 31 *Mobile Seat Page Two*

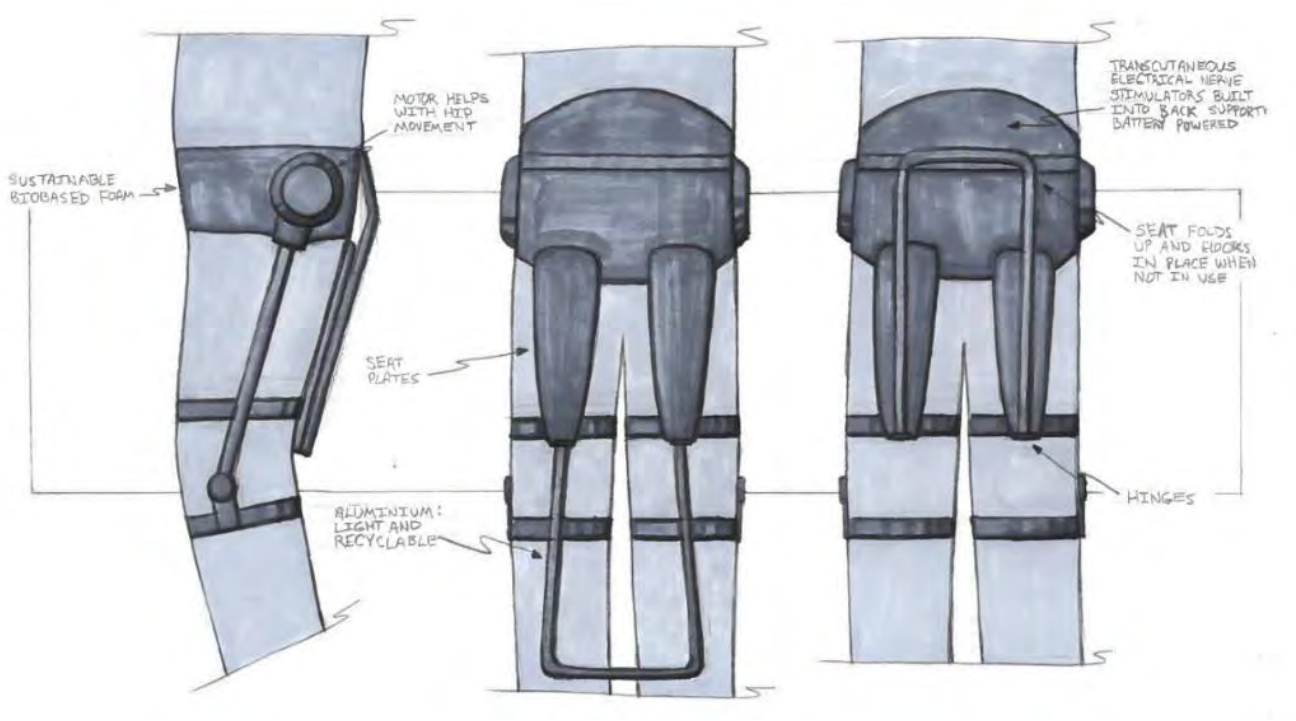


Figure 32 *Hipharbor Fabric Brace*

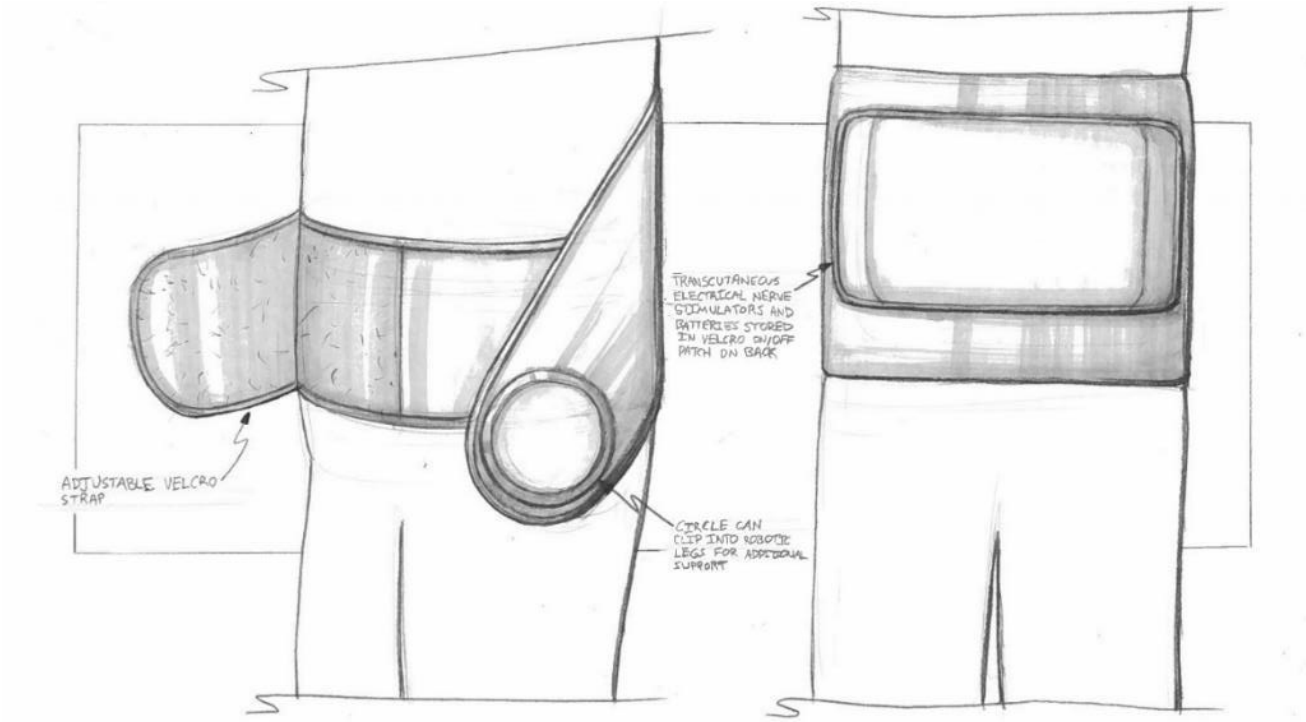


Figure 33 *Hipharbor Fabric Brace with Robotic Legs Page One*

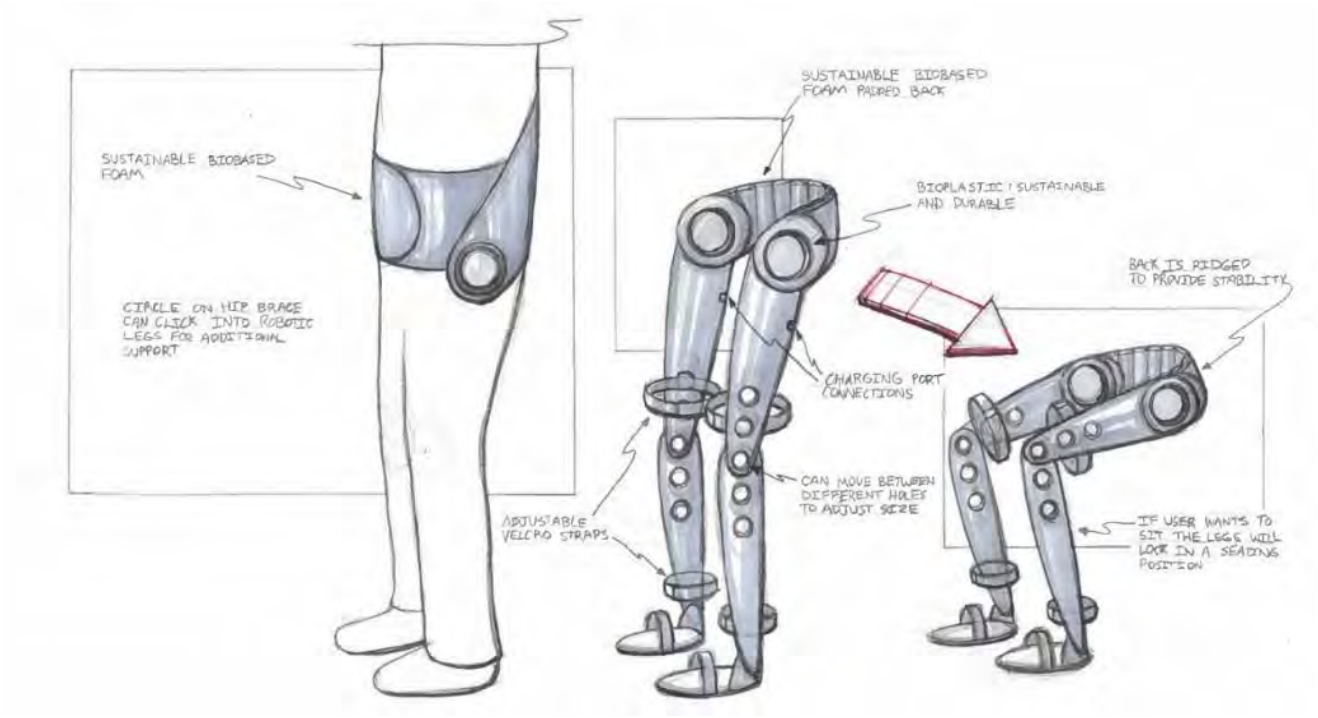


Figure 34 *Hipharbor Fabric Brace with Robotic Legs Page Two*

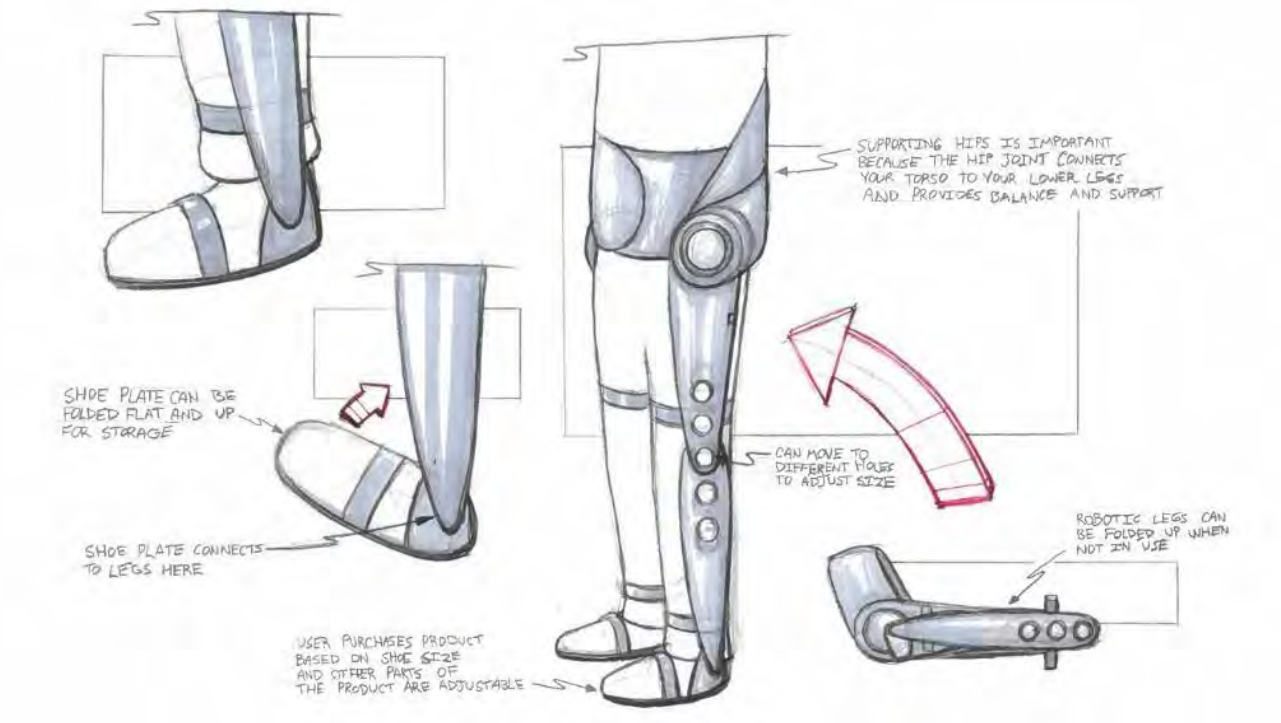


Figure 35 *Hipharbor Configuration Diagram – 99% Elderly Man*

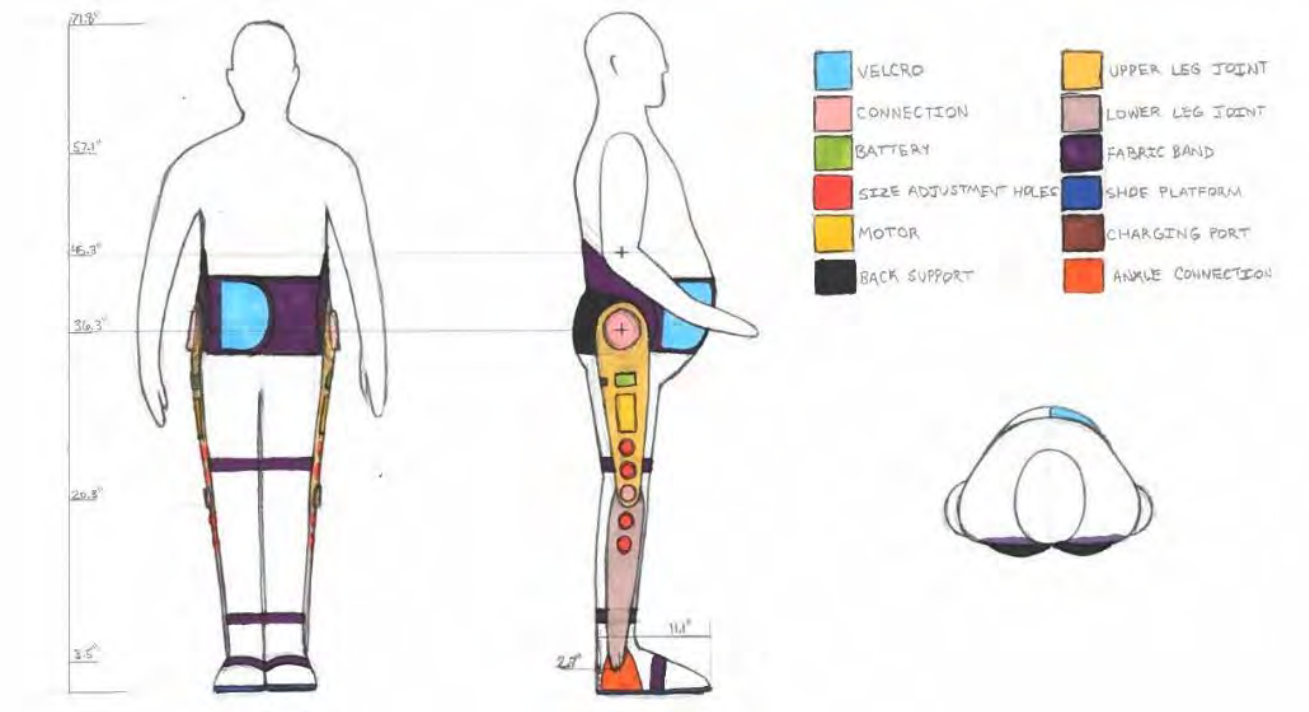
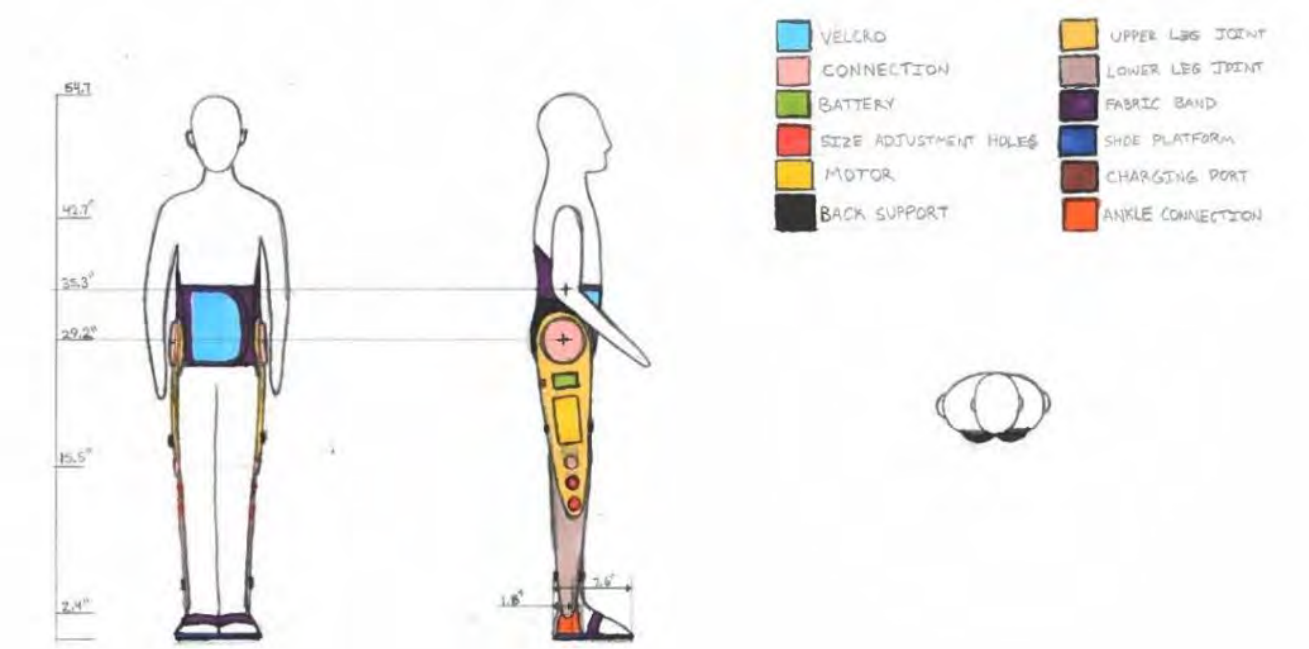


Figure 36 *Hipharbor Configuration Diagram - 1% Elderly Women*



4.3.2 Concept Direction & Product Schematic Two

Figure 37 *V-Fold Walker*

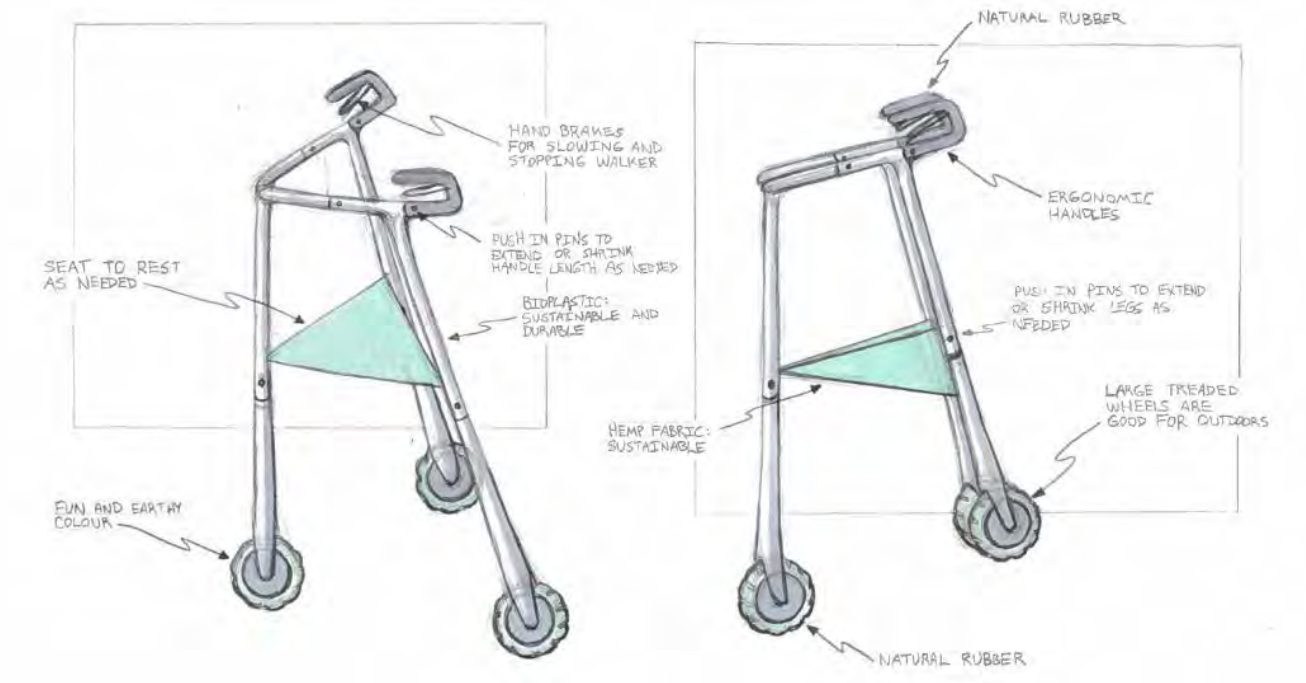


Figure 38 *V-Fold Walker Configuration Diagram - 99% Elderly Man*

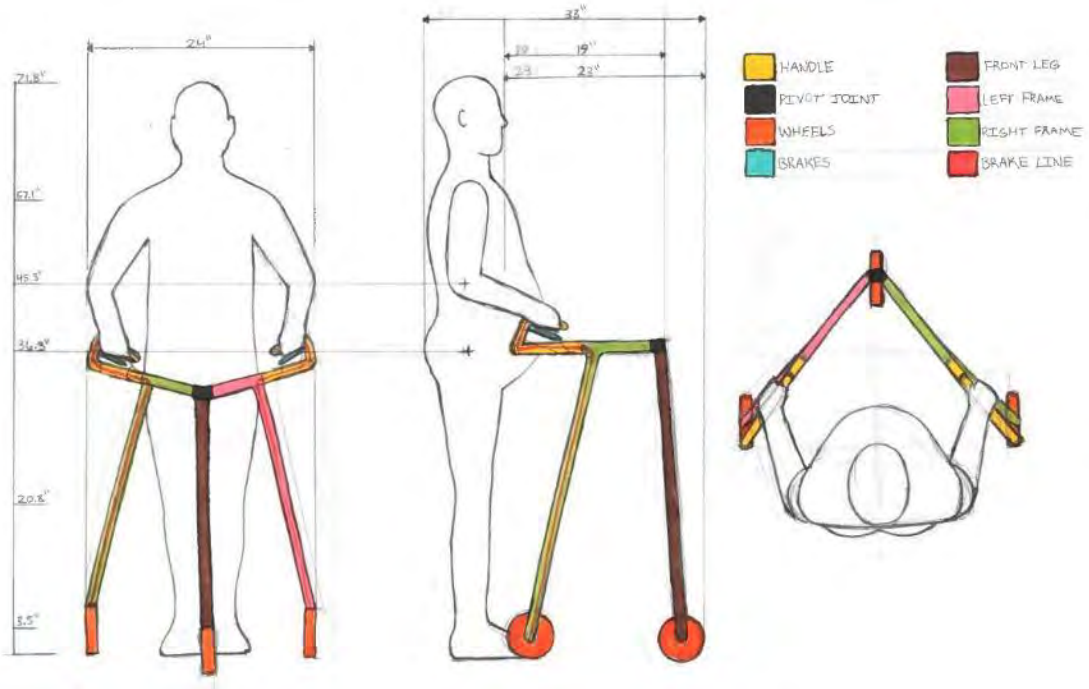
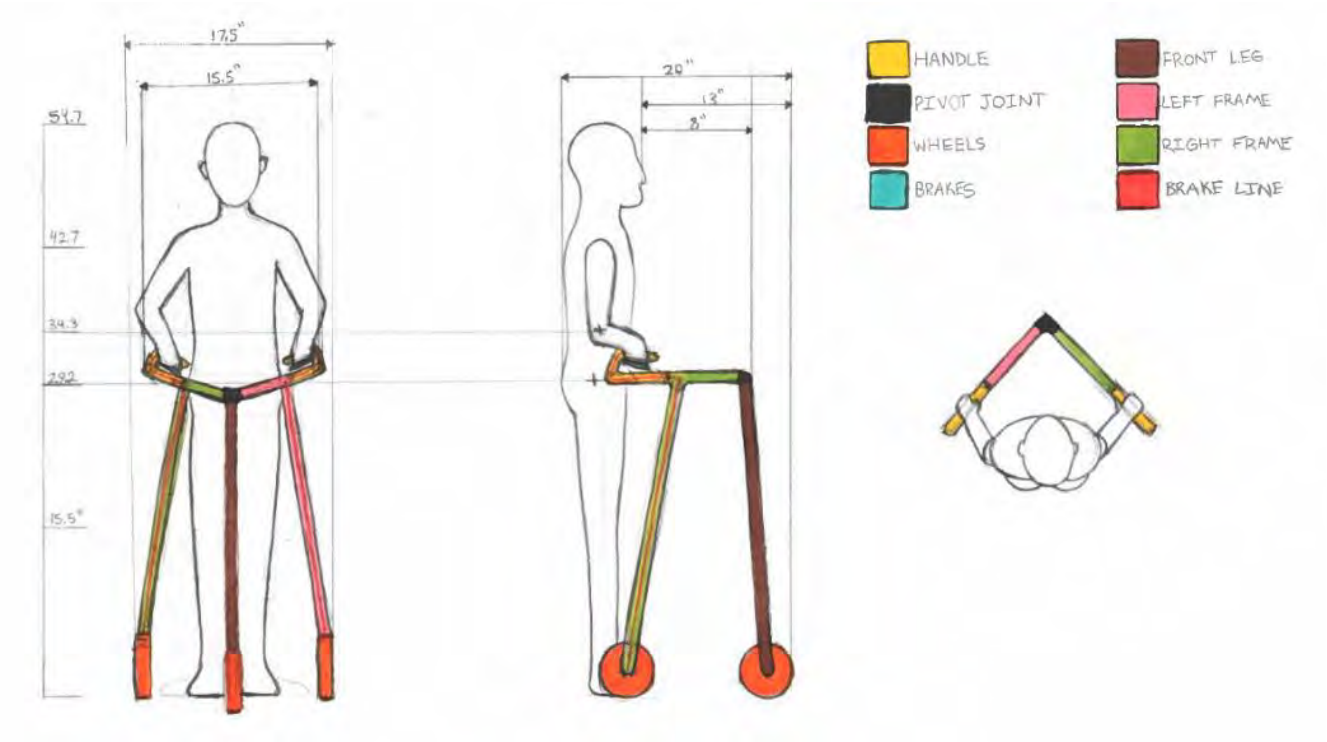


Figure 39 *V-Fold Walker Configuration Diagram - 1% Elderly Women*



4.4 Concept Refinement & Validation

In the concept refinement and validation phase, the consideration of what electronics to include in the brace, and how electronics would be removed and recharged began. The refined concept developed in this phase featured a top garment and a bottom garment that each featured different electronics to reduce pain and increase strength.

