ZETA

Adaptive Climbing Equipment

Designed By:
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Adaptive Climbing Equipment

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Abstract

Rock climbing has become increasingly popular in recent years and has garnered a lot of attention in the media especially after its debut in the Tokyo 2020 Olympics. Climbing as a sport offers full body activation and mental benefits. However, due to the nature of the sport, those with physical impairments are unable to fully experience everything that climbing has to offer.

Current products and technologies such as traditional harnesses and climbing walls are primarily targeted for able-bodied users, but there is little innovation towards those with physical disabilities. At its core, climbing is an individual sport. Those with physical impairments lack the ability to be independent. How can we make the climbing experience more independent for these users? Overall, how can we further enhance the sense of accomplishment for those feeling inadequate about their lack of mobility?

Acknowledgements

I wouldlike to express my gratitude and acknowledge my instructors for the thesis course, Catherine Chong and Sandro Zaccolo. Due to their selfless dedication to both the course and program as a whole, the project could not have reached its current level. The guidance, encouragement, and advice towards the process and direction were invaluable to the overall success of the project. Thank you for going beyond that of simple professors not only for myself for the class of 2022.

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1.1 Problem Definition

Rock climbing is an incredible sport boasting a full-body workout and an inclusive community. In addition to the physical benefits, research has shown that there are many psychological and mental health benefits as well. Being able to control and develop your body to achieve complex physical challenges can provide boosts to one's confidence and self-esteem.

Individuals with paraplegia are severely limited when it comes to participating in the sport. Without mobility of the lower limbs, the upper body must compensate for this lack of balance, posture, and support that the legs provide. As such, the breadth of climbs available are limited. With full functionality to only half of their body, the types of climbs they are able to ascend must be fairly linear, systematic, and accommodating for upper body strength utilization. These can become repetitive and uninspiring for the casual intermediate climber.

1.2 Rationale & Significance

Senior level thesis is a unique design project. From problem definition to a planned idea/concept, it a full encompassing proposal that is the culmination of the four-year industrial design program. With the thesis, there are four essential criteria pillars to be followed:

1) Enhancement of human lifestyle
2) Full-bodied human interaction design (FBHID)
3) Full-bodied ergonomics and human factors design
4) Sustainability and social responsibility

These four pillars provide the basis for which all research and subsequent sections strive to understand and provide information for in order to propose a design solution on an evidence-based approach.

1.3 Background & Social Context

Just in the past decade there has been a surge of popularity with the sport of rock climbing. According to the Climbing Business Journal "the commercial climbing industry grew 6.9 percent in 2016, 10 percent in 2017, and 11.8 percent in 2018" (Olhorst, 2020). Furthermore, numerous climbing gyms have been opening up in North America that offer a climbing experience known as bouldering. Bouldering refers to rock climbing without the use of a harness or rope. This style of rock climbing is known for being fairly inexpensive to join, which has only added to the increased popularity of the sport. Rock climbing has even garnered the attention at the Olympics; the sport being featured in the Tokyo 2020 Olympics for the first time (Olhorst, 2020).

Paraclimbing or adaptive climbing is a branch of climbing that is dedicated to those with disabilities. Often heralded for the beginnings of adaptive climbing, Hugh Herr is an adaptive climber who lost his legs to frostbite, but adopted prosthetics in order to pursue his passion for climbing (Moja Gear, 2020). The