Figure 40 *Posture Correction Indicator*

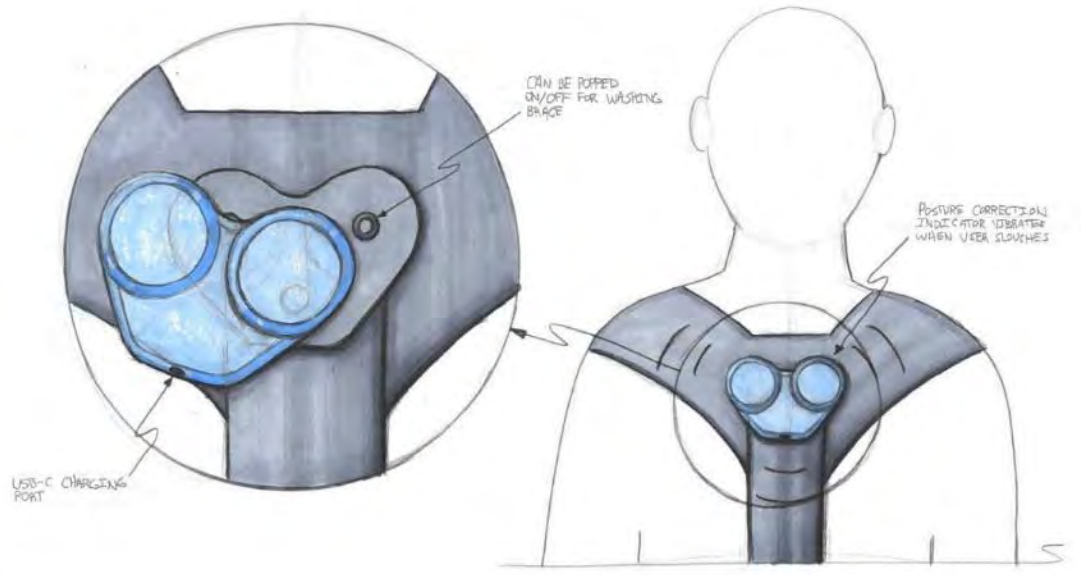


Figure 41 *Removing the Motor to Wash the Brace*

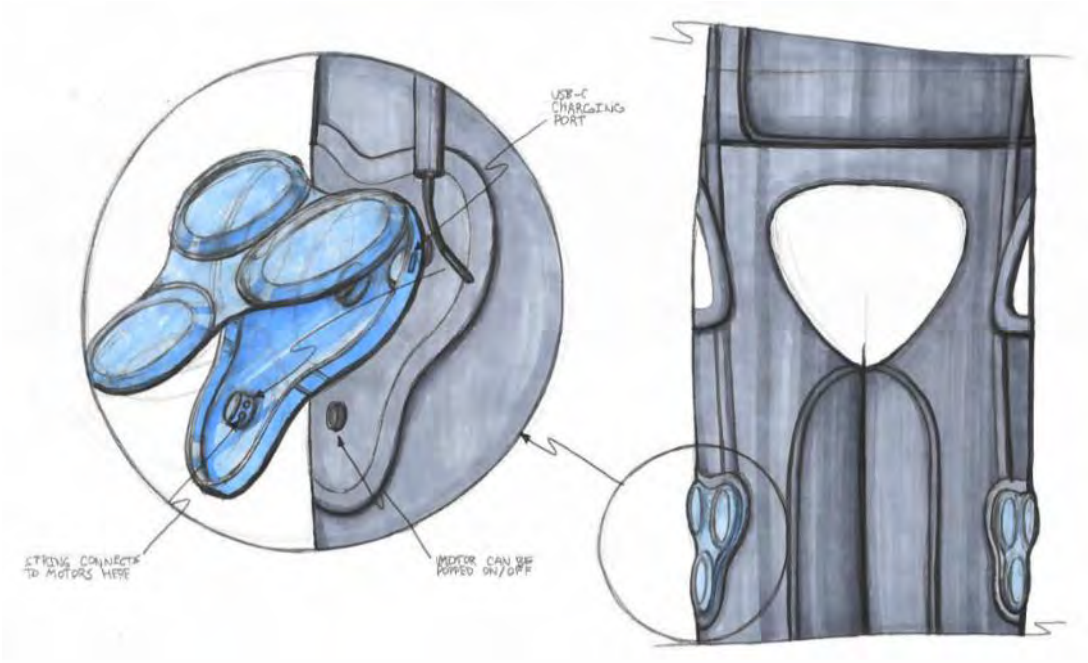
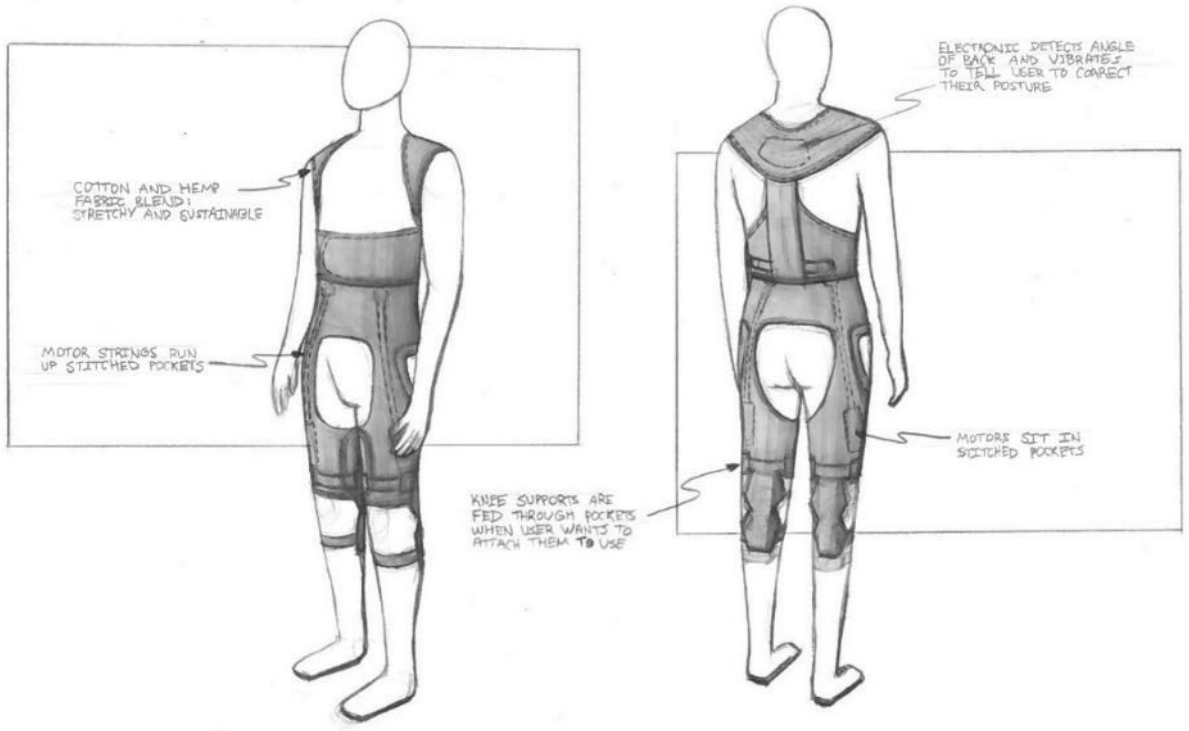


Figure 42 *AlwaysAble Body Brace for Seniors*



4.4.1 Design Refinement

Afterwards, the aesthetic design of the brace was refined to make it more attractive. A wrap-around design that followed the artificial tendon lines in the brace was developed. This made it easy to hide the tendon lines and motor and battery housings. The refined design can be seen on the pages following.

Figure 43 *AlwaysAble Body Brace for Seniors – First Revision*

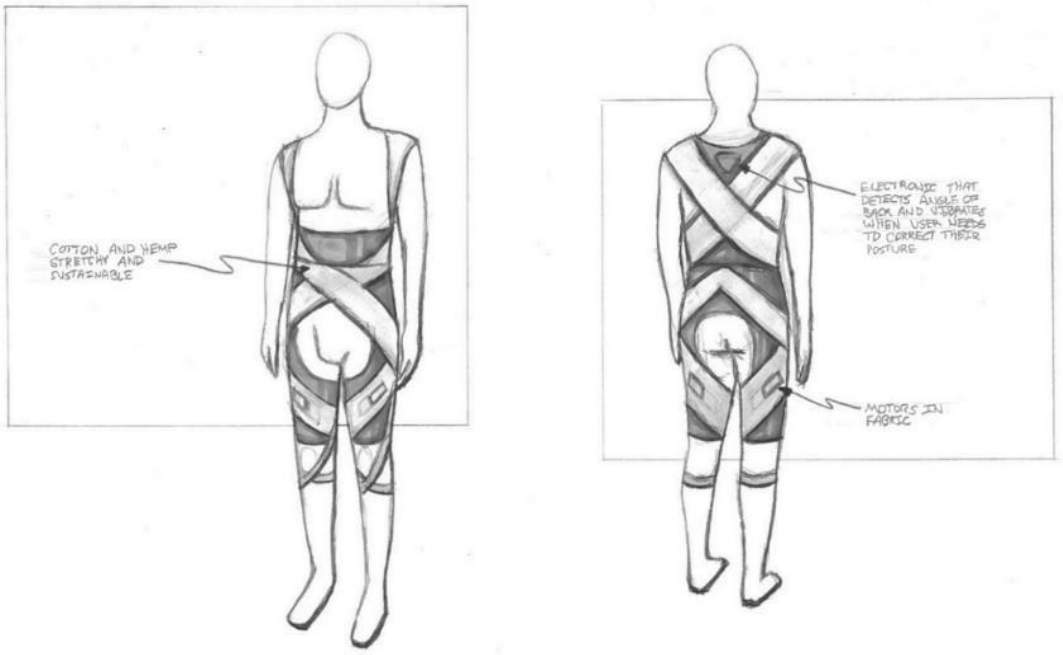


Figure 44 *AlwaysAble Body Brace for Seniors – Second Revision*

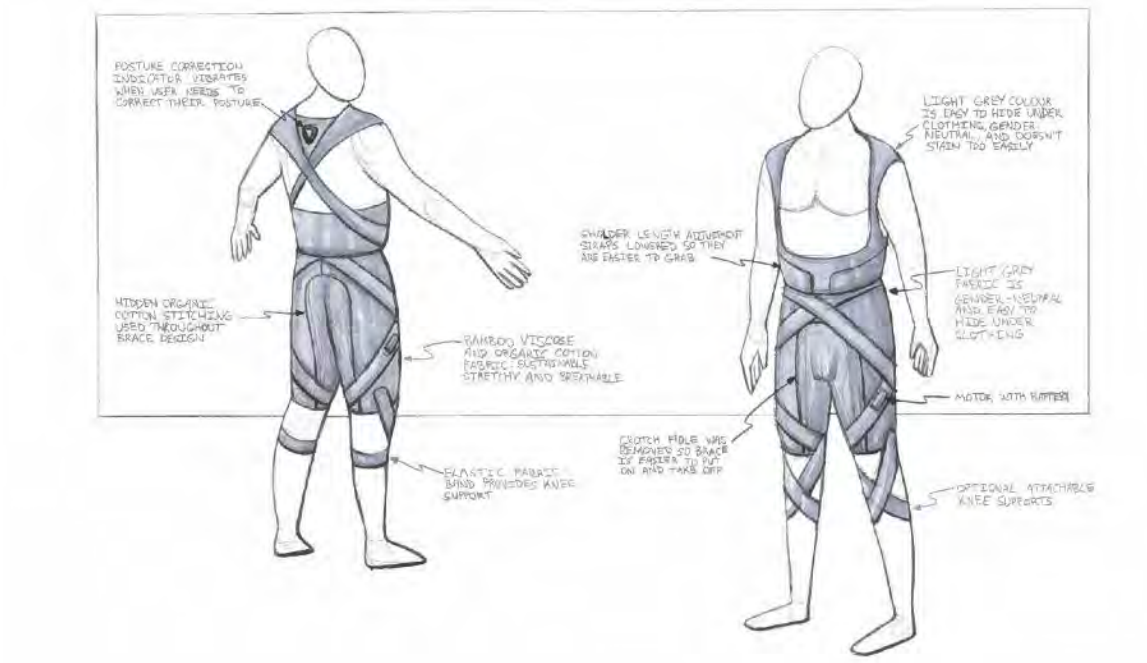


Figure 45 *Brace Top for Posture Correction and Pain Relief*

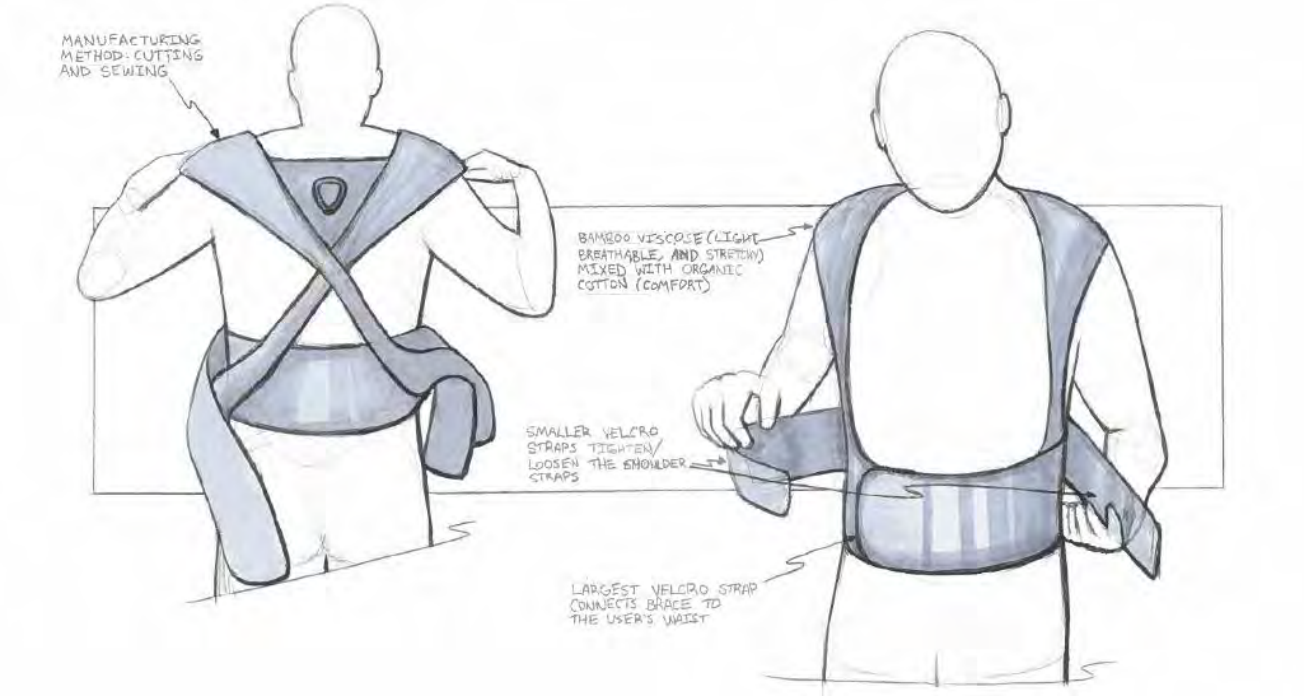


Figure 46 *Brace Bottom for Leg Support*

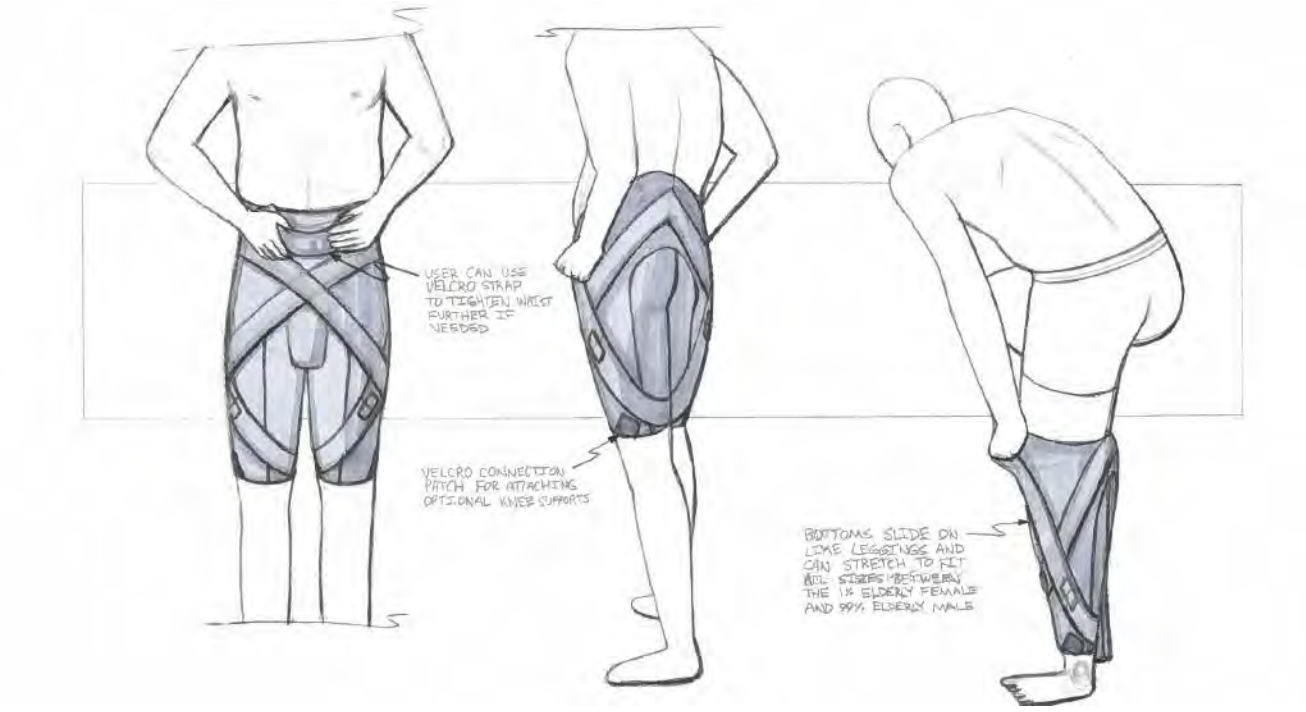


Figure 47 *Vibrating Posture Corrector*

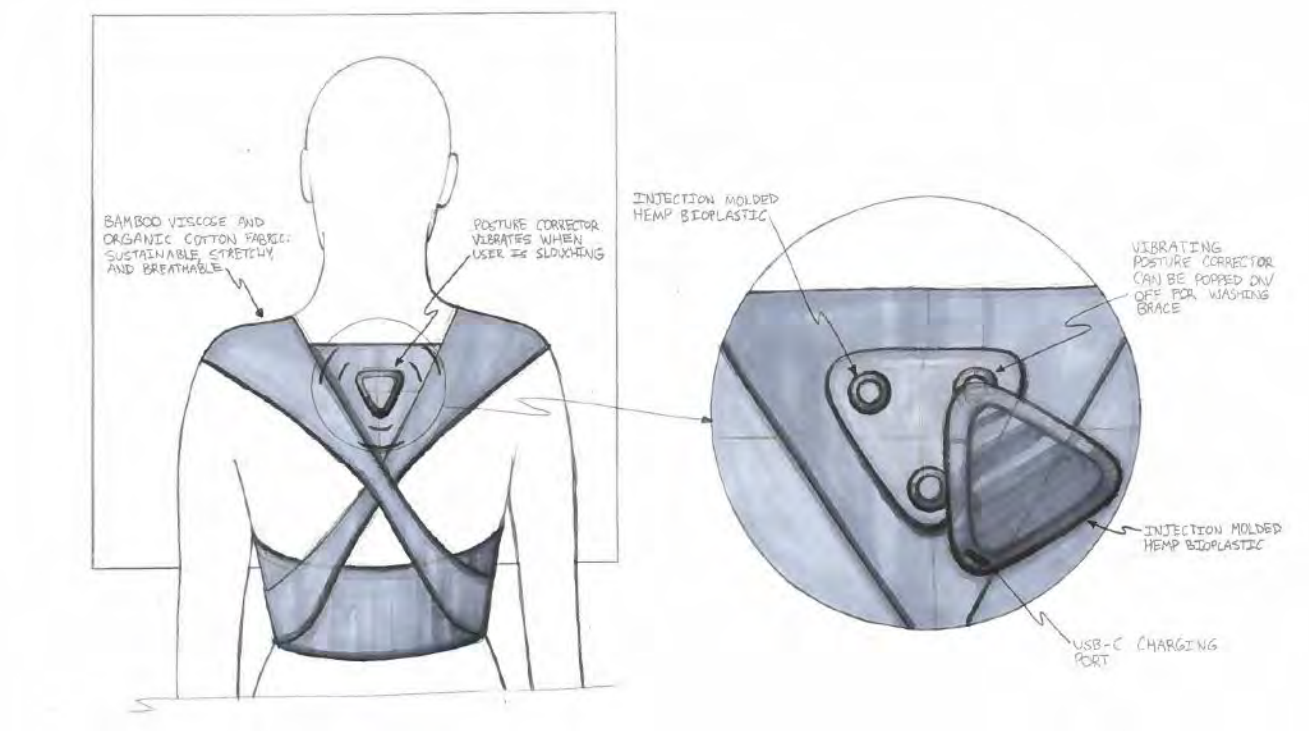
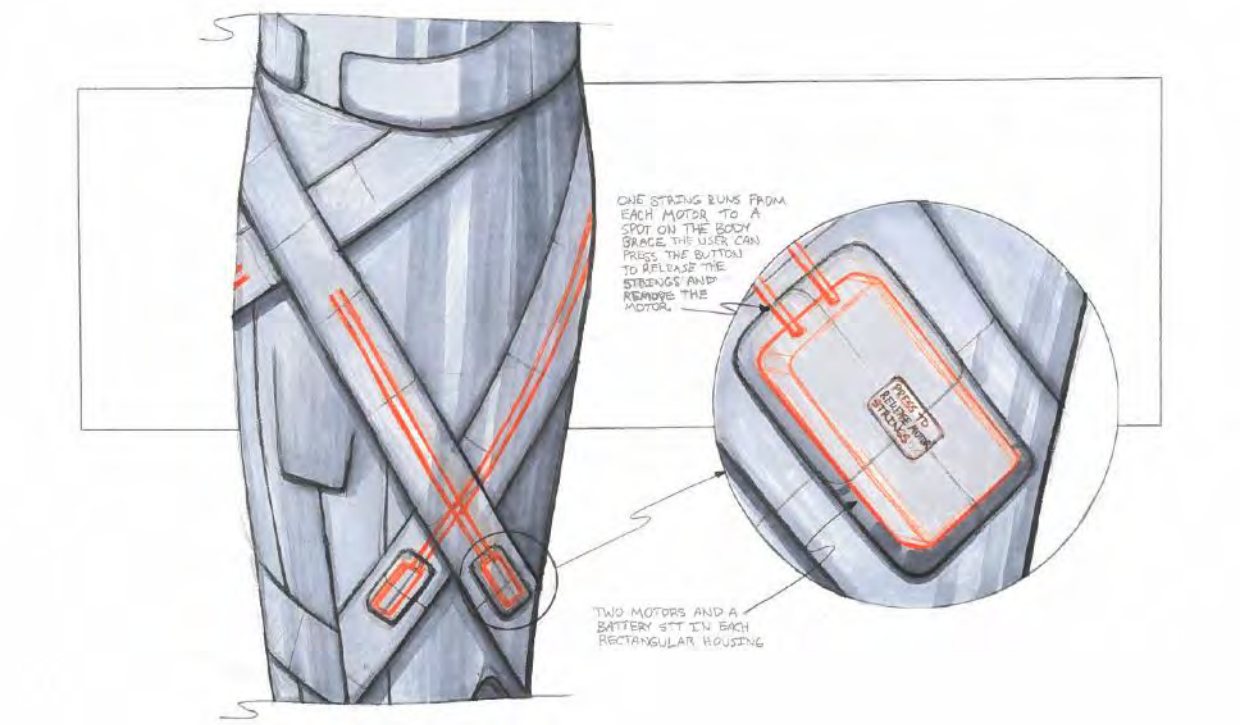


Figure 48 Motors with Strings



4.4.2 Detail Development

The detail development phase consisted of designing a housing for the motor and batteries, a pocket to hold the motor and batteries, and a hook and loop (Velcro) attachment system for the transcutaneous electrical nerve stimulator.

Figure 49 *Motor Components and Charging the Motors*

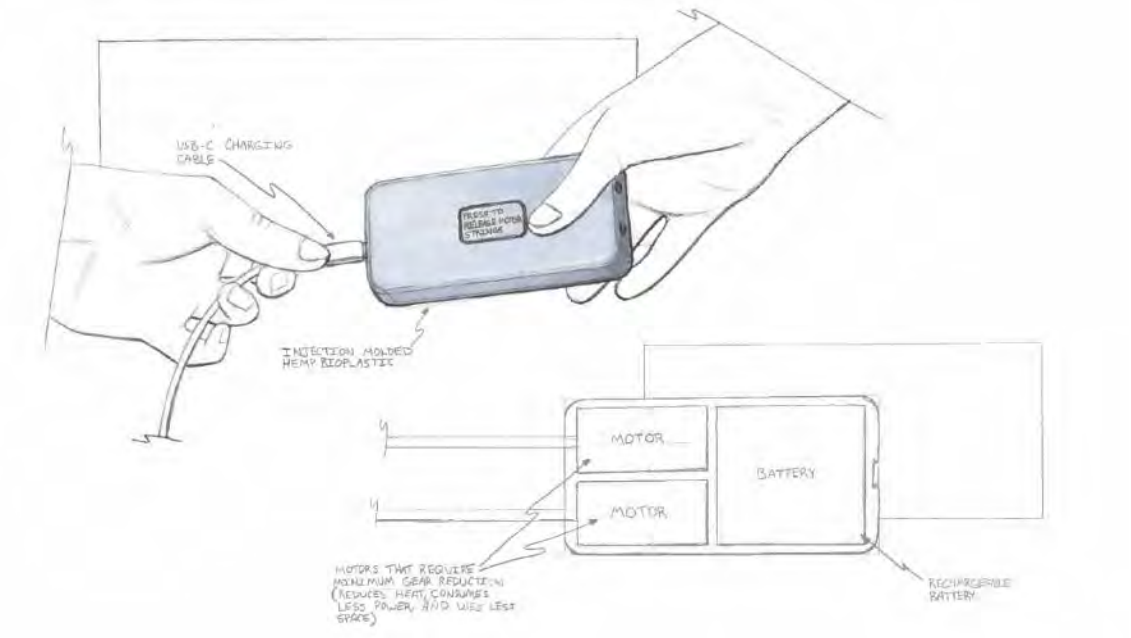


Figure 50 *Removing the Motors*

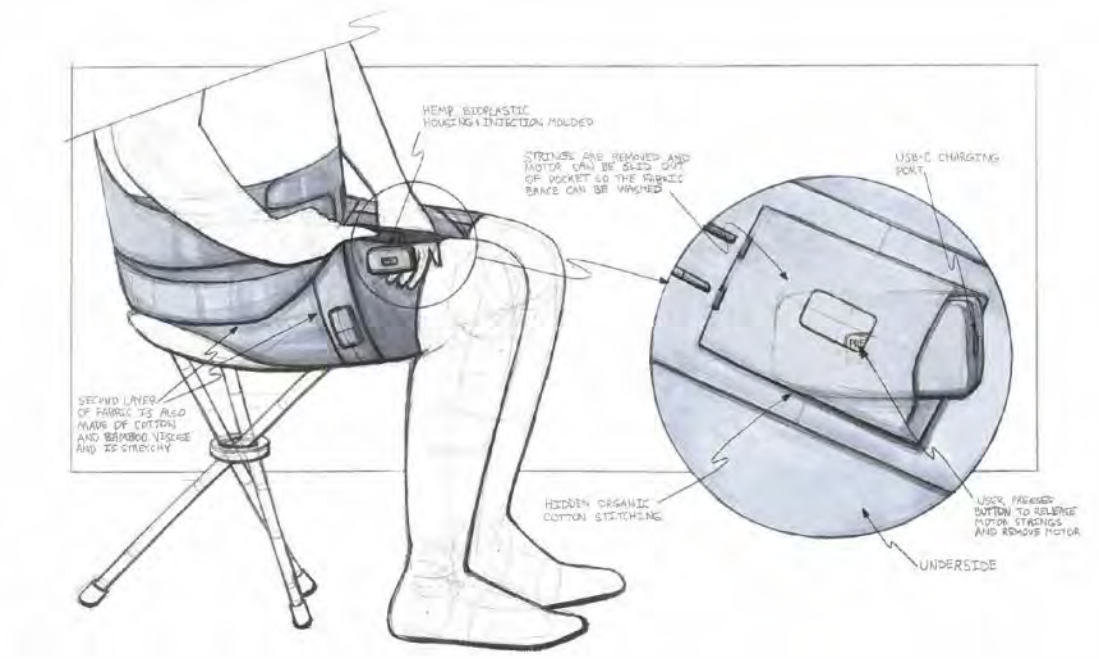
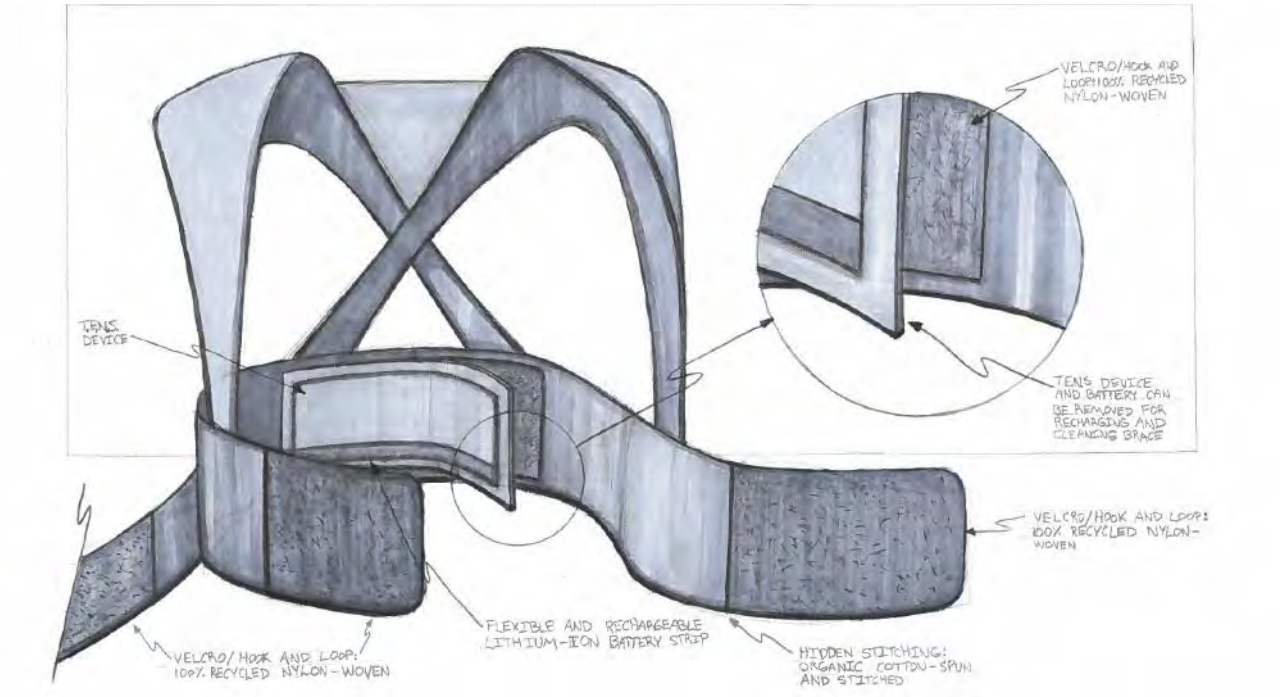


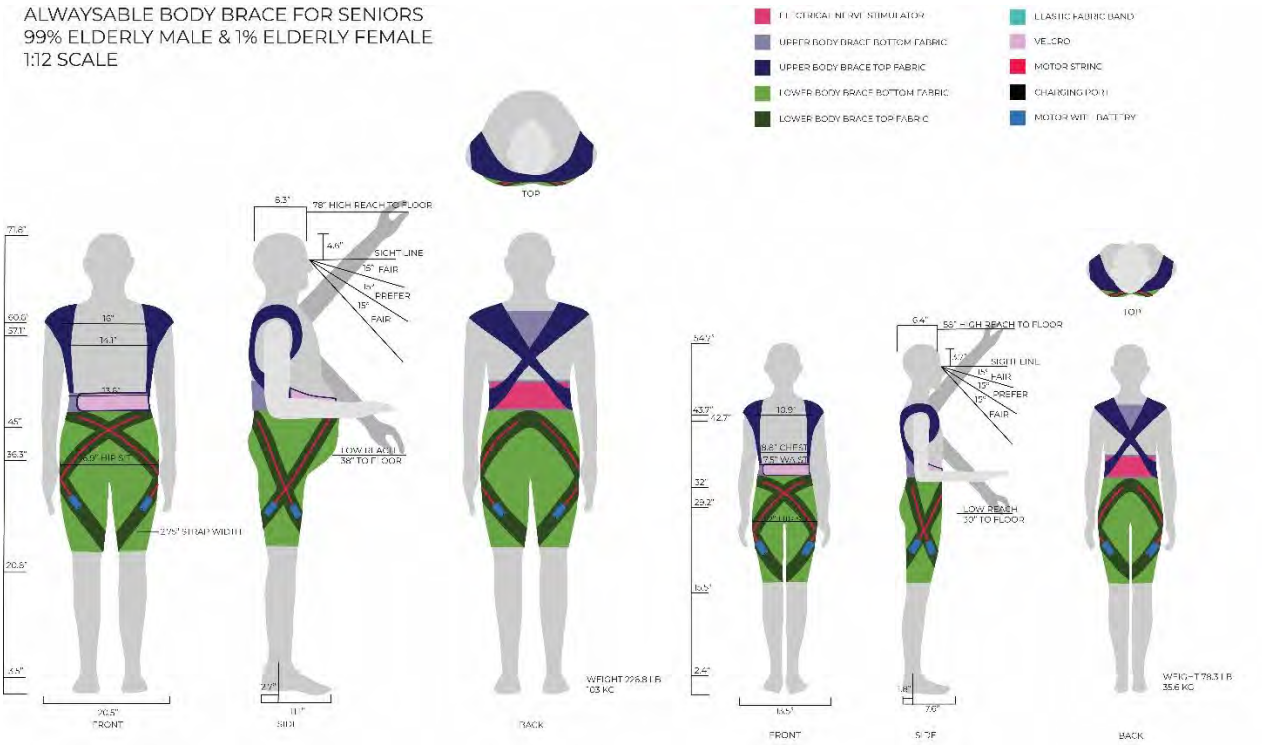
Figure 51 *Transcutaneous Electrical Nerve Stimulator, It's Components, and Removing It*



4.4.3 Refined Product Schematic & Key Ergonomic

Shortly after this phase, the product schematic configuration diagram was also updated to reflect the changes made up to this point.

Figure 52 *Refined Product Schematic Configuration Diagram*



4.5 Concept Realization

The concept realization stage was completed using multiple physical study models rather than sketches. More details on how the design was realized throughout building the physical study models can be found in section 4.5.2.

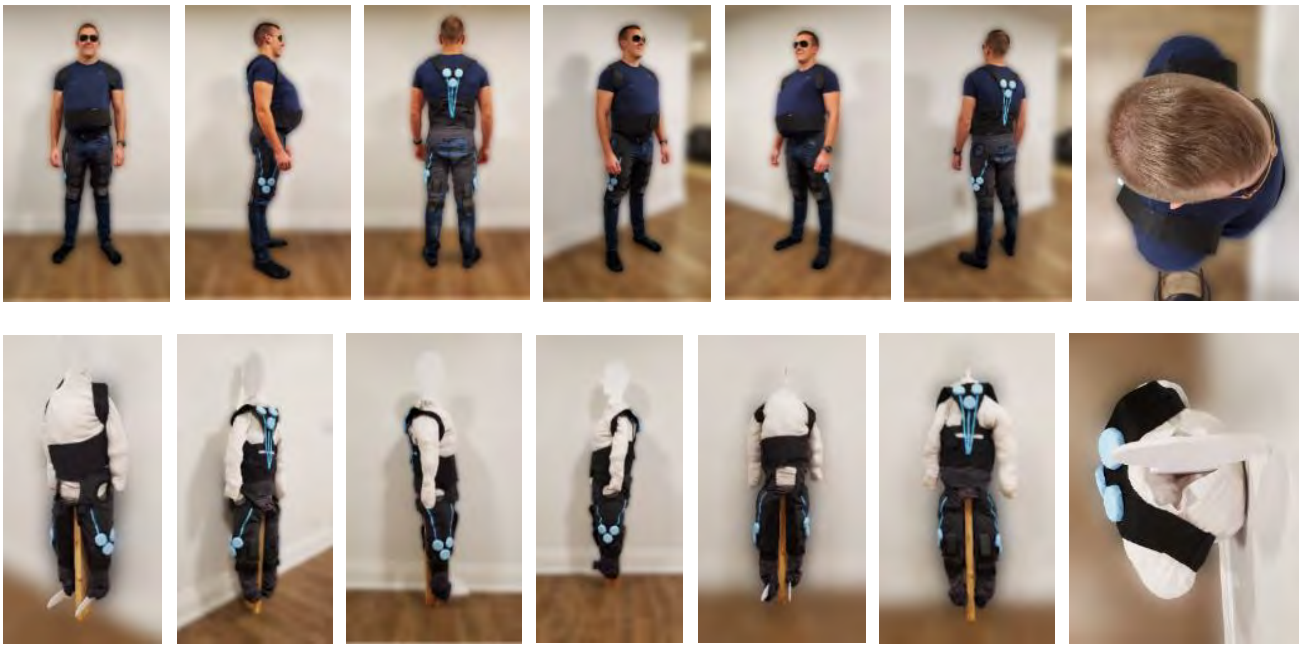
4.5.1 Design Finalization

The design was finalized through building its final prototype. The only difference between the final design and the one made in the concept realization stage was that the transcutaneous electrical nerve stimulator on the top piece of the brace was removed to simplify the design.

4.5.2 Physical Study Models

The first one-to-one scale physical study model can be seen in Figure 53. This model made evident that every part of the body brace needed to be adjustable to fit both the 99% elderly male user and the 1% elderly female user. Extendable straps were added to the model in this stage, and some of the strap lengths and attachment points were extended to fit both users. It also became evident that the arm straps needed to be positioned at a particular angle, so the arm straps were readjusted and remade repeatedly until they were positioned comfortably. It was realized that the positioning of the motor strings would need to move to have them properly aid with hip movements, and that the shoulder straps could be wider at the top and narrower at the base to make them more comfortable. Moreover, it was decided that the multiple fastening straps at the front of the brace be combined to make the brace easier to fasten and undo.

Figure 53 *First One-to-One Scale Physical Study Model of Body Brace*



The second one-to-one scale physical study model can be seen in Figure 54. In this model, the shoulder straps were wider at the top and narrower at the bottom for comfort. The motor strings were also repositioned upwards to a place above the hip to properly facilitate movement. Since the string was moved up, the hip line on the lower piece of the body brace was also raised. This one-to-one scale study model also involved a redesign of the motor housings to make them less like Yves Béhar's design. After this one-to-one scale study model was finished, the technical details of how the brace would function were fully realized, but there were still some aesthetic refinements needed to ensure that all the parts flowed cohesively together, that the product looked comfortable and stylish, and that the motors were not too protruded that they would be seen under clothing.

Figure 54 *Second One-to-One Scale Physical Study Model of Body Brace*

Figure 55 shows the third one-to-one scale physical study model. This physical study model involved removing the chunky motor housings from the exterior of the brace and finding ways to make them smaller and hide them in the fabric housing instead. It also involved removing the posture corrector, which unnecessarily complicated the design and would likely be seen as an annoying feature to seniors. In this model, the goal was to make the form of the brace look slim, organic, and cohesive. The connection strap around the waist was slimmed and moved down so that it could still accommodate the raised motor string connection points but was not so large. The hip cutouts were removed because they took away from the design and made the brace confusing to put on. Masking tape was placed over the model to show where a second layer of fabric would run over the brace. This two-layered fabric design was sleeker and more stylish than the previous designs. After making this model, it was determined that some additional small adjustments to the proportions of the straps were still required. Additionally, there was still a need to consider the different materials and stitching patterns that could be used in the design.

Figure 55 *Third One-to-One Scale Physical Study Model of Body Brace*

4.6 Design Resolution

To fully resolve the design, the changes mentioned above were made, and the knee support pieces were removed. The knee supports were removed because they did not add much support and were difficult to put on.

4.7 CAD Development

CAD development began shortly after the third one-to-one scale physical study model was completed. The CAD model was made using Fusion 360, since it was possible to easily create an organic form in Fusion that could be imported into SolidWorks to produce technical drawings (which was a project requirement). The first draft of the CAD model can be seen below. It was made primarily using the organic form tool and began by mapping out the general shape of the body brace. Additional CAD development images can be seen in Appendix E.

Figure 56 *CAD Model First Draft*

4.8 Physical Model Fabrication

The final physical model of the AlwaysAble Body Brace was made using a combination of traditional sewing techniques and 3D printing. Before it was sewn from fabric, it was made from paper to build a cut pattern for the fabric pieces. The build process of the final model is depicted below.

Figure 57 *The Paper Model Used to Create a Fabric Cut Pattern*

Figure 58 *Cutting the Fabric*

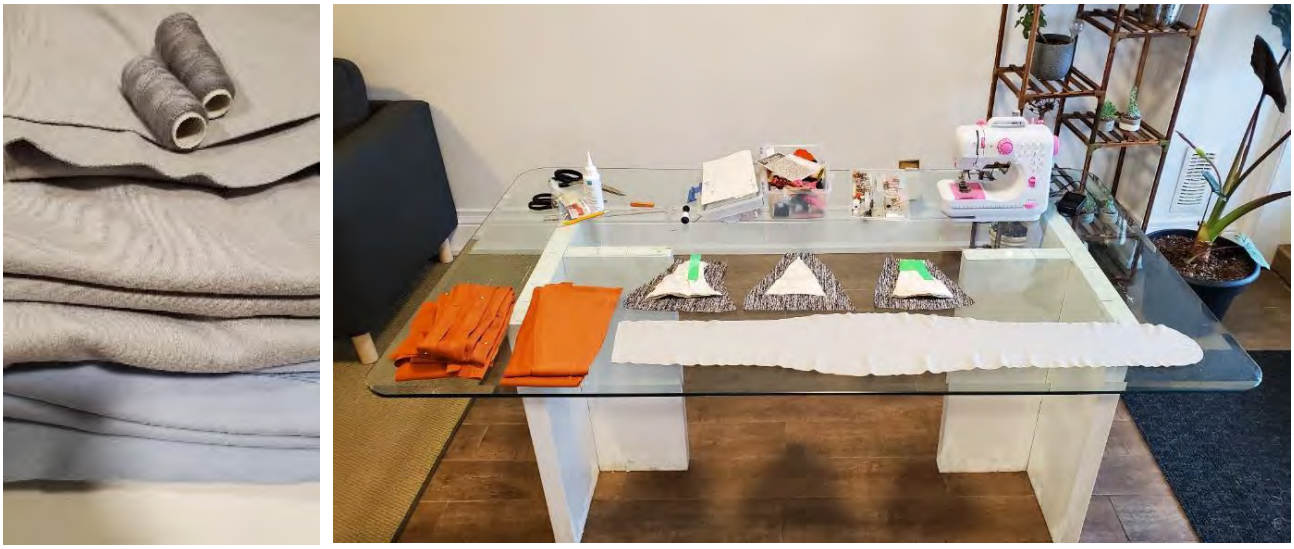


Figure 59 *Putting the Model Together*

Figure 60 *3D Printing the Motor and Battery Housings*

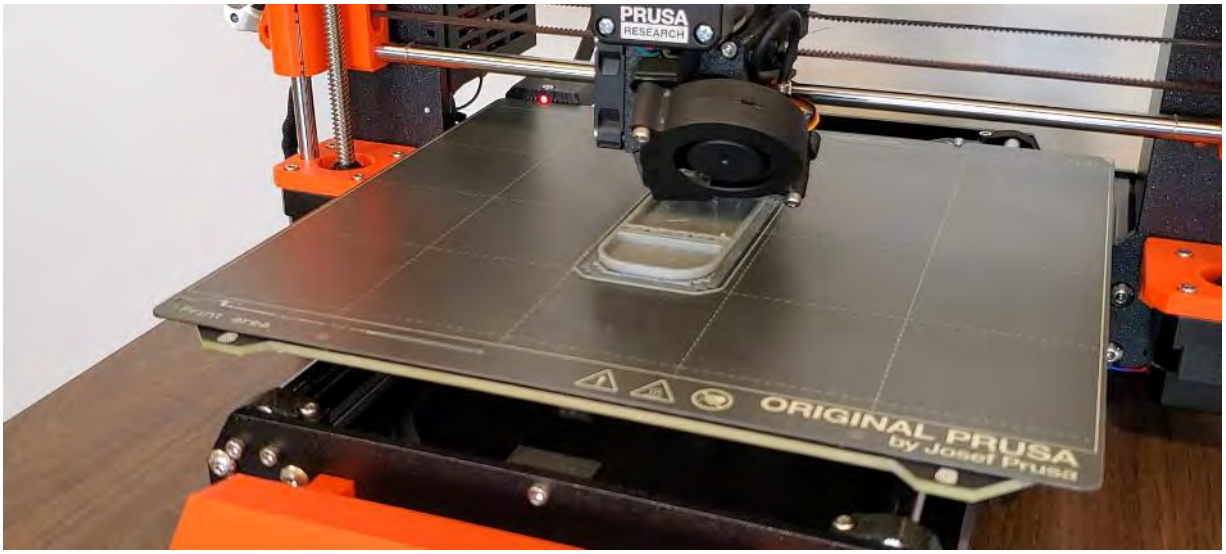


Figure 61 *Connecting the Motor and Battery Housings*

CHAPTER #5:
FINAL DESIGN

5.1 Design Summary

AlwaysAble is a wearable for seniors that can enhance their mobility, reduce pain, and prevent overstrain. Secondary and primary research both indicated that when it comes to physical activities, seniors experience concerns such as a fear of injury, lack of energy, and the need for frequent breaks to prevent overstrain. This body brace design addresses these concerns in a discreet manner by allowing seniors to wear the brace under clothing. The intention of the design is for it to be sold in three size options, small, medium, and large, so that it can fit a range of users. By enhancing senior mobility, seniors can participate in active activities which provide them with enriching experiences and improve their physical and mental health. Moreover, by enhancing seniors' mobility and improving their health, the medical system will experience less strain from the large senior population.

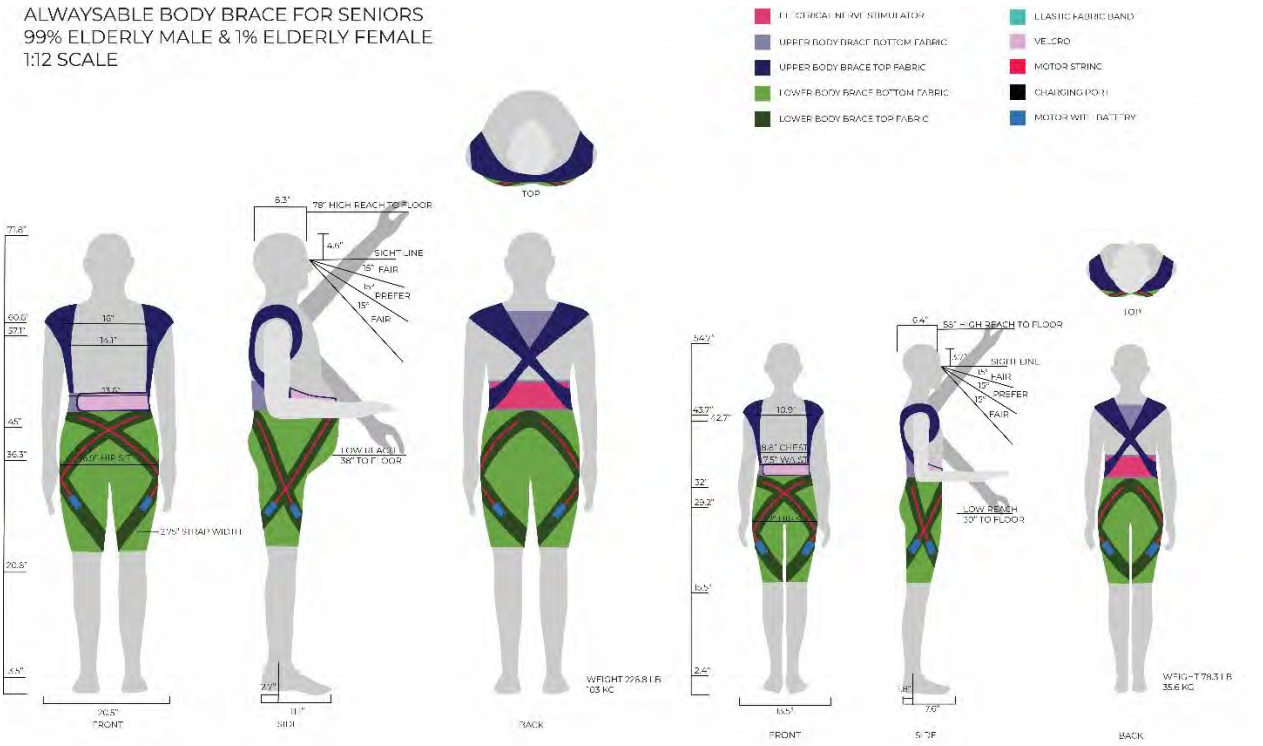
5.2 Design Criteria Met

The final design needed to meet certain criteria to be a successful thesis project. How the design meets the set criteria is detailed below.

5.2.1 Full Bodied Interaction Design

The AlwaysAble Body Brace includes many touchpoints. The first touchpoint is the hook and loop (Velcro) size adjustment strap on the user's waist. The waist strap on the pants is the second touch point. The pants include a tendon system. This tendon system runs over the user's thighs and hips to provide support. This is a touch point. The upper body brace pulls the user's shoulders back and presses on their lower back to correct the user's posture and reduce pain. The shoulder and lower back areas on the upper body brace are touch points. Additionally, the brace's batteries can be recharged while the brace is washed, so that the user does not need to purchase new batteries regularly. The battery pockets and batteries are touch points. The waterproof motors further simplify maintenance, allowing for washing while attached to the brace. Moreover, the motors are another touchpoint since the user must hold onto the motors to remove the batteries from them. The product schematic configuration diagram of the brace is shown on the following page for reference.

Figure 62 *Product Schematic Configuration Diagram*



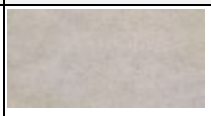
5.2.2 Materials, Processes and Technology

The final design would be manufactured using the materials and manufacturing methods detailed in the bill of materials on the next page. These materials and manufacturing methods were chosen for comfort, sustainability, convenience, and cost-effectiveness.

5.2.3 Design Implementation

The bill of materials breaks the fabric pieces up based on their colour. However, there are multiple fabric pieces of each colour that would be stitched together. An exploded view of all the fabric pieces that are to be cut and stitched together can be found in Appendix G.

Table 25 *AlwaysAble Bill of Materials*

Part Description	Image Reference	Material Description	Colour	Supplier	Manufacturing Method	Quantity
Fabric		Organic cotton and organic bamboo fibre fabric, two-way stretch, lightweight	Light grey	Fabricland	Cut	4m
		Organic cotton and organic bamboo fibre fabric, two-way stretch, lightweight	Burnt orange	Fabricland	Cut	3m
		Organic cotton and organic bamboo fibre fabric, two-way stretch, lightweight	White and black pattern	Fabricland	Cut	1m
Thread		Organic cotton	Light grey	Fabricland	Spun, and stitched into fabric	500m
Hook and Loop (Velcro) 3” wide		100% recycled nylon	Black	Velcro	Woven	8in
Maxon DCX Brushed Motors with GPX gearheads and chains	 (Maxon, n.d.)	Mix	Silver	Maxon	Purchased from Maxon	8
Rechargeable batteries	N/A	Mix	Silver	Maxon	Purchased from Maxon	4
Battery housing		Hemp bioplastic & natural rubber	Medium grey	Manufactured in-house	Injection molded using hemp bioplastic, and dipped in natural rubber coating	4
Motor housing		Help bioplastic & natural rubber	Medium grey	Manufactured in-house	Injection molded using hemp bioplastic, and dipped in natural rubber coating	4
Motor chain housing, 4mm inner diameter, 6mm outer diameter		Natural rubber	Medium grey	Fisher Scientific	External supplier	10m

5.3 Final CAD Rendering

After the CAD model was complete, it was rendered in PhotoView 360. These renderings were further edited in Photoshop to create in-situ renders or add stitching to areas that were missing stitches in the CAD model. Two of the final renderings can be seen below. Additional renderings can be found in Appendix E.

Figure 63 *Render of Male Senior Wearing Brace Under Clothing While Gardening*

Figure 64 *Render of Female Senior Wearing Brace While Doing Yoga*

5.4 Physical Model

A one-to-one scale physical model of the body brace was built using a combination of 3D printing and traditional sewing methods. It is depicted below.

Table 26 AlwaysAble Physical Model

5.5 Technical Drawings

Dimensioned technical drawings of the final design were generated in SolidWorks. Some of the technical drawings of the main assemblies are shown below. Additional technical drawings can be found in Appendix G.

Figure 65 *Top, Bottom, Front, Back, Rear and Sides*

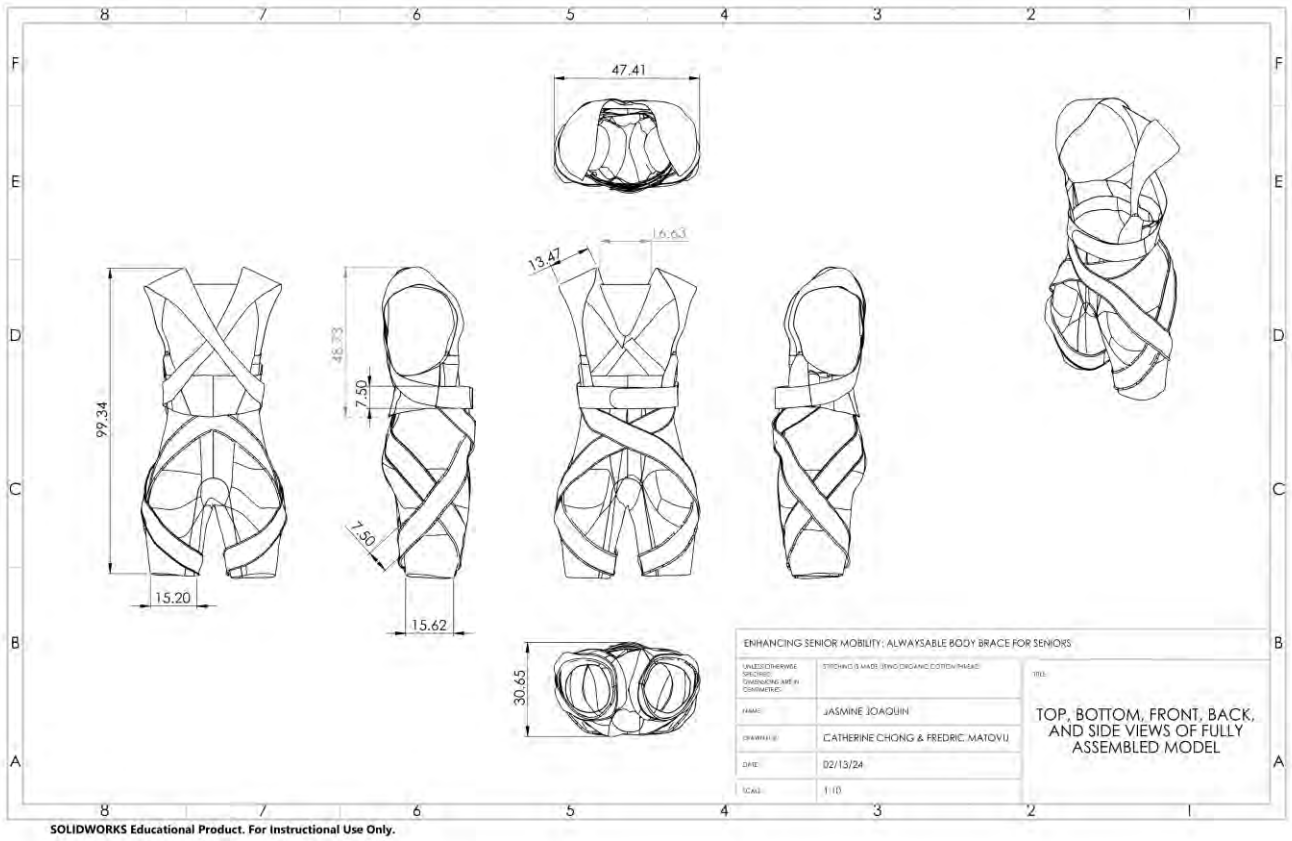


Figure 66 *Top of Brace*

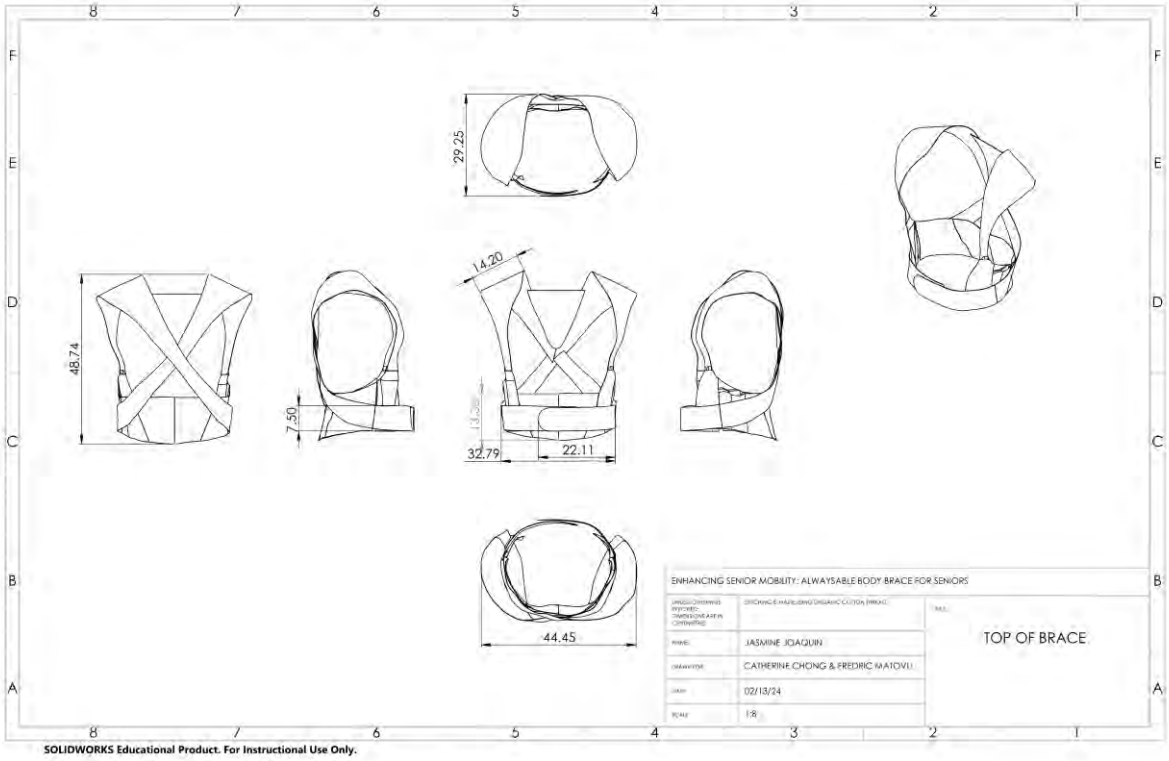
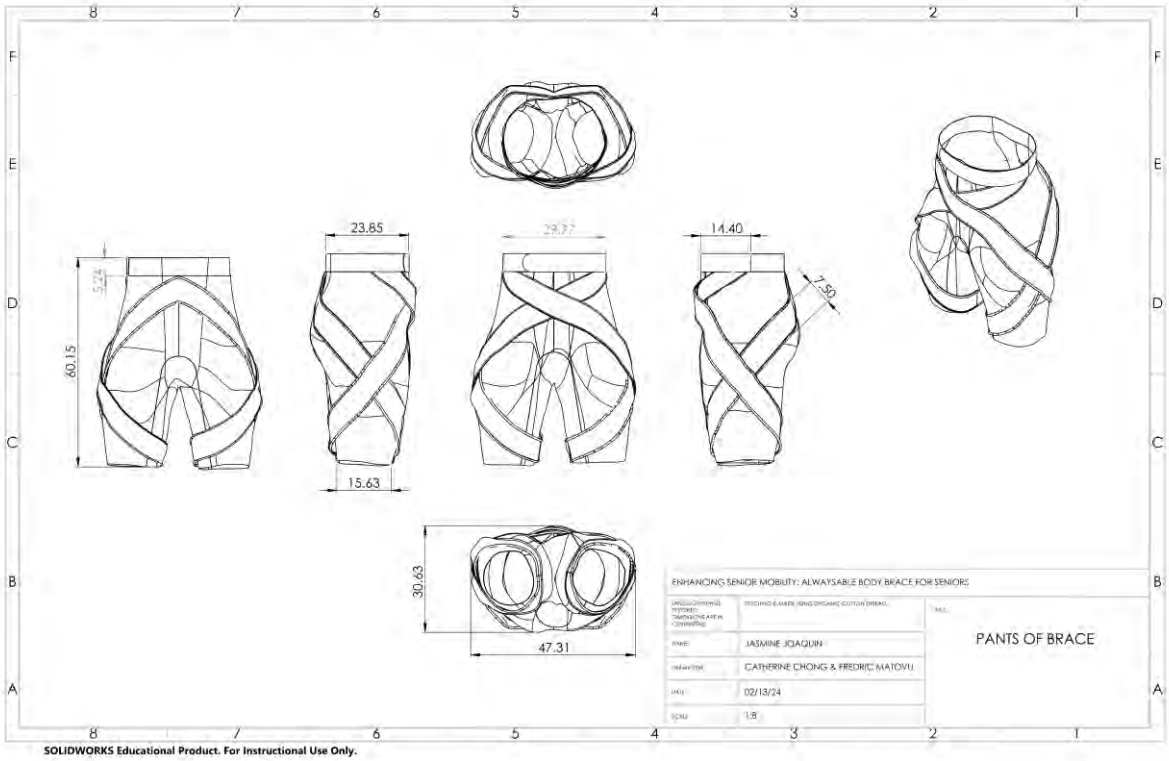


Figure 67 *Pants of Brace*



5.6 Sustainability

Materials and manufacturing methods that appeared to provide the most benefits from a sustainability, health, and safety standpoint were selected to make the design. These chosen materials and manufacturing methods are detailed below, along with an explanation of the benefits they provide. Note that although the ideal situation would be to have all the materials that the brace is made from be biodegradable and rapidly renewable, hook and loop (Velcro) cannot be made biodegradable, so as an alternative the hook and loop straps on the brace will be made of recycled nylon.

Table 27 *Sustainable Materials to Be Included in The Design*

Photo	 (Krohn, 2018)	 (kazuend, 2015)	 (Sosa, 2023)	 (Kasyan, 2020)	 (Yan, 2018)
Material(s)	Organic cotton	Bamboo viscose	100% recycled nylon	Hemp bioplastic	Natural rubber
Material Benefits	• Reduced chemicals • Biodiversity • Safer for farmers • Foil fertility • Reduced water usage • Non-GMO • Soft on skin • Comfortable • Widely accessible • Biodegradable	• Rapidly renewable • Lightweight • Breathability • Stretch • Naturally antibacterial • Soft • Biodegradable • Odor resistant • Slow fashion • Low carbon footprint	• Less extraction of petroleum • Saved energy • Reduced landfill waste	• Biodegradable • Rapidly renewable • Requires less pesticides and fertilizers • High tensile strength and durability • Hemp plants absorb and remove contaminants from the soil (OpenAI, 2024)	• Elasticity and flexibility • Abrasion resistance • Tear strength • Low heat buildup • Water and weather resistance • Biodegradable • Electrical insulation • Low heat generation • Renewable resource • Cost effective
Where is it used	Threading & fabric	Fabric	Straps	Electronic housings	Coating on motor/battery covers Chain covers
Manufacturing method(s)	Spun	Cut and stitched	Woven	Injection molded	Dipped (motor/battery covers) Extrusion (chain covers)
Manufacturing Method(s) benefit	Additive process	The standard process	No other option	Easy to rapidly produce Little waste	Fast Little waste

CHAPTER #6:
CONCLUSION

The design presented in the thesis project effectively addresses the challenge of enhancing senior mobility to promote physical activity. Through research involving interviews, surveys, and user observations, valuable insights were gained on senior lifestyles, physical abilities, and interests. The resulting product not only caters to the initial focus of enhancing outdoor physical activities for seniors but expands its scope to enhance senior mobility in general.

The strength of this design lies in its adaptability and inclusivity, ensuring that seniors with different physical abilities and interests can benefit from it. Seniors can wear just the top garment or just the bottom garment, and it is adjustable and sold in multiple size options. The emphasis on feasibility and ergonomics during the development phase ensured that the brace was inclusive. Moreover, making the design discreet by designing it to fit under clothing created a design that seniors would not be embarrassed to be seen wearing. Using a mobility support no longer needs to be embarrassing for seniors. Seniors can appear just as able as younger individuals without others knowing that they are using the mobility-enhancing body brace.

The design not only tackles the immediate issue of seniors struggling to be physically active, but also addresses the broader goal of preventative healthcare for the aging population. By making exercise more appealing and accessible, the product contributes to the overall well-being of seniors, promoting physical fitness, mental health, and social engagement. This multilevel approach aligns with the current push for preventative healthcare measures to alleviate the strain on the medical system caused by the aging population.

In summary, the design's benefits are extensive. It can revolutionize senior exercise, enhance their quality of life, and greatly alleviate the burden on the healthcare industry by promoting preventative healthcare. The comprehensive research, design exploration, and design refinement that went into this project makes it a promising solution for enhancing senior mobility.

References

ACRE. (2022). *Our Favourite 8 Design Objects Changing Seniors' Lives.* https://www.byacre.com/top-8-design-objects/

Amazon.ca. (n.d.-a). *Rocking Multifunctional Chair for Seniors with Massage and Foldable Design*. Retrieved from https://www.amazon.ca/Rocking-Multifunctional-Seniors-Massage-Foldable/dp/B07VJ7WF1L

Amazon.ca. (n.d.-b). *TheXceptional Wheelie Gardening Work Seat (Model EX530). Retrieved from* https://www.amazon.ca/TheXceptional-Wheelie-Gardening-Work-Seat-EX530/dp/B0BN2MS9PS

Ambrens, M., Razee, H., Stanners, M., & Valenzuela, T. (2021). Exploring Older Adults' Experiences of a Home-Based, Technology-Driven Balance Training Exercise Program Designed to Reduce Fall Risk: A Qualitative Research Study Within a Randomized Controlled Trial. *Journal of Geriatric Physical Therapy*, *1*(1), 1-10. https://www.researchgate.net/publication/353397414_Exploring_Older_Adults'_Experiences_of_a_Home-Based_Technology-Driven_Balance_Training_Exercise_Program_Designed_to_Reduce_Fall_Risk_A_Qualitative_Research_Study_Within_a_Randomized_Controlled_Trial

Aritzia. (n.d.). *TnaCOZY™ Tread Sports Bra*. https://www.aritzia.com/en/product/tnacozy%E2%84%A2-tread-sports-bra/96567.html

Artilect. (n.d.). *M-Boulder 125 Legging*. https://www.artilect.studio/m-boulder-125-legging-2211122-dsb-1225#selection.color=6569

ASTM. (2023, September 12). *ASTM F2276-10(2015): Standard Specification for Fitness Equipment*. https://www.astm.org/f2276-10r15.html

Athleta. (n.d.). *Momentum Seamless Top*. https://athleta.gapcanada.ca/browse/product.do?pid=658514003&vid=1&tid=acpl000010&kwid=1&ap=7&gad_source=1#pdp-page-content

Bamboocycles. (n.d.). *Texcoco (GRAVEL)*. https://bamboocycles.com/product/texcoco/

Boody. (n.d.). *Active High-Waisted 5" Short with Pockets* [photograph]. https://boody.com/products/active-high-waisted-5-short-with-pockets#

Bosmere. (n.d.). *Bosmere G125B Bosneeleze Luxury Garden Kneeler, Blue.* https://shorturl.at/dDNXY

Brazos. (n.d.). *Brazos Handcrafted Wood Walking Stick, Twisted, Backpacker Style Handle, for Men & Women, Made in The USA.* Amazon. https://amazon.ca/Hiking-Walking-Trekking-Stick-Handcrafted/dp/B00W5TILUA/ref=sr_1_33?keywords=titanium%2Btrekking%2Bpoles&sr=8-33&th=1&psc=1

British Plastics Federation. (n.d.). *Polyvinyl Chloride PVC*.

https://www.bpf.co.uk/plastipedia/polymers/PVC.aspx

Brownson, R. C., Leet, T. L., & Petersen, A. M. (2005). Correlates of physical activity among pregnant women in the United States. *Medicine and Science in Sports and Exercise.* 37(10). 1748-1753. https://europepmc.org/article/med/162609763

Callaway. (n.d.). *Callaway Strata Complete Golf Set*. Amazon. https://www.amazon.ca/Callaway-Strata-Complete-Piece-Package/dp/B07H2HQJR5/ref=sr_1_5?keywords=golf%2Bclub&sr=8-5&th=1&psc=1

Callinan N., Hank M., Lewis E. J., Schousboe J,T, Stern E.B., & Ytterberg SR. (1998). *Neoprene splinting: dermatological issues.* Am J Occup Ther. *52*(7), 573-8. https://doi.org/10.5014/ajot.52.7.573

Canadian Tire. (n.d.). *Pelican Explorer Deluxe 2-Person Canoe w/2 Folding Seats & Cooler, Tin Grey/Burgundy, 14.6-ft*. https://www.canadiantire.ca/en/pdp/pelican-explorer-deluxe-2-person-canoe-w-2-folding-seats-cooler-tin-grey-burgundy-14-6-ft-0791823p.0791823.html?loc=plp

Carrier, K., Evenson, K. R., Moos, M. K., & Siega-Riz, A. M. (2009). *Perceived Barriers to Physical Activity Among Pregnant Women. Maternal and Child Health Journal*. 13. 364–375. https://doi.org/10.1007/s10995-008-0359-8

Centers for Disease Control and Prevention. (2021, December 22). *Physical Activity*. https://www.cdc.gov/physicalactivity/community-strategies/social-supports.html

Centers for Disease Control and Prevention. (2022). *Adults 50 and Older Need More Physical Activity.* Cdc. https://www.cdc.gov/physicalactivity/inactivity-among-adults

Chang, L., Marston, G., & Martin, A. (2022, October 17). *Anatomy, Cartilage*. National Library of Medicine. https://www.ncbi.nlm.nih.gov/books/NBK532964/#:~:text=Cartilage%20has%20many%20functions%2C%20including,which%20resides%20within%20the%20lacunae

Clapp, J. F., & Cram, C. (2012, May 1*). Exercising Through Your Pregnancy. Independent Publishers Group*. https://books.google.ca/books?hl=en&lr=&id=Ue9hez0-QNQC&oi=fnd&pg=PP1&dq=e

CleanPrene. (n.d.). *CleanPrene Knee Support* [Photograph]. https://cleanprene.com/products/cleanprene-knee-support

Cottonbro studio. (n.d.). *Elderly Man Sitting on Bed* [photograph]. Pexels. https://www.pexels.com/photo/elderly-man-sitting-on-bed-8860212/

Crowe, S. (2018, September 6). *Seismic Powered Clothing wants to augment your everyday strength*. https://www.therobotreport.com/seismic-powered-clothing/

Danilyuk, P. (n.d.). [photograph of elderly women walking with hiking poles]. Pexels. https://www.pexels.com/photo/a-woman-in-a-black-jacket-walking-on-white-snow-6874413/

DE Staff. (2022, October 24). *CIRI study finds fumes from common 3D printers are toxic*. Design Engineering, https://www.design-engineering.com/siri-study-finds-fumes-from-common-3d-printers-are-toxic-1004039344/

Dreyfuss, H. (1993). *The Measure of Man and Women*. Whitney Library of Design. https://arc104201516.files.wordpress.com/2016/02/the-measure-of-man-and-woman-human-factors-in-design-alvin-r-tilley-henry-dreyfuss.pdf

Engelke K., Häberle L, Kalender W.A., Kemmler W. & Von Stengel S.,. (2010). Exercise effects on bone mineral density, falls, coronary risk factors, and health care costs in older women: the randomized controlled senior fitness and prevention (SEFIP) study. *Arch Intern Med 170*(2), 179-85. doi: 10.1001/archinternmed.2009.499. PMID: 20101013.

The Engineering ToolBox (2010). *Densities of common Products*. https://www.engineeringtoolbox.com/density-materials-d_1652.html

Envisioned. (n.d.). *Reusable Cinch Straps 2" x 60" - 6 Pack, Multipurpose Strong Gripping, Quality Hook and Loop Securing Straps (Black)*. https://www.amazon.ca/Reusable-Cinch-Straps-x60-Pack/dp/B01G4IVO0Q?th=1

Faverio, M. (2022, January 13). *The share of those 65 and older who are tech users has grown in the past decade*. Pew Research Center. https://www.pewresearch.org/short-reads/2022/01/13/share-of-those-65-and-older-who-are-tech-users-has-grown-in-the-past-decade/

FitTrek. (n.d.). *FitTrek Trekking Poles - Carbon Fibre Walking Poles - Hiking Poles Telescopic - Lightweight Nordic Walking Pole for Women, Men and Kids with Walking Poles Rubber Tips and Pole Bag, 1 Pair*. Amazon. https://shorturl.at/pvNZ0

Flaticon. (n.d.-a). *Happiness free icon* [Icon]. Flaticon. https://www.flaticon.com/free-icon/happiness_158420?term=emoji+faces&page=1&position=1&origin=search&related_id=158420

Flaticon. (n.d.-b). *Neutral face-free icon* [Icon]. Flaticon. https://www.flaticon.com/free-icon/neutral-face_4989647?term=emoji+face+neutral&page=1&position=1&origin=search&related_id=4989647

Flaticon. (n.d.-c). *Sad free icon* [Icon]. Flaticon. https://www.flaticon.com/free-icon/sad_158398?term=emoji+faces&page=1&position=7&origin=search&related_id=158398

Foamorder. (n.d.). *EVA Foam for Cosplay*. https://www.foamorder.com/do-it-yourself-foam/cosplay#:~:text=Lightweight,more%20without%20getting%20weighed%20down

Foamparts. (2018, September 30). *Technical Data Sheet: Foam | EVA | VA35* https://www.foamparts.com/wp-content/uploads/2018/10/va35.pdf

Freepik. (n.d.-a). *Crying free icon* [Icon]. Flaticon. https://www.flaticon.com/free-icon/crying_158436?term=crying+emoji&page=1&position=10&origin=search&related_id=158436

Freepik. (n.d.-b). *Happiness free icon* [Icon]. Flaticon. https://www.flaticon.com/free-icon/happiness_158420?term=smiley+face&page=1&position=1&origin=search&related_id=158420

Freepik. (n.d.-c). *Happy free icon* [Icon]. Flaticon. https://www.flaticon.com/free-icon/happy_1023656?term=happy+emoji&page=1&position=2&origin=search&related_id=1023656

Freepik. (n.d.-e). *Sad free icon*. Flaticon. https://www.flaticon.com/free-icon/sad_158398?term=smiley+face&page=1&position=9&origin=search&related_id=158398

FuseProject. (n.d.). *Seismic Powered Suit, Redefining Wearable Tech I Fuseproject*. https://www.google.com/imgres?imgurl=https%3A%2F%2Ffuseproject.com%2Fwp-content%2Fuploads%2F2017%2F01%2FAura_12_case_study_2x_3360x1270-1600x604.96350364964-c-default.jpg&tbnid=QjGThWLAfUDPNM&vet=12ahUKEwjOxe7UI-eCAxXRIlkEHY_0AqoQxiAoCnoECAAQMw..i&imgrefurl=https%3A%2F%2Ffuseproject.com%2Fwork%2Fseismic-powered-suit%2F&docid=T97SOUjZf52roM&w=1600&h=604&itg=1&q=Aura%20Powered%20Clothing&ved=2ahUKEwjOxe7UI-eCAxXRIlkEHY_0AqoQxiAoCnoECAAQMw

Girlfriend Collective. (n.d.). *Black Dylan Tank Bra* [Photograph]. https://girlfriend.com/products/black-dylan-tank-bra?query=7e5b3bed0d82d907339c912c446b8246&objectID=32911029534783

The Green Way. (n.d.). *Redecker Gardening Tools*. https://thegreenway.ca/products/gardening-tools

Gymshark. (n.d.). *Everyday Seamless Sports Bra*. https://ca.gymshark.com/products/gymshark-everyday-seamless-sports-bra-black-ss24

Halco. (n.d.) *REVIVE™ – RECYCLED HOOK AND LOOP*. Halcousa. https://www.halcousa.com/products/recycled-eco-friendly-hook-and-loop/

Harris, K. (2007, January). *The Impact of Aging Populations on Outdoor Recreation*. American trails. https://www.americantrails.org/resources/the-impact-of-aging-populations-on-outdoor-recreation

The Hemp Plastic Company. (n.d.) *Join the Hemp Plastic Revolution*. https://hempplastic.com/

Insider Tech. (2017, July 26). *You can take a seat anywhere with this wearable chair* [Video]. YouTube. https://www.youtube.com/watch?v=RFkT_Is8aRw

Jameson, A. (2023, April 20th). *How to Choose Trekking Poles*. Treelinereview. https://www.treelinereview.com/howtochoose/trekking-poles

JBL. (n.d.). *JBL Boombox 3 Wi-fi*. https://uk.jbl.com/bluetooth-speakers/BOOMBOX-3-WIFI.html?dwvar_BOOMBOX-3-WIFI_color=Black-UK-Current&cgid=bluetooth-portables

Kampus Production. (n.d.). [photograph of elderly man gardening]. Pexels. https://www.pexels.com/photo/elderly-man-holding-a-trowel-7658768/

Kasyan, R. (2020, December 24). *person holding green leaf plant* [photograph]. Unsplash. https://unsplash.com/photos/person-holding-green-leaf-plant-zlUgzTz56jo

kazuend. (2015, August 5). *green bamboo shoots* [photograph]. Unsplash. https://unsplash.com/photos/green-bamboo-shoots-LVdiXyu2eTc

Kim, E. (2010, October 29). *Designboom*. https://www.designboom.com/design/omhu-cane/

Kiran, U. V., & Singh (2014). Recreational Activities for Senior Citizens. *IOSR Journal Of Humanities And Social Science*, *19*(4), 24-30. https://www.iosrjournals.org/iosr-jhss/papers/Vol19-issue4/Version-7/E019472430.pdf

Kloecknermetals. (2021, April 5). *COMPARING 7075 ALUMINU M VS 6061*. https://www.kloecknermetals.com/blog/7075-aluminum-vs-6061-aluminum/#:~:text=The%20density%20of%207075%20aluminum,temper%20being%207075%2DT6

Knippenberg, E., Palmaers, S., Spooren, A. & Timmermans, A. (2021). Use of a technology-based system to motivate older adults in performing physical activity: a feasibility study. *BMC Geriatr* 21, 81 (2021). https://doi.org/10.1186/s12877-021-02021-3

Korotchenko, A. (2007, April). *"It's Not That I Can't Walk": Older Adults' Experiences of Using Canes and Walkers*. The University of British Columbia. https://open.library.ubc.ca/media/stream/pdf/24/1.0345603/3

Krohn, M. (2018, June 15). *Cottons on white surface* [photograph]. Unsplash. https://unsplash.com/photos/cottons-on-white-surface-RNqZbnBnMQk

Krukau, Y. (n.d.-a). [photograph of elderly couple walking together]. Pexels. https://www.pexels.com/photo/an-elderly-couple-walking-on-the-sidewalk-6816055/

Krukau, Y. (n.d.-b). [photograph of elderly women in yoga class]. Pexels. https://www.pexels.com/photo/elderly-woman-in-white-shirt-doing-yoga-8436593/

Kuo. S. & Lin, H. (2019). How does health consciousness influence attitudes of elderly people towards traceable agricultural products? Perspectives of the technology acceptance model Ageing & *Society*, *(40)*8, 1808 – 1821. https://doi.org/10.1017/S0144686X19000308

Kuyarck. (n.d.). *Blowout Sale - 49% OFF Breathable Non-Slip Joint Support Knee Pads*. https://www.kuyarck.com/products/knee-pads-27bd4d1e6-619e-402f-99a6-25da6efa63b9?variant=63dc8f6b-34f0-43a1-bfb0-50e5078ed449&pp=0&epik=dj0yJnU9V0RoMTBwd3BsLTNuUFBoMmJNZVhOeTdrclBDejVYVF8mcD0xJm49TmNRZkNzU0I5Z1dSRi1oWFViT0VyZyZ0PUFBQUFBR1ZTZ19F

Lebenskleidung. (n.d.). *Elastic Rubber Band Organic – Blac*k [Photograph]. https://www.lebenskleidung.com/en/organic-rubber-bands/elastic-rubber-band-organic-black-en

L.L.Bean. (n.d.). *Garden Kneeler*. https://www.llbean.ca/shop/Garden-Kneeler/1000127922.html

Lululemon. (n.d.). *License to Train Tight-Fit Tank Top*. https://shop.lululemon.com/en-ca/p/women-maintops/License-To-Train-Tight-Fit-Tank-Top/_/prod11520046?color=1966&sz=2&cid=Google_PMAX_CA_NAT_EN_W_Hybrid_Womens-Everything-Else-Omni_GEN_Y23_ag=&gad_source=1

Lypnytskyi, I. (n.d.). *Senior Man Walking along Colonnade at Sea Embankment*. https://www.pexels.com/photo/senior-man-walking-along-colonnade-at-sea-embankment-9851056/

Mace R.,A., Mattos M.,K., & Vranceanu A.,M. Older adults can use technology: why healthcare professionals must overcome ageism in digital health. *Transl Behav Med*. 2022 Dec 30;12(12):1102-1105. doi: 10.1093/tbm/ibac070

Matsouka, O. & Trigonis, I. (2008). Outdoor recreational exercise programs and functional capacity: a study of sedentary seniors. *International Journey of Sport Management Recreation & Tourism*, *2*, 1-13. https://www.researchgate.net/publication/49613279_Outdoor_Recreational_Exercise_Programs_and_functional_capacity_a_Study_of_Sedentary_Seniors

Maxon. (n.d.). *The Fusion of Robotics and Apparel*. https://drive.tech/en/stream-content/the-fusion-of-robotics-and-apparel

Medline. (n.d.). *Medline Heavy Duty Rollator Walker with Seat, Bariatric Aluminum Rolling Walker Supports up to 400 lbs, Burgundy*. Amazon. https://www.amazon.ca/Medline-Standard-Bariatric-Rollator-Burgundy/dp/B000LU5JKK/ref=asc_df_B000LU5JKK/?hvadid=292927229241&hvpos=&hvnetw=g&hvrand=22903079503534269 9&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9000976&hvtargid=pla-492022005784&psc=1

Mitchell, J. (2018, September 7). *Density of wood in kg/m3, g/cm3, lb/ft3 – the ultimate guide*. Engineeringclicks. https://www.engineeringclicks.com/density-of-wood/

Morby, A. (2017, January 12). *Yves Béhar's Aura Power Clothing helps the elderly with mobility*. https://www.dezeen.com/2017/01/12/yves-behar-aura-power-clothing-helps-elderly-mobility-design-museum-london/?li_source=LI&li_medium=bottom_block_1

Nachmani, G. (2018, February 8). *Once and for All: Cork or EVA Handle?* CNOC Outdoors. https://cnocoutdoors.com/blogs/blog/once-and-for-all-cork-or-eva-handle

National Institute on Aging. (n.d.). *Mental Health Benefits of Exercise and Physical Activity* [infographic]. https://www.nia.nih.gov/health/infographics/mental-health-benefits-exercise-and-physical-activity

NEISRAI. (n.d.). *Garden Kneeler Seat Garden Bench Multifunction Garden Stools with Tool Bag Seat with Thicken EVA Foam Pad Outdoor Portable Kneeler for Gardening NEISRAI (Gray)* https://shorturl.at/dsJ25

Northwoods. (n.d.). *Northwoods Aluminum Full Suspension Mountain Bike*. Amazon. https://www.amazon.ca/Northwoods-Suspension-Mountain-24-Inch-Green/dp/B008B2N0V0/ref=sr_1_32?keywords=bike&sr=8-32&th=1&psc=1

Noyed, D. (2023, January 31). *How is Foam Density Measured?* Sleepfoundation. https://www.sleepfoundation.org/best-mattress/foam-density

Ober. (n.d.). *HKAFO Knee Ankle Foot Orthosis Braces.* https://www.oberhealth.com/product/hkafo-knee-ankle-foot-orthosis-braces-ober-health/?attribute_style=Right&attribute_size=S&gad_source=4

O'Connor, P. J., & Poudevigne, M. S. (2006). A Review of Physical Activity Patterns in Pregnant Women and Their Relationship to Psychological Health. *Sports Medicine 36*, 19–38. https://doi.org/10.2165/00007256-200636010-00003

Omnexus. (n.d.). *Density of Plastics: Technical Properties.* https://omnexus.specialchem.com/polymer-properties/properties/density

Ondaring. (n.d.). *Ondaring Posture Corrector Women Men, Adjustable Back Brace Support, Breathable Back Straightener Posture Corrector, Pain Relief for Neck, Shoulder, Clavicle and Back*. Amazon. https://www.amazon.ca/Ondaring-Corrector-Adjustable-Breathable-Straightener/dp/B0BLCB8F3R/ref=asc_df_B0BLCB8F3R/?hvadid=578924877482&hvpos=&hvnetw=g&hvrand=14283923415706867161&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlo

OpenAI. (2023). ChatGPT [Large language model]. https://chat.openai.com

OpenAI. (2024). *ChatGPT* (3.5) [Large language model]. https://chat.openai.com

Organic Cotton Plus. (n.d.). *Thread- 300 yard spool*. https://organiccottonplus.com/collections/notions-thread/products/thread-300-yard-spool

Orthomed. (n.d.-a). *Bauerfeind Spinova Osteo Back Brace*. https://www.orthomed.ca/bauerfeind-spinova-osteo?gad_source=1

Orthomed. (n.d.-b). *DonJoy X-Act ROM Knee*. https://www.orthomed.ca/donjoy-x-act-rom-knee?gad_source=1

Orthomed. (n.d.-c) *M-Brace 10" Abdominal Binder* [Photograph]. https://www.orthomed.ca/m-brace-air-abdominal-binder?gad_source=1

Orthomed. (n.d.-d). *Orliman Jewett Hyperextension Brace*. https://www.orthomed.ca/orliman-jewett-hyperextension-brace?gad_source=1

Orthomed. (n.d.-e). *Push Med Back Brace*. https://www.orthomed.ca/push-med-back-brace?gad_source=1

OSPNIEEK. (n.d.). *Foldable Walking Cane with LED Light, Adjustable Ergonomic Walking Sticks, Aluminum with T Handles Hand Walking Stick, Collapsible Crutch with Torch, Mobility Aid for Elderly, Seniors & Handicap*. Amazon. https://www.amazon.ca/Foldable-Adjustable-Ergonomic-Aluminum-Collapsible/dp/B0B2N3RVHY/ref=sr_1_14?keywords=cane&sr=8-14

Outsunny. (n.d.). *Outsunny Garden Kneeler Seat Foldable Stool Bench 2 EVA Foam Kneeling Pad and 1 Large Tool Pouch*. Amazon. https://shorturl.at/oHIX4

Patagonia. (n.d.). *Black Hole® Mini MLC® 30L*. https://shorturl.at/adkwC

Patel, R. (2019, August 23). *Old People Pictures* [Photograph]. https://unsplash.com/photos/VMGAbeeJTKo

PAZAPO. (n.d.). *Posture Corrector for Men&Women - Back Brace for Lumbar Support and Upright - Breathable Back Straightener Back Corrector Posture Improve and Neck, Back, Shoulder Pain Relieve (X-Large(37-42Inches)*. Amazon. https://www.amazon.ca/Posture-Corrector-Men-Women-Straightener/dp/B0BTLLRRNZ/ref=asc_df_B0BTLLRRNZ/?hvadid=578928242567&hvpos=&hvnetw=g&hvrand=15354358974964555&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9061009&hvtargid=pla-1968767239810&mcid=668e38fb2d7f3a8991a8b920561de820&th=1

The Piping Mart. (2022, November 30). *The Weight Formula for Steel*. https://blog.thepipingmart.com/formulas/the-weight-formula-for-steel/#:~:text=The%20unit%20weight%20of%20a,m3%20or%20489.84%20lb%2Fft3

Plastics Europe. (n.d.). *Polyolefins*. https://plasticseurope.org/plastics-explained/a-large-family/polyolefins/#:~:text=PP%20(polypropylene)%3A%20The%20density,plastic%20with%20the%20lowest%20density

PublicMyth. (n.d.). *Live Wire Sports Bra*. https://shop.publicmyth.ca/collections/bamboo-sports-bras/products/live-wire-sports-bra

Pure Garden. (n.d.). *Pure Garden Rolling Garden Work Scooter with Tool Tray*. Amazon. https://t.ly/hkuOB

Reynolds, A., L. (n.d.). *Grey Organic Dye*. https://www.alrdyeing.com/products/grey-organic-dye

Roxofit Store. (n.d.). *Hip Brace for Sciatica Pain Relief: Ease Pain from Sciatic Nerve, Pulled Thigh, Hip Flexor Strain, Groin Injury, Hamstring Pull, Sacroiliac Joint, Labral Tear, Arthritis, Bursitis - Compression Support Stabilizer Wrap - SI Belt Device for Men, Women*. Amazon. https://www.amazon.ca/Hip-Brace-Sciatica-Pain-

Relief/dp/B01N2TL9U7/ref=asc_df_B01N2TL9U7/?hvadid=292950082213&hvpos=&hvnetw=g&hvrand=2571988423310923054&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9061009&hvtargid=pla-571186422903&th=1

Scommegna, P. (2018, November 12). *Eight Demographic Trends Transforming America's Older Population.* PRB. https://www.prb.org/resources/eight-demographic-trends-transforming-americas-older-population/

Scott-Leslie, D. (2018, June 15). *19 Useful Gadgets for the Elderly*. Cad crowd. https://www.cadcrowd.com/blog/19-useful-gadgets-for-the-elderly/

Seasons Retirement Communities. (2023). *7 Types of Hobbies for Older Adults. Seasonsretirement*. https://seasonsretirement.com/7-types-of-hobbies-for-older-adults/

Singh, Bhawana & Kiran, UV. (2014). Recreational Activities for Senior Citizens. International Journal of *Humanities and Social Science*, *19*. 2279-837. 10.9790/0837-19472430

Sohobloo. (n.d.). *SOHOBLOO'S BackPal Posture Corrector (Free Shipping TODAY!).* https://shopsohobloo.com/products/sohobloos-backpal-posture-corrector-free-shipping-today?variant=46809989415208&pp=0&epik=dj0yJnU9MG9SamNONjBTUHJub2dPaHNKNTdaSlJIemhsWTJxT1kmcD0xJm49b2JNQks4cmgtRWc0OG5wN0ItVVNydyZ0PUFBQUFBR1ZTZ3B3

Sosa, O., F. (2023, July 12). [nylon hot air balloon] [photograph]. Pexels. https://www.pexels.com/photo/european-ballon-festival-17580501/

Spratt, A. (2016, March 28). *Assorted Succulents in Clay Pots* [photograph]. Unsplash. https://unsplash.com/photos/ncQ2sguVlgo

Statistics Canada. (2022a, April 27*). A portrait of Canada's growing population aged 85 and older from the 2021 Census*. https://www12.statcan.gc.ca/census-recensement/2021/as-sa/98-200-X/2021004/98-200-x2021004-eng.cfm

Statistics Canada. (2022b, April 27). *In the midst of high job vacancies and historically low unemployment, Canada faces record retirements from an aging labour force: number of seniors aged 65 and older grows six times faster than children 0-14*. https://www150.statcan.gc.ca/n1/daily-quotidien/220427/dq220427a-eng.htm

Tavel, R. (2023, April 18). *A Guide To The Best Exercises For Seniors*. https://www.forbes.com/health/healthy-aging/best-exercises-for-seniors/

Texonic. (n.d.). *FIBER PROPERTIES: Your guide to structural fibres Fiber selection, a key component in our reinforcements*. https://texonic.net/en/tableau/technical/

TheFitLife. (n.d.). *TheFitLife Nordic Walking Trekking Poles-2 Pack with Antishock and Quick Lock System, Telescopic, Collapsible, Ultralight for Hiking, Camping, Mountaining, Backpacking, Walking, Trekking*. Amazon.

https://www.amazon.ca/TheFitLife-Nordic-Walking-Trekking-Poles/dp/B01MYXGC1T/ref=sxin_17_pa_sp_search_thematic_sspa?content-id=amzn1.sym.88b8493a-3875-4dce-9d00-0aeaf18dcaf7%3Aamzn1.sym.88b8493a-3875-4dce-9d000aeaf18dcaf7&cv_ct_cx=walking%

TheXceptional. (n.d.). *TheXceptional Wheelie Easy-Up | Wheeled Garden Stool with Handles Relieve Pain Getting Up and Down | Gardening Work-Seat with Wheels for Elderly Seniors Kneeler | Made in USA by Vertex | Model EX530*. Amazon. https://www.amazon.ca/TheXceptional-Wheelie-Gardening-Work-Seat-EX530/dp/B0BN2MS9PS

Th studio. (n.d.-d). *Neutral Face free i*con. Flaticon. https://www.flaticon.com/free-icon/neutral-face_4989647?term=neutral+face&page=1&position=1&origin=search&related_id=4989647

Top Chi. (n.d.). *Top Chi Tai Chi Baoding Balls with Bamboo Stand (Medium 1.6 Inch).* Amazon. https://www.amazon.ca/Top-Chi-Baoding-Bamboo-Medium/dp/B08914KV22/ref=sr_1_15?keywords=tai+chi+ball&sr=8-15

Toptry. (n.d.). *2 Pack Collapsible Trekking Pole Folding Walking Stick, Adjustable Hiking Stick with a Storage Bag, Suitable for Camping, Hiking, Backpacking, and More.* Amazon. https://t.ly/gxqhJ

TrailBuddy. (n.d.). *TrailBuddy Collapsible Hiking Poles - Ultralight Aluminum Trekking Poles for Hiking, Camping & Backpacking - Pair of 2 Adjustable Walking Sticks w/Cork Grip*. Amazon. https://t.ly/82vTz

UF Health. (2018, September 7). *A Day in the Life of a Senior Center Member* [Video]. YouTube. https://www.youtube.com/watch?v=RHullTeuIu4

UK Government. (2019). *UK Chief Medical Officers' Physical Activity Guidelines.* assets.publishing.service.gov.uk https://assets.publishing.service.gov.uk/media/5d839543ed915d52428dc134/uk-chief-medical-officers-physical-activity-guidelines.pdf

Underarmour. (n.d.-b). *Men's HeatGear® Long Sleeve*. https://www.underarmour.ca/en-ca/p/shirts_and_tops/mens_heatgear_long_sleeve/1361524.html?dwvar_1361524_color=410&dwvar_1361524_size=MD&dwvar_1361524_length=R&dwvar_1361524_length=&country=CA&currency=CAD&&cid=PLA_SC_CA_23_YBD2kxZl2Xw&gad_source=1

VAN BERGËN. (n.d.). *VAN BERGËN - Waxeless Cross Country XC Skis with Skintec Technology and Rottefella NNN Bindings - Lightweight Touring Classic Ski - Fast and Efficient Skiing - Black and Red - 52X48X50*. Amazon. https://www.amazon.ca/VAN-BERG%C3%8BN-Technology-Rottefella-Lightweight/dp/B0BFBQJ728/ref=sr_1_1?keywords=adult%2Bcross%2Bcountry%2Bskis&sr=8-1&th=1

ViaGasaFamido Store. (n.d.). *EVA kneeling pad. EVA Kneeling Pad Garage Garden Kneeler Knee Protection Mat Kneel Cushion for Gardening, Baby Bath, Yoga, Pilates, Exercise(Black), Garden Kneeling Pad Seat*. https://www.amazon.ca/Kneeling-Kneeler-Protection-Gardening-

Exercise/dp/B07TF6JDQ2/ref=sr_1_3_sspa?keywords=gardening+kneeler+vea+foam&sr=8-3-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9hdGY&psc=1

Walmart. (n.d.). *Wchiuoe 4-Sections Trekking Pole, Outdoor Trekking Pole, Rubber Handle Grip Support Body For Men Or Women For Outdoor Activities Hiking Mountaineering.* https://www.walmart.ca/en/ip/Wchiuoe-4-Sections-Trekking-Pole-Outdoor-Rubber-Handle-Grip-Support-Body-For-Men-Or-Women-Activities-Hiking-Mountaineering/2W1UGKO4LLFB

Wang, Z. (2014). *Nearby outdoor environments and seniors physical activities. Frontiers of Architectural Research, 3*(3), 265-270. https://doi.org/10.1016/j.foar.2014.04.002

Wikipedia. (2023, September 27). *Steel*. https://en.wikipedia.org/wiki/Steel#:~:text=The%20density%20of%20steel%20varies,4.65%20oz%2Fcu%20in

World Intellectual Property Organization. (n.d.). *Getting rid of bulky plasters with 3-D printed technology* [Photograph]. https://www.wipo.int/wipo_magazine/en/ip-at-work/2022/3d-printed-technology.html

Yan, G.R. (2018, May 25). [rubber tires in a pile] [photograph]. Unsplash. https://unsplash.com/photos/assorted-verhicle-tire-lot-ud0twV98uvg

YAOYAOO. (n.d.). *Garden Stool with Wheels, Rolling Weeding Stool Adjustable Gardening Seat for Easy to Move Reduce Work Fatigue, Light Garden Seat Workshop Work Chair for Picking, Planting, Car Repair.* Amazon. https://www.amazon.ca/Rolling-Adjustable-Gardening-Workshop-Planting/dp/B097YT7SKB

Appendix A – Discovery

This infographic shows the UK Chief Medical Officers' physical activity guidelines for adults and older adults and highlights some of the benefits of physical activities for seniors.

Figure A1 *Physical Activity for Adults and Older Adults*

(UK Government, 2019)

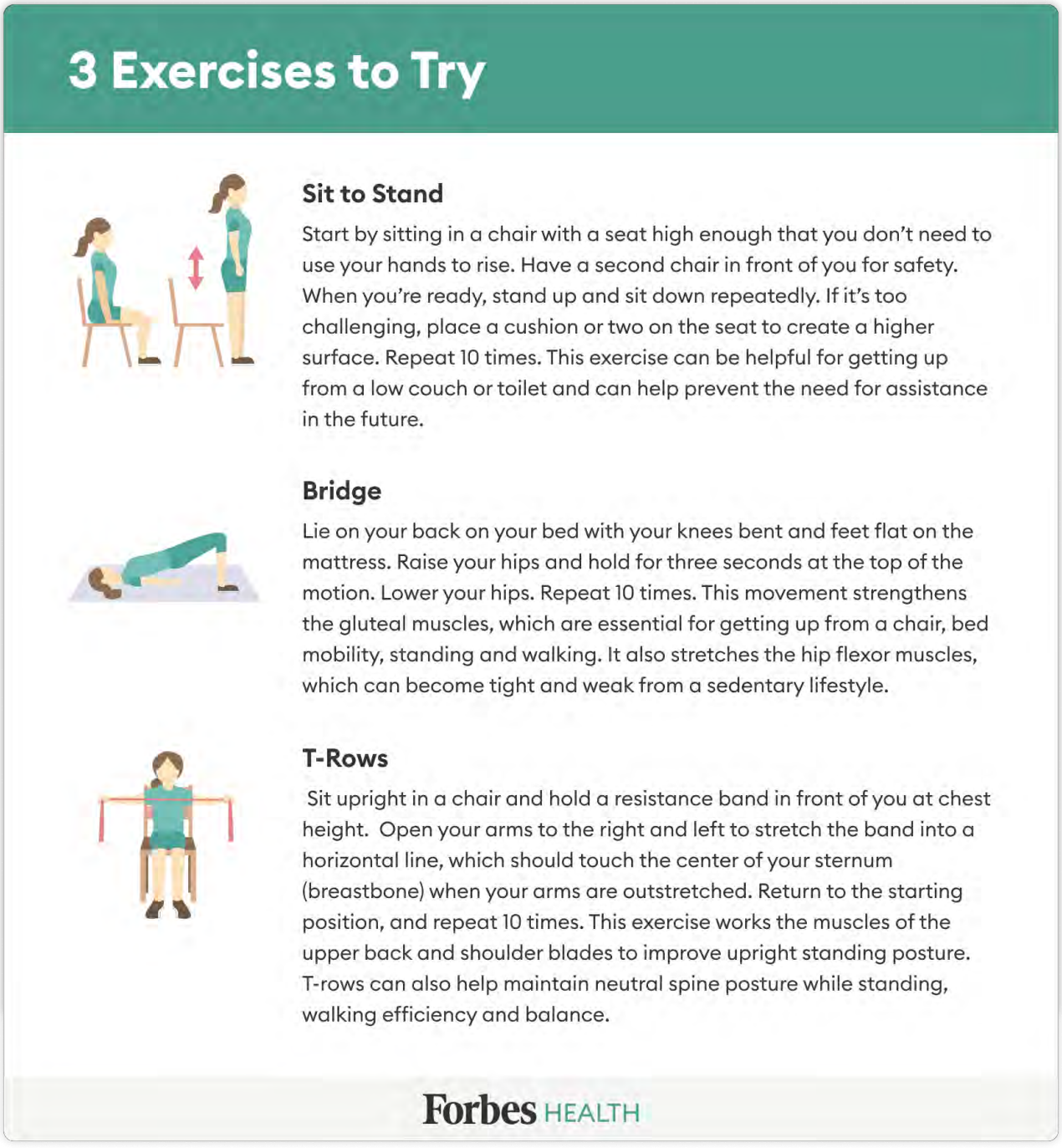
This infographic shows the mental health benefits of exercise and physical activity for seniors.

Figure A2 *The Mental Health Benefits of Exercise and Physical Activity*

(National Institute on Aging, n.d.)

The below infographic shows some beneficial exercises recommended for seniors.

Figure A3 *3 Exercises to Try*



(Tavel, 2023)

Appendix B – Contextual Research (User)

Contextual research was conducted by reviewing YouTube videos on the lives of seniors. Notes were taken from the video *A Day in the Life of a Senior Center Member*. These notes can be seen below.

Table B1 *A Day in the Life of a Senior Center Member - Video Notes*

 (UF Health, 2018)	Video notes: • The video talks about a unique senior center that is **free** to seniors. • Seniors were shown participating in **dance lessons** and **crafts.** Video highlights the importance of **building social networks** • Seniors **develop friendships** as they participate in programs • Seniors tend to **become friends with those who have mutual interests** • The senior center invites people to go there during the day to **socialize.** • Seniors talk about how the senior center is helpful for **preventing loneliness** – especially for those who **do not have access to family.** • Seniors shown participating in **yoga** • Senior talks about how **getting out of the house** is important • The senior center services are **free due to fundraisers** (affordable for seniors who may not have the money) • One of the seniors says he **still has a lot of curiosity** and likes to do things. • The center must figure out how to keep functioning at no cost or low cost because **if a seniors cannot afford to attend, their quality of life will be reduced.**

The interview and survey questions, as well as the summarized transcripts of the interviews, are provided below.

Table B2 *Interview Questions for Seniors*

Interview Questions for Seniors	a) What are some active outdoor activities that you enjoy? b) What types of outdoor spaces do you prefer for outdoor activities? - may follow up by asking why they enjoy these spaces c) What are some concerns or limitations related to mobility or physical fitness that you have? d) What are some methods you use to make your physical activities more fun? e) How do you feel about exercising in a group? **Generated in combination with (ChatGPT, 2023)**

Table B3 *Interview Questions for People Who Support Seniors*

Interview Questions for People Who Support Seniors	a) What are some concerns that seniors come to you with? b) What do you often see seniors struggling with? c) What are some active activities that you find that seniors do frequently? d) What activities do you see seniors doing that make them happy? e) What are some methods you use to enhance seniors' active lives? **Generated in combination with (ChatGPT, 2023)**

Table B4 *Survey Questions for Seniors*

Survey Questions for Seniors	**How old are you?** Under 65 65-75 76-85 86-95 Over 95 **What type of community do you live in?** Urban Suburban Rural **On a scale from 1 to 5, how physically limited do you feel when participating in outdoor physical activities?** 1 – I can do every outdoor physical activity that a 20-year-old could. 2 – I cannot do as much as a 20-year-old, but I can do a lot. 3 – I can do the easier half of the physical activities that a 20-year-old could. 4 – I can do less than half of the easier physical activities that a 20-year-old could do. 5 – I am so physically limited that I cannot do any of the things that a 20-year-old could. **Select all the physical activities that you currently participate in:** Yoga Gardening Walking Tai chi Pilates Skiing Dancing Rowing/boating/ kayaking Fishing Golfing Camping Swimming or other water exercises Stretching/physiotherapy Weights Biking **Select all the areas where you are physically active:** Backyard Garden Balcony Park Pool Driveway Road Sidewalk Camping site Field Outdoor Club Outdoor fitness class Hiking trail Beach Bike path Hill Lake/river Golf course Public garden Nature reserves or conservation area **What, in your opinion, would do the most to enhance your outdoor physical activities?** a) Making outdoor activities more fun b) Making outdoor activities more suited to my physical abilities c) Making outdoor activities more financially accessible d) Making outdoor activities more convenient e) Making outdoor activities more socially acceptable f) I am not physically active outdoors

Table B5 *Interview Transcript Contact #1*

Interviewer

- Explained the basis of the study and why I am looking to interview her
- Explained that being a research participant is voluntary
- Indicated that participation is anonymous and confidential, and her identity will not be revealed
- Told the participant she could leave the interview at any time
- Indicated that there is no penalty for withdrawing from the interview
- Asked if she would like to volunteer to participate in the study
- Asked if she permitted the conversation to be recorded for transcription and analysis purposes

Interviewee

- Gave consent to participating in the interview
- Gave consent to being recorded

What are some active outdoor activities that you enjoy?

- Gardening
- Walking
- Doesn't do sports
- Likes these outdoor activities because they provide her with exercise and fresh air and let her see new things
- Other active activities she does: treadmill, hand weights, and stretch bands, cleaning, cooking, and physio exercises

What types of outdoor spaces do you prefer for outdoor activities?

- Participates in physical activities in open spaces - around the block and the backyard
- Bush
- Other people's gardens
- Botanical gardens – likes to see things growing

What are some concerns or limitations related to mobility or physical fitness that you have?

- Arthritis
- Osteoporosis
- Atrial fibrillation
- Sore back (vertebrae collapsed)

What are some methods you use to make your physical activities more fun?

How do you feel about exercising in a group?

- Group exercise makes activities more fun
- She used to go to the local hall and exercise with friends before moving
- Group exercises were organized
- She liked doing exercises she was familiar with
- Recently joined a new exercise group for seniors
- Does physio exercises in her exercise groups
- Senior group exercises consist of arm, leg, and heel movements
- Her old group also did floor exercises (can't do these now because she hurt her back)
- Nice because these senior fitness groups are inexpensive
- Previously she paid $20 to the hall for 4 months of activity
- Now the exercise group she is in is completely free
- A small group of 8-10 women previously
- Now 16-20 people are in the church hall
- Group exercises led by a couple of knowledgeable instructors
- One of them was a nurse
- One instructor did tai chi
- Sometimes in her group, they would take turns leading. She didn't like being the leader and felt that it was uncomfortable.

Table B6 *Interview Transcript Contact #2*

Interviewer

- Explained the basis of the study and why I am looking to interview him
- Explained that being a research participant is voluntary
- Indicated that participation is anonymous and confidential and his identity will not be revealed
- Told the participant he could leave the interview at any time
- Indicated that there is no penalty for withdrawing from the interview
- Asked if he would like to volunteer to participate in the study
- Asked if he permits the conversation to be recorded for transcription and analysis purposes

Interviewee

- Gave consent to participating in the interview
- Gave consent to being recorded

What are some active outdoor activities that you enjoy?

- Walking
- Helping wife in the garden
- Doesn't do sports activities due to back injuries and other muscle pains
- Walks around the subdivision (2.5 blocks) - used to be 4 blocks before they moved to a smaller area
- Walks around the subdivision with their puppy
- Went scuba diving with my family
- Likes the fresh air and exercise he gets when participating in outdoor activities

What types of outdoor spaces do you prefer for outdoor activities?

- Likes exercising in the backyard, had a larger yard before – then downsized
- Downsized because they couldn't keep up with the maintenance
- Other places (not the garden or the block) are expensive for exercise

What are some concerns or limitations related to mobility or physical fitness that you have?

- Bulging back disk (caused leg pain and had surgery to fix it)
- Had shoulder surgery
- Had hand surgery
- Had gallbladder surgery
- Needs to hold something to get up now
- Needs a cane to walk
- Is considering getting a walker – but doesn't want to yet *(Note: there appeared to be some social stigma with using a walker)*

What are some methods you use to make your physical activities more fun?

- The exercise itself is already fun
- Wife motivates him to exercise more
- Likes travelling and having new experiences while exercising- cautious about travelling costs - pension doesn't pay much

How do you feel about exercising in a group?

- Did group exercises when recovering from surgeries or injuries
- Did physio exercises in a group
- *Note: I was unable to get a clear answer from this participant as to whether he liked group exercises or not. My best guess was that he was indifferent to them.*

Other:

- Strongly believes that staying active improves his health

Table B7 *Interview Transcript Contact #3*

Interviewer

- Explained the basis of the study and why I am looking to interview her
- Explained that being a research participant is voluntary
- Indicated that participation is anonymous and confidential and that her identity will not be revealed
- Told the participant that she leave the interview at any time
- Indicated that there is no penalty for withdrawing from the interview
- Asked if she would like to volunteer to participate in the study
- Asked if she permitted the conversation to be recorded for transcription and analysis purposes

Interviewee

- Gave consent to participating in the interview
- Gave consent to the interview being recorded

What are some active outdoor activities that you enjoy?

- Biking- biked 50 km today
- Hiking
- Snowshoeing
- Jogs daily on the treadmill - saves her knees

What types of outdoor spaces do you prefer for outdoor activities?

- Trails
- Doesn't do road biking - uncomfortable with that
- Likes nature
- Doesn't like exercising on the street

What are some concerns or limitations related to mobility or physical fitness that you have?

- None

What are some methods you use to make your physical activities more fun?

- Hike with a friend
- Belongs to a hiking group
- Having lunch with friends after exercising with them

How do you feel about exercising in a group?

- Enjoys exercising with a group

Other

- She believes exercise is important for maintaining health

Table B8 *Interview Transcript Contact #4*

Interviewer

- Explained the basis of the study and why I am looking to interview him
- Explained that being a research participant is voluntary
- Indicated that participation is anonymous and confidential and his identity will not be revealed
- Told the participant he could leave the interview at any time
- Indicated that there is no penalty for withdrawing from the interview
- Asked if he would like to volunteer to participate in the study
- Asked if he permits the conversation to be recorded for transcription and analysis purposes

Interviewee

- Gave consent to participating in the interview
- Gave consent to the interview being recorded

What are some active outdoor activities that you enjoy?

- Biking – the biked to Omemee (a town) and back today
- Hiking
- Canoeing
- Cross country skiing
- Snowshoeing
- Doesn't like organized sports - ex. hockey, baseball, or golf
- Likes woodsy activities

What types of outdoor spaces do you prefer for outdoor activities?

- Natural world
- Forest
- Fields
- Meadows
- Provincial parks
- Conservation reserves
- Trails
- Rail trails
- Sometimes bikes on roads – only if not with his wife
- City parks
- Remote areas
- Do not use the treadmill unless it is a last resource

What are some concerns or limitations related to mobility or physical fitness that you have?

- Still very physically fit
- No injuries
- No health issues

What are some methods you use to make your physical activities more fun?

- Likes small group activities
- Believes that coffee and a treat after hiking or biking is a nice reward for your exercise
- Also likes independent exercise so he can go at his own pace – the challenge of a range of abilities in a group
- 50% of his outdoor exercise is social and 50% is solo

How do you feel about exercising in a group?

- Not into gym groups
- He believes that the social aspect is an important part of less structured physical activities like walking

Other

- He benefits greatly from nature
- Nature reduces his stress and keeps him healthy

Table B9 *Interview Transcript Contact #5*

Interviewer

- Explained the basis of the study and why I am looking to interview her
- Explained that being a research participant is voluntary
- Indicated that participation is anonymous and confidential and that her identity will not be revealed
- Told the participant she could leave the interview at any time
- Indicated that there is no penalty for withdrawing from the interview
- Asked if she would like to volunteer to participate in the study
- Asked if she permitted the conversation to be recorded for transcription and analysis purposes

Interviewee

- Gave consent to participating in the interview
- Gave consent to the interview being recorded

What are some concerns that seniors come to you with?

- Financial issues
- Not being able to afford medication or home care
- Pension is not good enough to cover healthcare expenses

What do you often see seniors struggling with?

- Mental changes
- Infection – resulting in loss of memory
- Getting frustrated with losing memory

What are some active activities that you find that seniors do frequently?

- Walks
- Walking groups
- Aquafit

What activities do you see seniors doing that make them happy?

- Spending time with family
- Seniors complain about being lonely or isolated

What are some methods you use to enhance seniors' active lives?

- Encouragement
- Reinforcement
- Go with them on a walk
- Have them exercise with someone they know
- Seniors want to exercise with someone they are comfortable with

Table B10 *Interview Transcript Contact #6*

Interviewer

- Explained the basis of the study and why I am looking to interview her
- Explained that being a research participant is voluntary
- Indicated that participation is anonymous and confidential, and her identity will not be revealed
- Told the participant she could leave the interview at any time
- Indicated that there is no penalty for withdrawing from the interview
- Asked if she would like to volunteer to participate in the study
- Asked if she permitted the conversation to be recorded for transcription and analysis purposes

Interviewee

- Gave consent to participating in the interview
- Gave consent to being recorded

What are some active outdoor activities that you enjoy?

- Picnic
- Walking - can't walk for very long - hard to motivate herself to get outdoors – other priorities and distractions

What types of outdoor spaces do you prefer for outdoor activities?

- Park
- Waterfront

What are some concerns or limitations related to mobility or physical fitness that you have?

- Heart palpitations
- Have to take breaks to sit

What are some methods you use to make your physical activities more fun?

- Songs, music, group activities, games

How do you feel about exercising in a group?

- Likes Zoom group
- Not comfortable doing exercises in person – unless it is spontaneous and she's already with the group in person
- Likes doing exercises at home - inconvenient to go in person - can wear whatever you want
- The downside of exercising remotely is that the instructor can't monitor you or correct your form

Table B11 *Interview Transcript Contact #7*

Interviewer

- Explained the basis of the study and why I am looking to interview her
- Explained that being a research participant is voluntary
- Indicated that participation is anonymous and confidential and her identity will not be revealed
- Told the participant she could leave the interview at any time
- Indicated that there is no penalty for withdrawing from the interview
- Asked if she would like to volunteer to participate in the study
- Asked if she permitted the conversation to be recorded for transcription and analysis purposes

Interviewee

- Gave consent to participating in the interview
- Gave consent to being recorded

What are some active outdoor activities that you enjoy?

- Gardening – most of the day she is in her garden - with different plants cared for in different seasons
- Gardening is good exercise and fun
- Plants replace her babies who moved out – emotionally fulfilling
- Has lots of pets that keep her active
- Goes on long walks 1 hour per day – weather permitting
- Boating
- Exploring nature - Deep appreciation for nature – nourishes her soul
- Takes photos of plants outdoors and tries to figure out what they are
- Writes in her backyard
- Walks on trails with her grandkids
- Walks her cat outdoors using a cat stroller
- Walks to the store
- Walks with friends
- Does art outside in public to find friends
- Do yoga and meditation outside
- Is motivated to go outside to meet new people
- Doesn't go to fitness centers, but exercises from home
- Knitts outside
- Does yoga/meditation exercises in the morning and then at night to help her sleep

What types of outdoor spaces do you prefer for outdoor activities?

- Lakeside
- Walks along the river
- Garden center (she misses it in the winter)
- Everywhere – exploring
- Travelling opens your mind

What are some concerns or limitations related to mobility or physical fitness that you have?

- Sciatica
- Used a cane - uses cat stroller instead now instead of a cane
- After starting yoga has not had to use the cane
- Does garden work in increments so she has time to recover
- Must be careful how she moves heavy things
- She puts her heavy plants on stools or rollers - so she doesn't hurt herself moving them
- She suggested that something that would help move plants would be helpful for seniors
- She slides heavy things instead of lifting them

What are some methods you use to make your physical activities more fun?

- Rollers, and other methods which make physical activities easier for her
- Doing them with a friend

How do you feel about exercising in a group?

- Loves it
- Socialization is important
- She suggested that it is easier to host group activities when they are kept simple

Table B12 *Interview Transcript Contact #8*

Interviewer

- Explained the basis of the study and why I am looking to interview her
- Explained that being a research participant is voluntary
- Indicated that participation is anonymous and confidential and her identity will not be revealed
- Told the participant she could leave the interview at any time
- Indicated that there is no penalty for withdrawing from the interview
- Asked if she would like to volunteer to participate in the study
- Asked if she permitted the conversation to be recorded for transcription and analysis purposes

Interviewee

- Gave consent to participating in the interview
- Gave consent to being recorded

What are some active outdoor activities that you enjoy?

- Gardening
- Cleaning – ex. cleaning shed

What types of outdoor spaces do you prefer for outdoor activities?

- Graden
- Backyard
- Patio

What are some concerns or limitations related to mobility or physical fitness that you have?

- Stiff joints
- Falls
- Bad knees

What are some methods you use to make your physical activities more fun?

- Has a special shovel for helping cut roots – cost $100
- This shovel has jaws

How do you feel about exercising in a group?

- Walks with her husband
- Enjoys it
- Doesn't do any other group physical activities

Table B13 *Interview Transcript Contact #9*

Interviewer

- Explained the basis of the study and why I am looking to interview him
- Explained that being a research participant is voluntary
- Indicated that participation is anonymous and confidential and their identity will not be revealed
- Told the participant he could leave the interview at any time
- Indicated that there is no penalty for withdrawing from the interview
- Asked if he would like to volunteer to participate in the study
- Asked if he permits the conversation to be recorded for transcription and analysis purposes

Interviewee

- Gave consent to participating in the interview
- Gave consent to being recorded

What are some active outdoor activities that you enjoy?

- Walking
- Helping his wife
- Preparing the water barrel (seasonal)
- BBQing
- Setting the BBQ up and making sure it is ready for winter
- Car maintenance
- Cutting grass
- Cleaning lawnmower
- Getting snowblower ready for winter
- Going to the bank
- Taking garbage out
- Yard work

What types of outdoor spaces do you prefer for outdoor activities?

- Backyard
- Deck

What are some concerns or limitations related to mobility or physical fitness that you have?

- Bad knees
- Stairs are challenging
- Sore ankle
- Has a hard time with balance
- Sore back
- Uses cane
- If he falls, he cannot get back up
- Can't do many physical activities - lots of doctor appointments due to health problems

What are some methods you use to make your physical activities more fun?

- Uses cane
- Electric tools instead of manual tools – ex. portable drill for home repairs

How do you feel about exercising in a group?

- Walks with his wife
- Enjoys it
- Doesn't do any other group physical activities

Table B14 *Interview Transcript Contact #10*

Interviewer

- Explained the basis of the study and why I am looking to interview her
- Explained that being a research participant is voluntary
- Indicated that participation is anonymous and confidential, and her identity will not be revealed
- Told the participant she could leave the interview at any time
- Indicated that there is no penalty for withdrawing from the interview
- Asked if she would like to volunteer to participate in the study
- Asked if she permitted the conversation to be recorded for transcription and analysis purposes

Interviewee

- Gave consent to participating in the interview
- Gave consent to being recorded

What are some active outdoor activities that you enjoy?

- Gardening – gardening provides her with lots of exercise – has to be careful not to injure herself gardening though
- Walked with her friend outdoors during winter – wasn't into the cold or walking – her arthritic knees hurt, and she had concerns about slipping on the ice
- Does yoga and pilates, but those are indoor activities

What types of outdoor spaces do you prefer for outdoor activities?

- Woods in winter
- Yard in summer
- Garden

What are some concerns or limitations related to mobility or physical fitness that you have?

- Slipping and falling
- Arthritis
- She said it's important to be mindful of your abilities as a senior and to not rush yourself
- She said stretching is important to avoid injury

What are some methods you use to make your physical activities more fun?

- Listens to audiobooks while gardening – multitasking
- Earbuds or Bluetooth speaker while exercising

How do you feel about exercising in a group?

- She loves it
- She goes to group yoga
- When she was participating in the exercise study at the University of Guelph, she exercised with 8-10 people
- Her group members were very friendly and supportive
- Hard to consistently exercise by herself
- Friends expect you to show up, which keeps you exercising regularly
- Friends guide you and help you correct your mistakes while exercising

Other

- Wonders about the ergonomics of canes – can they be more comfortable for seniors?
- Wonders about the ergonomics of outdoor exercise machines – are they for everybody?
- Walkers force seniors to bend over – not good for the back
- Seniors don't know how to use walkers
- Trails need to be wider for seniors, bikers should be separate from walking people
- Seniors in her yoga class complain about being unable to do some of the floor exercises because they struggle to get off the ground
- She recently finished the group exercise study she participated in at the University of Guelph and feels like she's going to lose the strength she gained because she doesn't have her exercise group anymore

Appendix C – Field Research (Product)

Table C1 *Gardening with a Walker Transcript A*

Gardening Senior Style With A Walker!
(2022, May 19)
http://www.youtube.com/watch?v=r00WxBK-Ik

Time	Location	Do	Say	Codes	Themes
0:00	Inside home	Taking to camera	Hey friends this the Mrs. Yovi from our half acre homestead and I'm going to try and do some gardening without Howie's help today, it's gonna take a lot but I'm at least going to try and get a few tomato plants planted.	Without help Trying Requires effort	Assistance Effort
0:21	Inside home	Making her 'magic dust' plant fertilizer	but first, I have to make my magic dust for my tomatoes. Here is all the egg shells that I threw into this bowl that sat on top of the woodstove all winter long and toast hism Here's plain Epsom salts to do is up my shelves in there and it says I have two and a half cups. The two that with How do I open this thing. I hate things that are childproof because it makes them arthritis proof as well. All right. And I'm gonna put in about a cup of epsom salts little you know absent salts. Now listen folks, don't put your tomatoes roots right on this. You want to mix it into the soil what this does, is it helps replenish the calcium and magnesium that the soil loses when you plant your tomato plants in the same place every year. This prevents blossom end rot and we're gonna grind it out into a baggie. This goes	Seniors' smart techniques Seniors struggling with childproof products Arthritis Plant challenges	Creativity Struggle Health
2:07	Outside by garden	Showing her tomato beds, putting soil onto her walker and taking the walker to the garden beds	on, that's plenty because you only really needed like a tablespoon under each a heaping tablespoon under each plant and mix it into the soil. I don't know how well you can see it because it says I'm blinded by the sun. These are three tomato beds that one is being taken up because it's now under too much shade. That's going to be a tomato bed and one beside it. I did some weeding yesterday. So let's go get some soil this is going to be the hard part. Here's what I'm doing. I'm going to take a bucket or a bin fill it up with soil put it on my walker and walk it back to the beds	Blinded Too much shade for plants Weeding Getting creative with a walker	Challenges Creativity

Table C2 *Gardening with a Walker Transcript B*

Gardening Senior Style With A Walker!
(2022, May 19)
https://www.youtube.com/watch?v=r00WxBK-Ik

Time	Location	Do	Say	Codes	Themes
3:40	In backyard	Sitting in a chair	Yeah my camera's gonna be backwards don't ask me why I was wearing my glasses when all I did was sweating on them I couldn't see anyway I'm covered and bug spray. We're taking a break	Bug spray Bugs sweat	Struggle
3:57	In backyard and then in garden	Sitting in a chair and then working in garden bed (dumping soil in and spreading it)	there's my plants. The tomatoes seem to be doing okay, so there's more than one way to skin a cat or fill a bed right? Just gotta take your time and plug away at it. I'm gonna sit here for a few minutes and then I'm gonna get back to work all right	Proud Working gradually Taking breaks	Breaks
4:29	Beside garden bed	Showing camera one of her plants and then planting them in the garden	This is what I meant when I said they got burned so I'm gonna be a little bit ruthless here. Pick these dead leaves off	Chores and maintenance	Chores
5:00	Working in garden bed	Spreading out the soul and mixing in fertilizer	I noticed that when the plants were bigger, I planted them all the way up and I took the dead leaves off and then I planted them all the way up to the next leaves and I mix and mix my magic dust in the soil. I didn't put the plants directly on the dust and mixed it in the soil of the whole. This is the missive ofi from our half acre homestead saying there's more than one way to plant a tomato. But this is all I've got me for today but I think I did really good six tomatoes in seven, eight to go.	Seniors' smart techniques Satisfaction from accomplishments	Achievement Proud

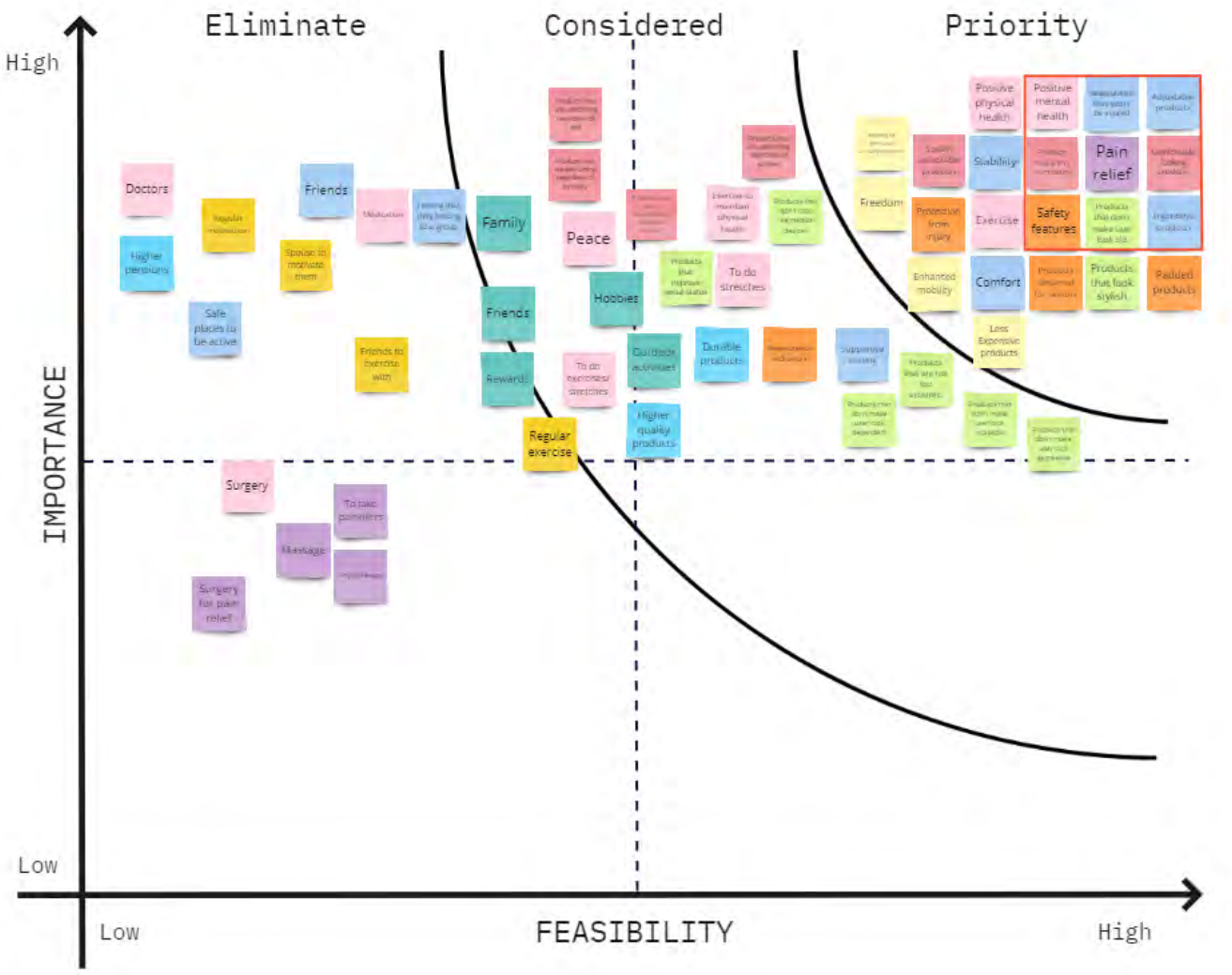
Table C3 *Coded Transcript of Senior Gardening with Walker*

Time	Location	Do	Say	Codes	Themes
0:00	Inside home	Taking to camera	Without Howie's help it's gonna take a lot I'm at least going to try	Without help Trying Requires effort	Assistance Effort
0:21	Inside home	Making her 'magic dust' plant fertilizer	magic dust I hate things that are childproof because it makes them arthritis proof as well This prevents blossom end rot	Seniors' smart techniques Seniors struggling with childproof products Arthritis Plant challenges	Creativity Struggle Health
2:07	Outside by garden	Showing her tomato beds, putting soil onto her walker and taking the walker to the garden beds	I'm blinded by the sun too much shade weeding take a bucket or a bin fill it up with soil put it on my walker and walk it back to the beds.	Blinded Too much shade for plants Weeding Getting creative with a walker	Challenges Creativity
3:40	In backyard	Sitting in a chair	sweating covered and bug spray taking a break	Bug spray Bugs sweat	Struggle
3:57	In backyard and then in garden	Sitting in a chair and then working in garden bed (dumping soil in and spreading it)	there's my plants Just gotta take your time and plug away at it gonna sit here for a few minutes	Proud Working gradually Taking breaks	Breaks
4:29	Beside garden bed	Showing camera one of her plants and then planting them in the garden	Pick these dead leaves off	Chores and maintenance	Chores
5:00	Working in garden bed	Spreading out the soul and mixing in fertilizer	magic dust there's more than one way to plant a tomato but I think I did really good	Seniors' smart techniques Satisfaction from accomplishments	Achievement Proud

Appendix D – Result Analysis

Based on the results gathered from primary and secondary research, a list of user needs was generated. These user needs were then colour coded by category and added to a prioritization grid to determine the most important ones to address.

Figure D1 *Prioritization Grid of User Needs*

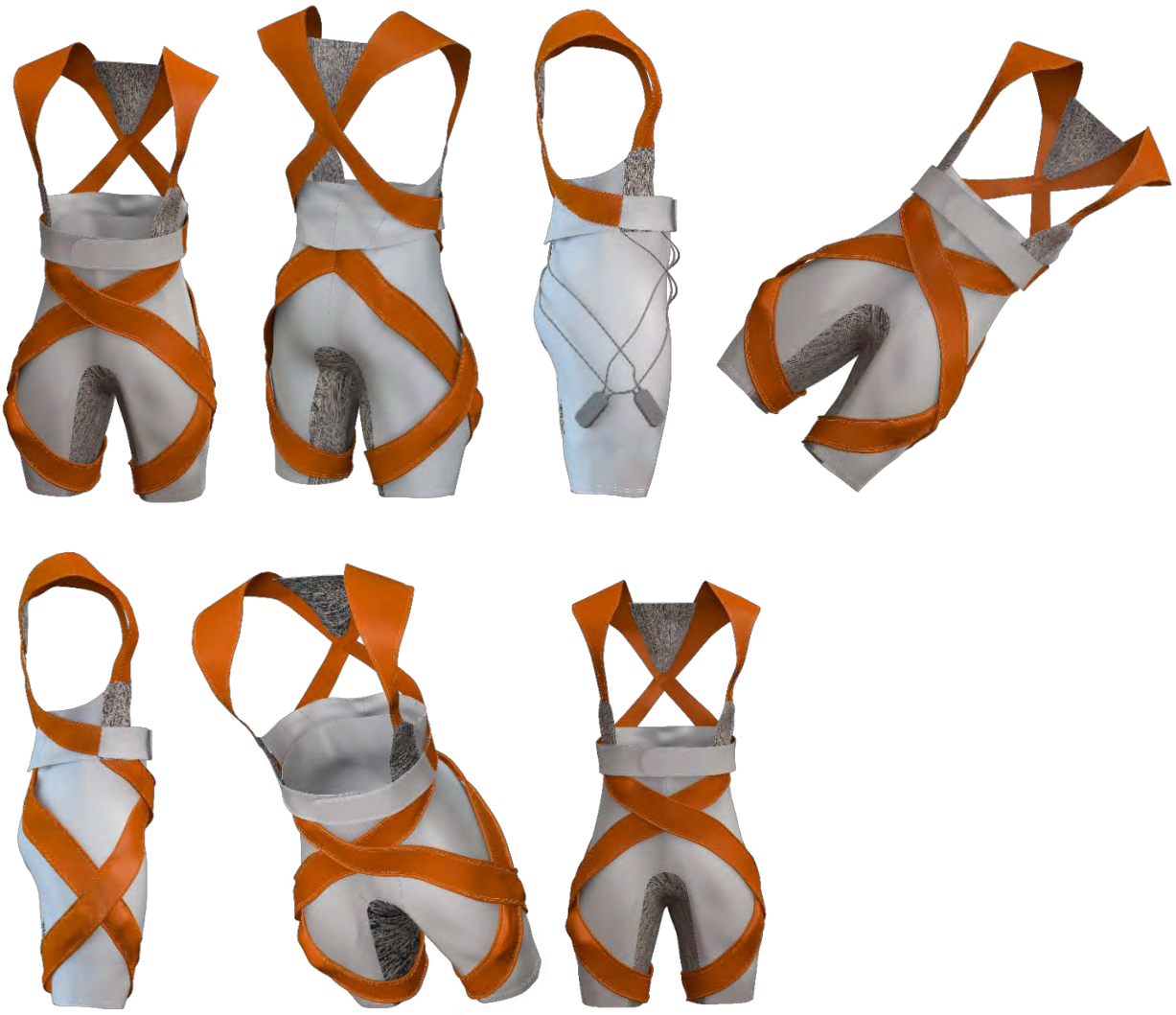


Appendix E – CAD Development

Figure E1 *CAD Process Work*

Figure E2 *CAD Development of Charger and Battery Housings*

Figure E3 *Final Renderings of the AlwaysAble Body Brace*



Appendix F – Technical Drawings

Figure F1 *Front and Rear 3/4 Views*

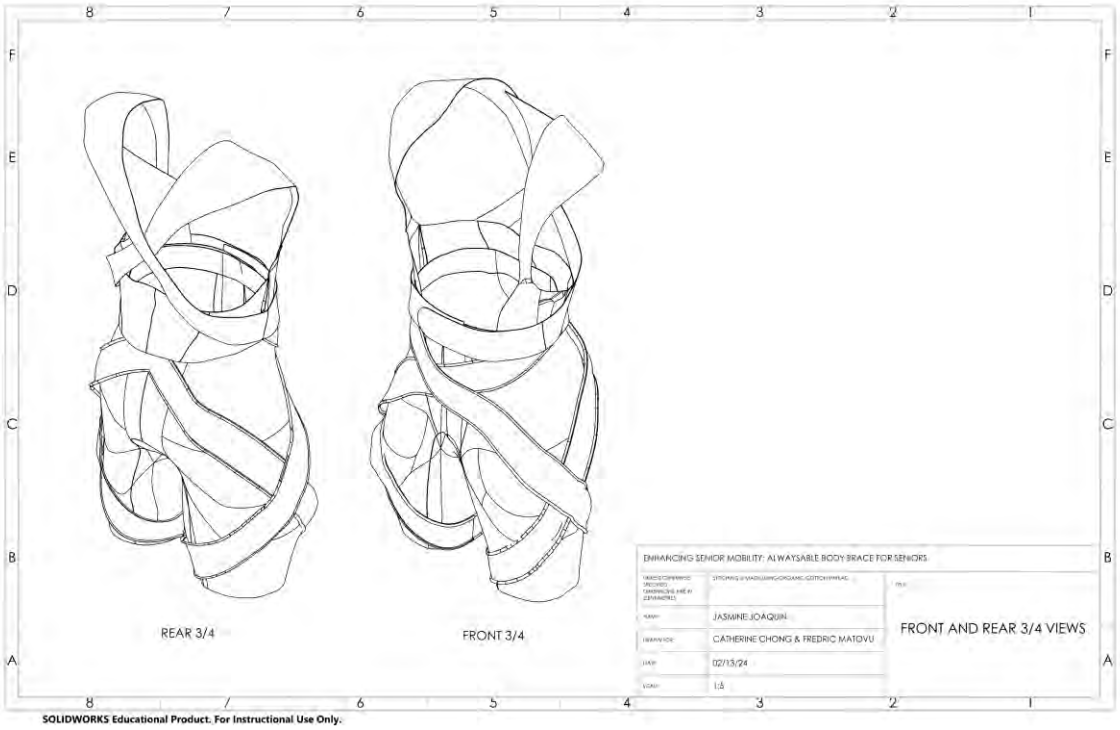


Figure F2 *Motor and Battery Housings*

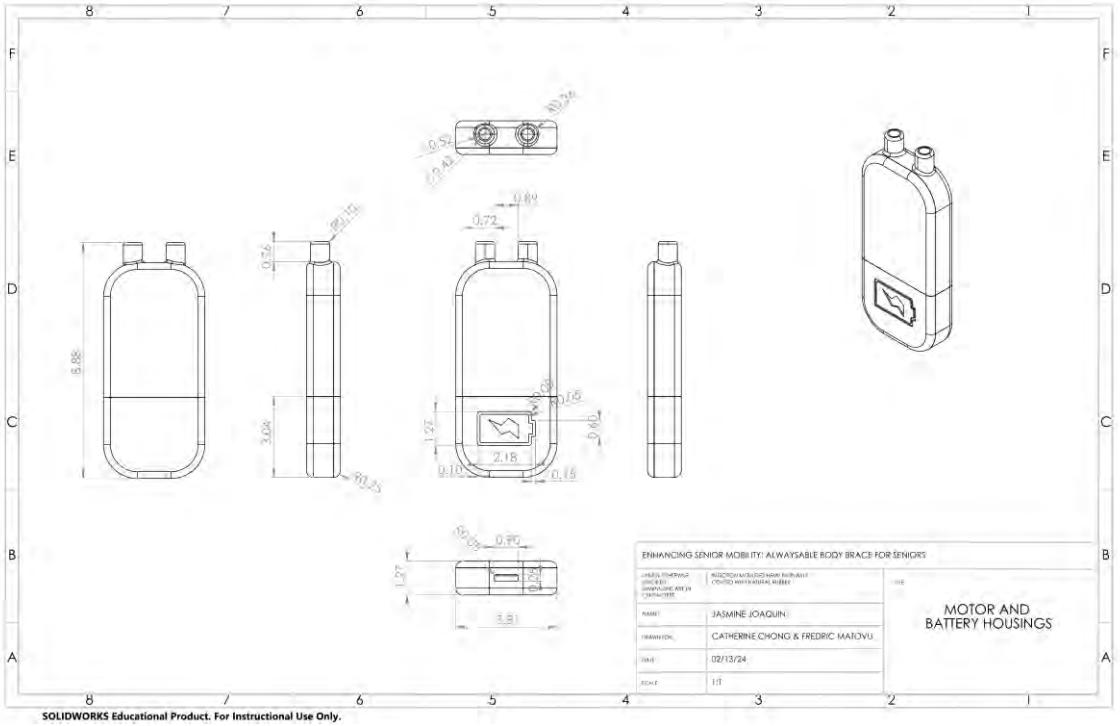


Figure F3 *Motor and Battery Housings Attached to Rubber Lines*

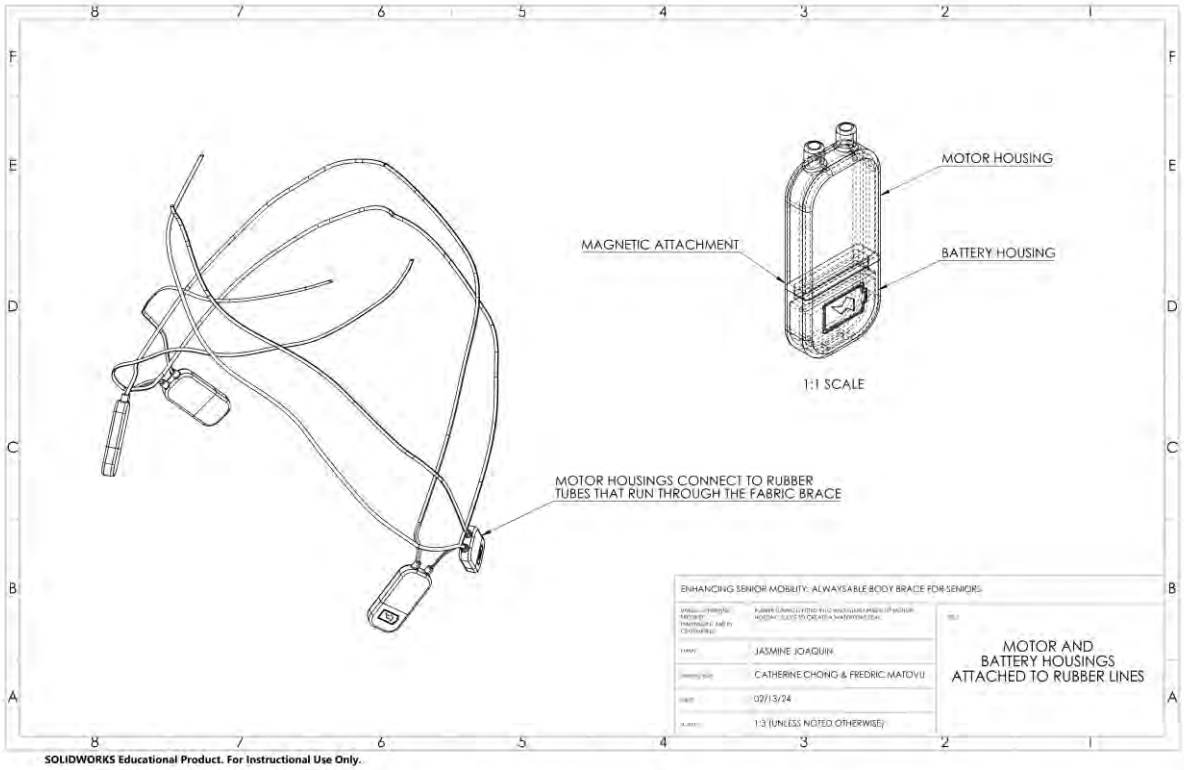


Figure F4 *Motors and Batteries in Fabric Wrap*

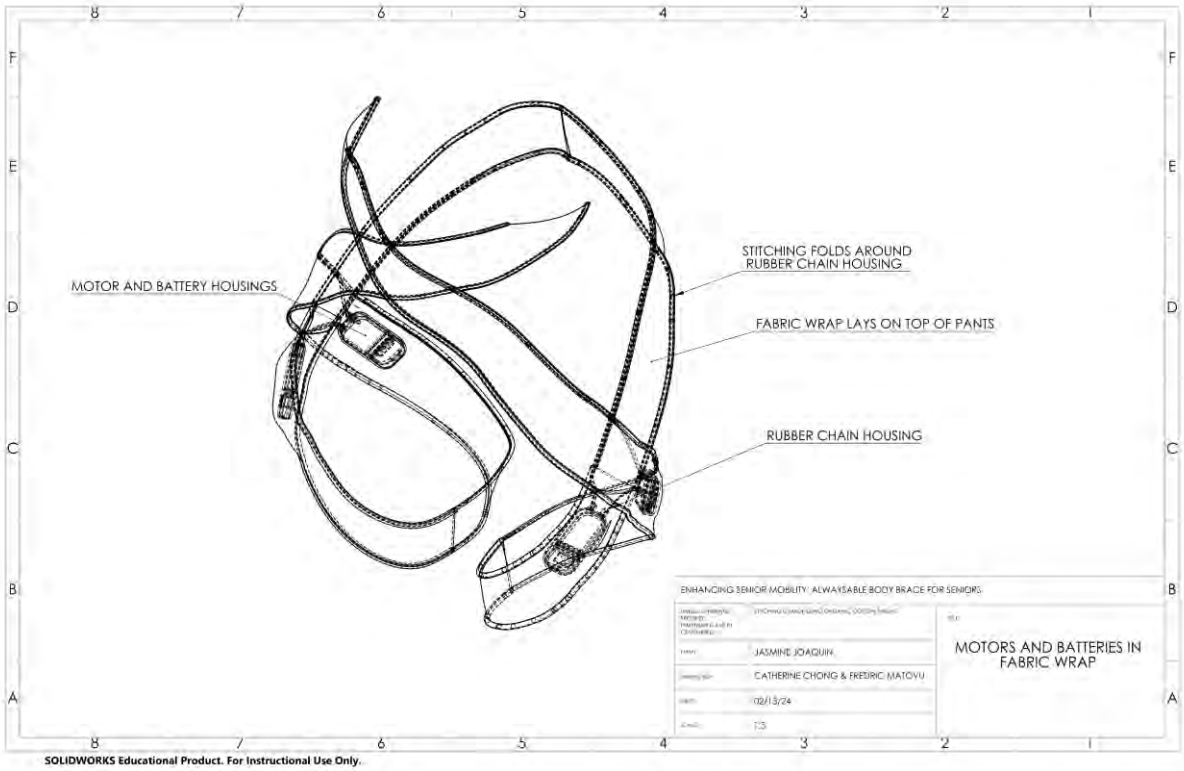
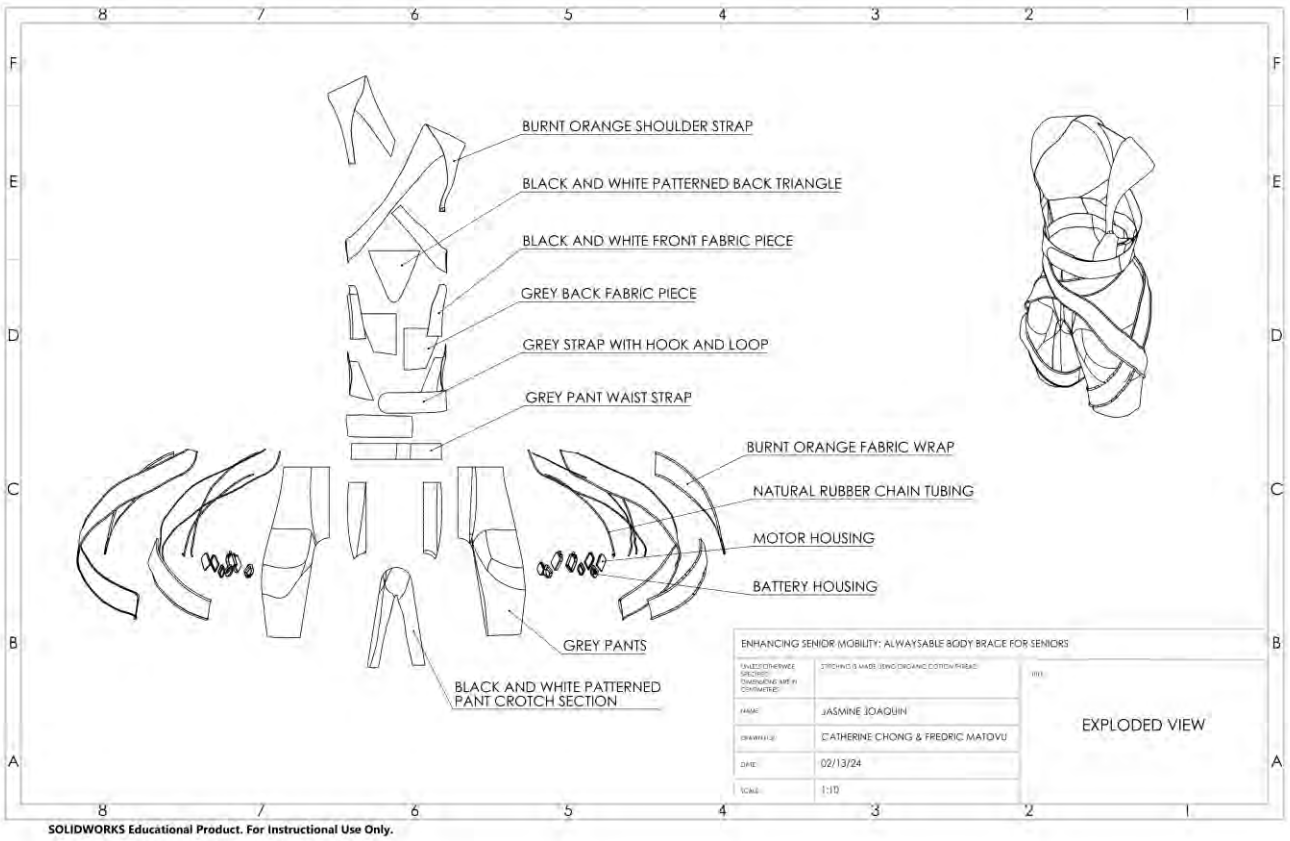


Figure F5 *Exploded View*



Appendix G – Sustainability Information/Data

Sustainability tables

The tables below show sustainable materials currently used in body braces and related products.

Table G1 *Sustainable Materials with Examples of Products They Are Used In*

Example	 Cleanprene Knee Support (CleanPrene, n.d.)	 FIIXIT Orthotic Lab 3D printed splint (World Intellectual Property Organization, n.d.)	 M-Brace 10" Abdominal Binder (OrthoMed, n.d.-c)	 Black Dylan Tank Bra (Girlfriend Collective, n.d.)	 Active High-Waisted 5" Short with Pockets (Boody, n.d.)
Sustainable Materials	Sugar cane Oyster shells Recycled plastics	PLA filament	Cotton	79% recycled plastic bottles (RPET) and 21% spandex	Bamboo viscose (lightweight breathability and stretch) mixed with organic cotton (for comfort)

Table G2 Su*stainable Materials with Examples of Products They Are Used In*

Example	 Elastic Rubber Band Organic – Black (Lebenskleidung, n.d.)	 Multicolour hemp plastic jars (The Hemp Plastic Company, n.d.)	 Revive – Recycled Hook and Loop (Halco, n.d.)	 Cotton thread spools (Organic Cotton Plus, n.d.)	 Grey natural dye (Reynolds, n.d.)
Sustainable Materials	65% organic cotton 35% natural rubber	Hemp Bioplastic	100% recycled nylon	100% organic cotton	charcoal, organic pink roses, Himalayan salt and sea salt

Implication

The commitment to sustainable initiatives, health considerations, and safety standards shaped and enhanced the design of the body brace. The design avoided the negative environmental consequences of manufacturing petroleum products (carbon and pollutant emissions) by prioritizing the use of biodegradable materials, alongside the incorporation of recycled materials where biodegradable materials were not an option. Using only commonly approved and safe materials and manufacturing methods ensured that the final design was reliable and safe. Moreover, avoiding irritant-prone materials ensured that the final design was user-friendly.

Appendix H – Approvals & Plans

Figure H1 *Thesis Topic Approval*

IDSN 4002/4502
SENIOR LEVEL THESIS ONE AND TWO

Humber ITAL / Faculty of Media & Creative Arts
Bachelor of Industrial Design / FALL 2023
Catherine Chong

FTA-2 (B) THESIS TOPIC APPROVAL (Preliminary Abstract)

THESIS TOPIC APPROVAL:

Student Name:	Jasmine Joaquin
Topic / Problem Definition:	How might we enhance outdoor activities for seniors?

TOPIC DESCRIPTIVE SUMMARY (PRELIMINARY ABSTRACT)

As the medical system struggles to keep up with the aging population, there is a push to take preventative healthcare measures by encouraging seniors to be more physically active outdoors. Engaging in physical activities and spending time outdoors not only promotes physical fitness, but also contributes to mental health, reduces loneliness, and provides a sense of environmental stewardship. Unfortunately, many seniors struggle to be physically active, which can have detrimental health outcomes and further burden the medical system. The goal of this thesis project is to develop a product that enhances outdoor activities for seniors to make exercise more appealing and accessible, while also incorporating a social aspect to reduce loneliness and encourage continuous use of the product. Interviews and surveys will be used to study senior lifestyles, physical abilities, and interests. The most prominent themes will be used to develop a design solution. Once a preliminary concept is developed, the feasibility and ergonomics of the design will be evaluated by the user. The resulting product will revolutionize senior exercise, improve the quality of life of seniors, and significantly reduce the current burden on the healthcare industry.

Student Signature: Jasmine Joaquin	Instructor Signature: Catherine Chong
Date: 24 / 09 / 2023	Date: 4th October 2023

Chong, Kappen

Figure H2 *TCPS 2: CORE 2022*

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE 2022

Certificate of Completion

This document certifies that

Jasmine Joaquin

successfully completed the Course on Research Ethics based on the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2: CORE 2022)

Certificate # 0000937951 20 June, 2023

The project timeline, research plan and advisor initiatives can be viewed at this link:

https://1drv.ms/x/s!ArVcrLCLFvCvnwoz2mPddWQye2C7?e=wBG6fd

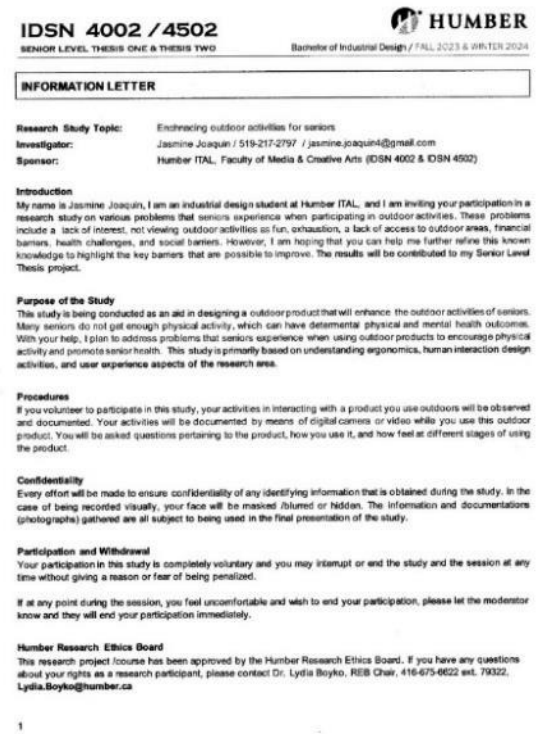
Appendix I – Advisor Meetings & Agreement Forms

Figure I1 *Participant Informed Consent and Information Letter – Advisor*

Table I1 *Advisor Meeting Notes*

Meeting Date	Meeting Details	Minutes
September 30th 12:10pm – 1pm	• Called and asked if she wanted to be my advisor • Arranged sending her the advisor form by email for her to print, sign, and hand to my mom who would scan the form and send it back to me • Explained form • Asked what her schedule was like for meetings	50
October 2nd 6:20pm – 7 pm	• Interviewed advisor	40
October 14th 9:25pm – 10 pm	• Adviser called to check the project's progress • We discussed that the adviser's signed form was successfully handed off to my mom to be scanned. • I explained that I emailed her a survey form to complete. • I asked if she could help distribute surveys.	35
October 17th 11:20am – 12pm	• Called to confirm that I received her signed form • Called to confirm that she received the survey link • Explained how digital survey worked • Asked if she could contact other seniors who may be interested in being interviewed	40
October 21 7:50pm – 8:10 pm	• Called to confirm that I was receiving new survey responses • Shared common interview and survey results collected thus far • Reflected on interview and survey findings with advisor	20
November 4th 7:30pm – 9 pm	• Chatted about survey results • Shared design concepts with advisor for feedback	90
November 25th 2:10pm – 3 pm	• Called advisor to let her know that I was no longer collecting research data, so she did not need to continue dispersing the survey. • Chatted about her life to catch up and gain additional insights on the life of a senior	50
November 27th 6:30 pm – 7 pm	• Called to explain the progress of the thesis project and thank advisor again for her research help in the previous weeks.	30
	Total hours	355

Figure I2 *Participant Informed Consent and Information Letter - User Observation*



IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO
HUMBER
Bachelor of Industrial Design / FALL 2023 & WINTER 2024

INFORMATION LETTER

Research Study Topic: Enchreacing outdoor activities for seniors
Investigator: Jasmine Joaquin / 519-217-2797 / jasmine.joaquin4@gmail.com
Sponsor: Humber ITAL, Faculty of Media & Creative Arts (IDSN 4002 & IDSN 4502)

Introduction
My name is Jasmine Joaquin, I am an industrial design student at Humber ITAL, and I am inviting your participation in a research study on various problems that seniors experience when participating in outdoor activities. These problems include a lack of interest, not viewing outdoor activities as fun, exhaustion, a lack of access to outdoor areas, financial barriers, health challenges, and social barriers. However, I am hoping that you can help me further refine this known knowledge to highlight the key barriers that are possible to improve. The results will be contributed to my Senior Level Thesis project.

Purpose of the Study
This study is being conducted as an aid in designing a outdoor product that will enhance the outdoor activities of seniors. Many seniors do not get enough physical activity, which can have detrimental physical and mental health outcomes. With your help, I plan to address problems that seniors experience when using outdoor products to encourage physical activity and promote senior health. This study is primarily based on understanding ergonomics, human interaction design activities, and user experience aspects of the research area.

Procedures
If you volunteer to participate in this study, your activities in interacting with a product you use outdoors will be observed and documented. Your activities will be documented by means of digital camera or video while you use this outdoor product. You will be asked questions pertaining to the product, how you use it, and how feel at different stages of using the product.

Confidentiality
Every effort will be made to ensure confidentiality of any identifying information that is obtained during the study. In the case of being recorded visually, your face will be masked /blurred or hidden. The information and documentations (photographs) gathered are all subject to being used in the final presentation of the study.

Participation and Withdrawal
Your participation in this study is completely voluntary and you may interrupt or end the study and the session at any time without giving a reason or fear of being penalized.

If at any point during the session, you feel uncomfortable and wish to end your participation, please let the moderator know and they will end your participation immediately.

Humber Research Ethics Board
This research project /course has been approved by the Humber Research Ethics Board. If you have any questions about your rights as a research participant, please contact Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca**

1

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO
HUMBER
Bachelor of Industrial Design / FALL 2023 & WINTER 2024

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.**

Click or tap here to enter text. ROBERT H. MIDDLEBROOK — Participant's Name
Participant's Signature
Click to enter a date 30 SEP 23 — Date

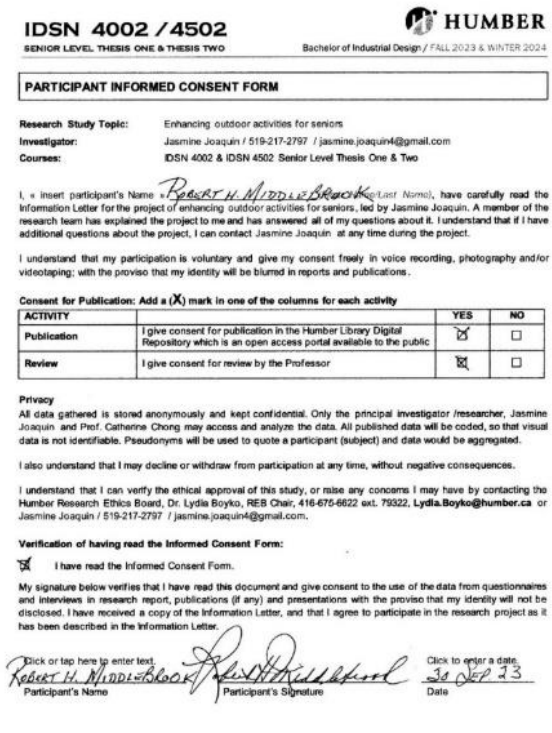
Project Information
Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: 519-217-2797

Email: jasmine.joaquin4@gmail.com

My supervisors are:
Prof. Catherine Chong, **catherine.chong@humber.ca**

2



IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO
HUMBER
Bachelor of Industrial Design / FALL 2023 & WINTER 2024

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: Enhancing outdoor activities for seniors
Investigator: Jasmine Joaquin / 519-217-2797 / jasmine.joaquin4@gmail.com
Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, « insert participant's Name » ROBERT H. MIDDLEBROOK (First/Last Name), have carefully read the Information Letter for the project of enhancing outdoor activities for seniors, led by Jasmine Joaquin. 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 Jasmine Joaquin 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	☒	☐
Review	I give consent for review by the Professor	☒	☐

Privacy
All data gathered is stored anonymously and kept confidential. Only the principal investigator /researcher, Jasmine Joaquin and Prof. Catherine Chong 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 Jasmine Joaquin / 519-217-2797 / jasmine.joaquin4@gmail.com.

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. ROBERT H. MIDDLEBROOK — Participant's Name
Participant's Signature
Click to enter a date 30 SEP 23 — Date

3

Appendix J – Survey Responses

Figure J1 *How old are you?*

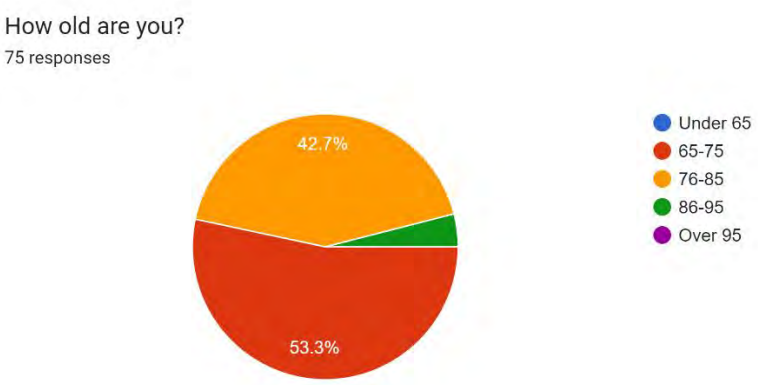


Figure J2 *What is your gender?*

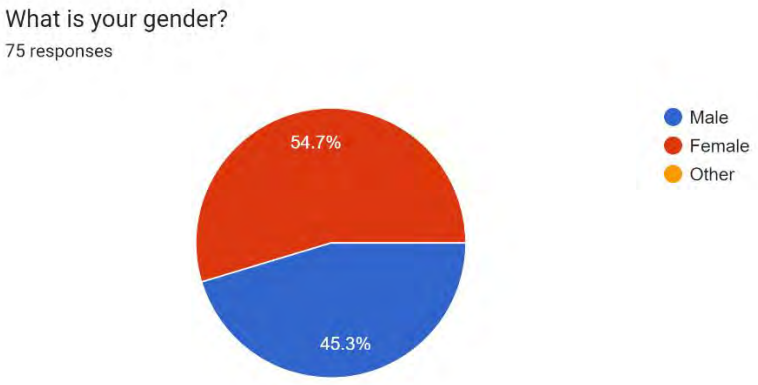


Figure J3 *What type of community do you live in?*

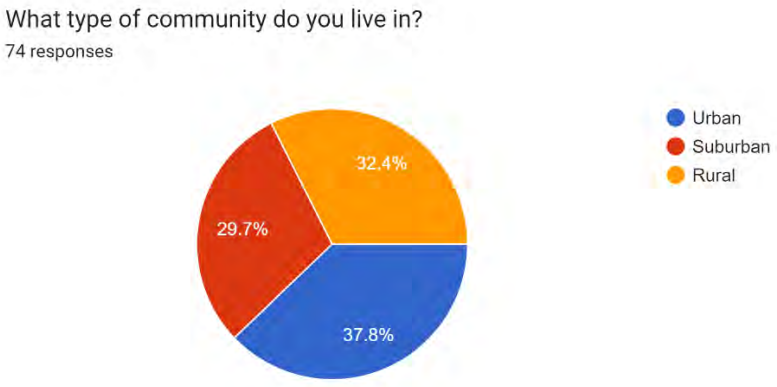


Figure J4 *How physically limited do you feel when participating in outdoor physical activities?*

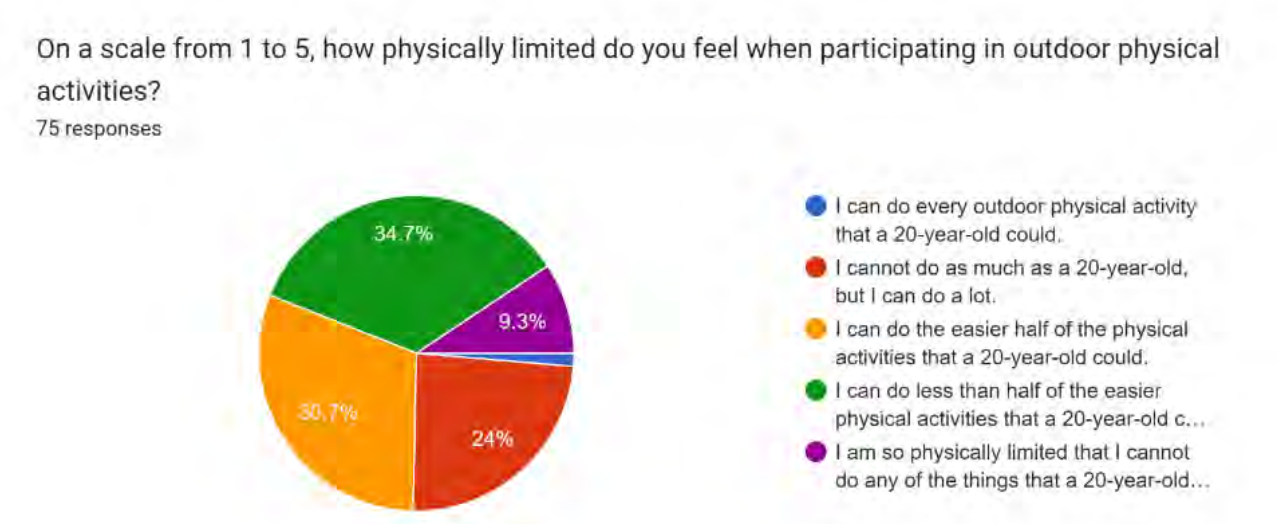


Figure J5 *Current or Recent Physical Activities*

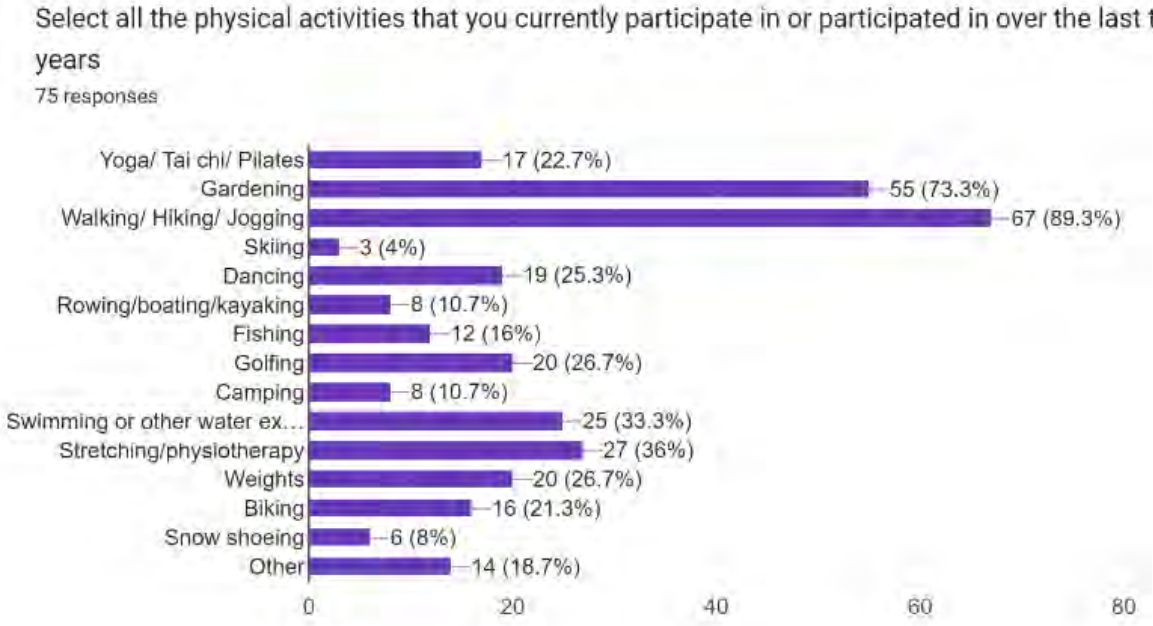


Figure J6 *Provide a brief description of how you participate in those physical activities*

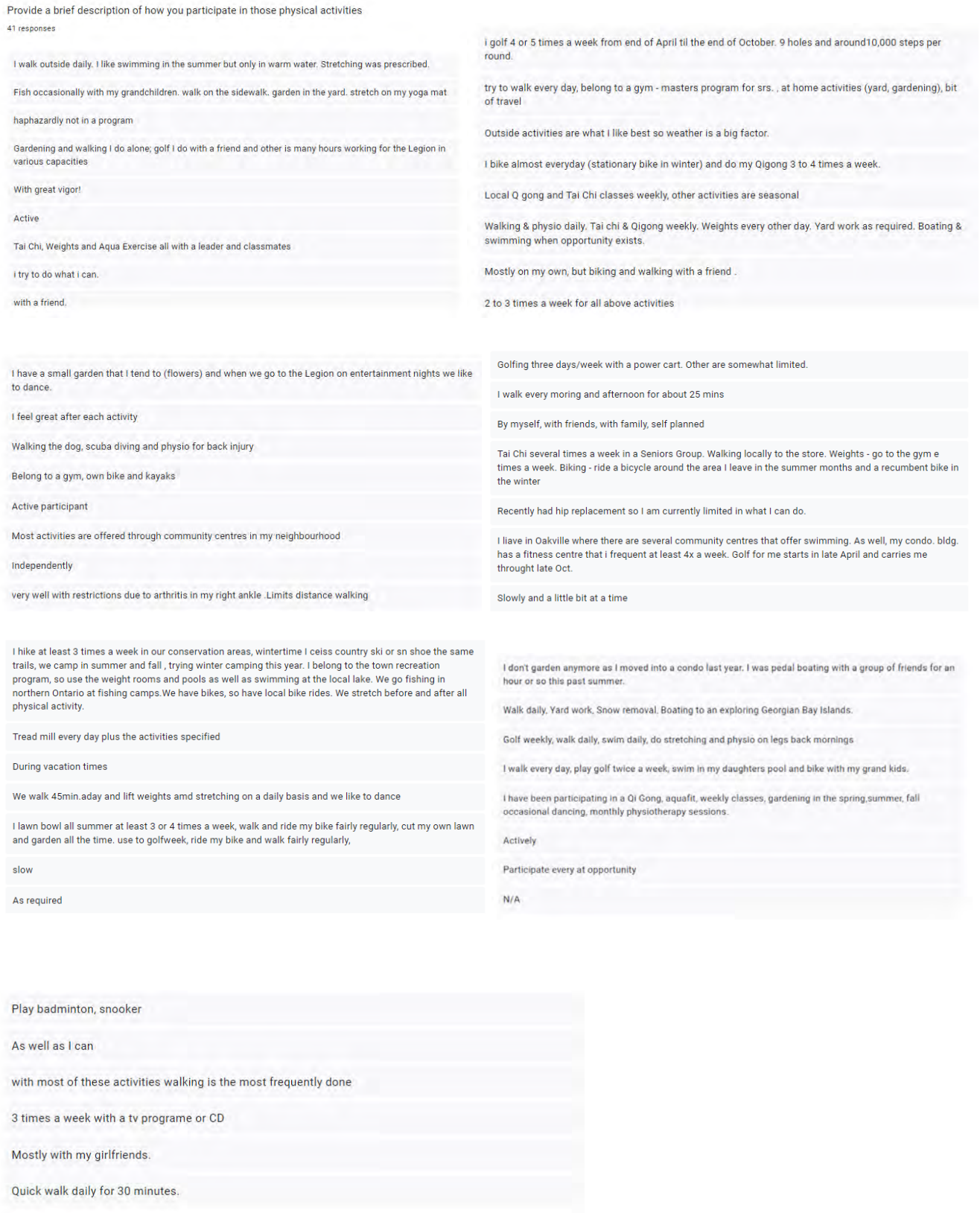


Figure J7 *Where Seniors Are or Were Physically Active Over the Last Three Years*

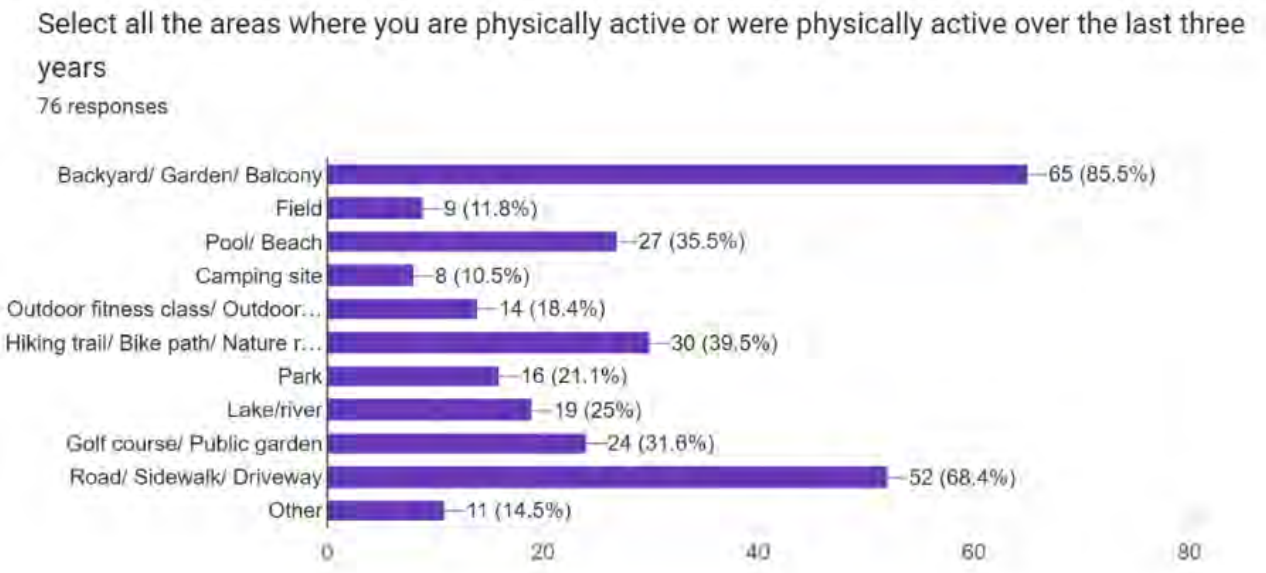
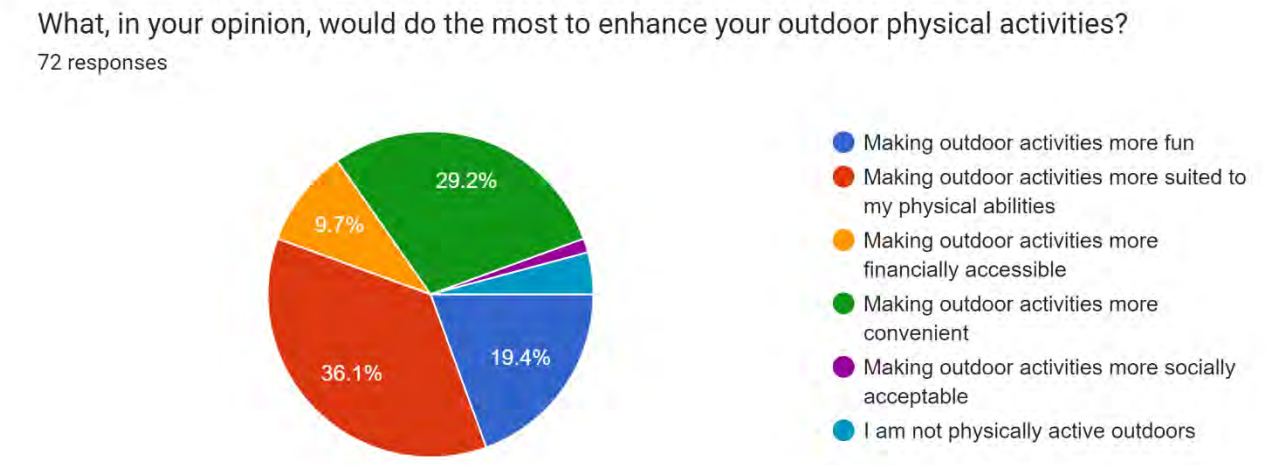


Figure J8 *What, in your opinion, would do the most to enhance your outdoor physical activities?*



Appendix K – Related Articles

Table K1 *Recreational Activities for Senior Citizens*

 IOSR Journal Of Humanities And Social Science (IOSR-JHSS) Volume 19, Issue 4, Ver. VII (Apr. 2014), PP 24-30 e-ISSN: 2279-0837, p-ISSN: 2279-0845. www.iosrjournals.org **Recreational Activities for Senior Citizens** *Bhawana Singh, **U. V. Kiran *Research Scholar **Assistant Professor Department of Human Development & Family Studies, School for Home Sciences, Babasaheb Bhimrao Ambedkar Central University Lucknow, India- 226026 **Abstract:** *Recreation plays a key role in the well-being of older adults and in enhancing their quality of life. For seniors, as for people of all ages, involvement in recreation activities can satisfy a variety of needs. Among the important benefits of recreation for the senior population is increased health and fitness, as well as opportunities for socializing, for using skills and talents developed throughout their lifetime, and for learning new skills. The aim of this article is to dwell upon various recreational activities for the elderly. These activities are very useful to them as they can spend their leisure time and enjoy by doing interesting tasks. The senior population is very varied with a diversity of interests, strengths, and abilities. Some seniors have enjoyed a positive use of leisure throughout their life, and are able to find appropriate activities to suit their changing physical abilities and interests. Other seniors, however, may not be aware of the potential positive values of recreation.* **Keywords:** *Elderly, physical activity, recreational activity* **I. Introduction** The ageing of population is an obvious consequence of the process of demographic transition. While the countries of the West have already experienced and have planned for their elderly population, it is only in the last one and half decades that countries in Asia too are facing a steady growth of the elderly, as a result of the decline in fertility and mortality, better medical and health care and improvements in the overall quality of life of people. Within Asia, as India and China are the two largest countries in the region, it is expected that they would have a significant proportion of the World's elderly because of their large population base. In fact, the situation in India presents two different scenarios with certain states grappling with curbing their high fertility rates while others, which have controlled high fertility rates, are already experiencing or are poised to experience an increase in their elderly population. There has been a progressive increase in both the number and proportion of the aged in India over time, particularly after 1951. Between 1901 and 1951, the proportion of population over age 60 increased marginally from 5 percent to 5.4 percent, while by 2001 this had increased to 7.0 percent. When changes in the decadal growth rate in the general population are compared with those for the elderly population, it is noted that the latter grew at a relatively much faster rate than the general population, since 1951. Furthermore, the decadal percent increase in the elderly population for the period 2001-2011 is likely to be more than double the rate of increase of the general population. The size of the elderly rose in absolute terms during the last century from 12 million in 1901 to approximately 71 million in 2001 and is likely to reach 113 million in 2016. Yet another feature of ageing in India is the fact that the proportion of elderly is much higher in the rural areas than in the urban areas. In recent years, there has been an increase of aging in the society. The aging of the population can lead to an increase in the number of individuals at risk for chronic diseases. In an article from the Center for Disease Control and Prevention's Healthy Aging Network, physical activity (PA) was considered one key element for determining health status. In fact, evidence suggests that PA is associated with more years of life, self-perceived healthy life, years without impairment in daily life activities, lower rates of functional decline, lower risk of mortality, increased longevity, reduced risk of type 2 diabetes, and better quality of life. Being active throughout the majority of one's lifetime has an important influence on overall health and well-being. The widely known definition of physical activity (PA) as "any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level". PA has been found to check many long lasting health problems as well as to promote mental health and well-being. Lower mortality rates occur among those who become physically active late in life as compared to those who were active in early life and stopped exercising. Outdoor recreational PA, defined as "to be outside in natural or cultural landscapes for well-being and encounters with nature without demands for competition" has been shown to be particularly good for promoting www.iosrjournals.org 24 | Page (Kiran & Singh, 2014)	**Key Takeaways.** • Recreational activities are important for seniors' health. • Recreational activities provide socialization opportunities and opportunities to use their existing skills. • The senior population is varied, and different seniors have different interests. • Some seniors have enjoyed recreational activities their whole life and continue to. • Some seniors do not know of the importance of recreation.

Table K2 *Use of technology-based system to motivate older adults in performing physical activity: a feasibility study*

 BMC Geriatrics RESEARCH ARTICLE Open Access Use of a technology-based system to motivate older adults in performing physical activity: a feasibility study Abstract Background: Maintaining or initiating regular physical activity (PA) is important for successful aging. Technology-based systems may support and stimulate older adults to initiate and persevere in performing PA. The aim of the current study was to assess to which extent a customised Kinect system is (1) a desirable tool to motivate PA in older adults, (2) motivating to perform PA by older adults, and (3) easy to be used in older adults. Methods: A mixed-method cross-sectional feasibility study was performed in 2 aged care facilities in Flanders, Belgium. Aged participants were asked to perform a 20–30 min set with the Intelligent Activity-based Client-centred Training (I-ACT)-system. After the set, the Credibility and Expectancy Questionnaire (CEQ), the Intrinsic Motivation Inventory (IMI), the System Usability Scale (SUS), and semi-structured interviews were conducted in the older adults. Feedback was gathered using the thinking aloud method in both aged participants and healthcare professionals. Results: A total of 48 older adults (25 males and 23 females, mean age = 81.19 (SD = 8.10)), were included. The scores pertaining to system credibility and expectancy, system usability, and motivation towards use were moderate to good. Participants reported that they liked using the I-ACT system, but that the content could be more attractive by adding more visualisations. Twelve professionals stated that they observed involvement in older adults as the I-ACT is better used in day care centres. Conclusions: This study indicates that I-ACT is a usable and motivational system to engage older adults to perform PA and therefore supports successful aging. Future research is necessary to investigate the efficacy of I-ACT to perform PA and the transfer to regain and/or maintain engagement in ADLs that older adults find meaningful and purposeful at an older age. Also, further development of I-ACT is advisable to adapt the I-ACT system towards implementation as 'the home of older adults'. Trial registration: ClinicalTrial.gov ID: NCT04489563, 23 July 2020 – Retrospectively registered. Keywords: Physical activity, Older adults, Technology, Client-centred BMC (Knippenberg et al., 2021)	**Key Takeaways.** • Physical activity is important for senior health. • Technology can help seniors stay active. • This study assessed how a custom Kinect system can encourage seniors to be more physically active.

Table K3 *"It's not that I can't walk" : older adults' experiences of using canes and walkers*

 "It's not that I can't walk" : older adults' experiences of using canes and walkers Korotchenko, Alexandra Abstract Item Metadata (Korotchenko, 2017)	**Key Takeaways.** • Canes and walkers are popular mobility aids. • There is a lack of research on canes and walkers. • This study aimed to understand perceptions of walking difficulties.

Table K4 *Exercise Efforts on Bone Mineral Density, Falls, Coronary Risk Factors, and Health Care Costs in Older Women*

 ORIGINAL INVESTIGATION Exercise Effects on Bone Mineral Density, Falls, Coronary Risk Factors, and Health Care Costs in Older Women The Randomized Controlled Senior Fitness and Prevention (SEFIP) Study (Engelke et al., 2010)	**Key Takeaways.** • Physical activity is good for disease prevention and promotes positive senior health. • Physical activity can reduce health treatment costs by improving senior health. • This study looked at how a single exercise program can reduce fracture risks, falls, coronary heart disease, and heath care costs.

Table K5 *Outdoor recreational exercise programs and functional capacity: a study of sedentary seniors*

International Journal of Sport Management, Recreation & Tourism

I.J.S.Ma.R.T.

Outdoor recreational exercise programs and functional capacity: a study of sedentary seniors

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(Matsouka & Trigonis, 2008)

Key Takeaways.

- This study examined how exercise can impact the physical abilities of seniors.
- Did this by measuring the impact of a 12-week outdoor recreational exercise program on the functional capacity in sedentary seniors aged 60 to 75 years
- Measuring participant functional capacity before and after the exercise program, and the group who participated in the exercise program had more physical abilities than the group that did not at the end

Thank you!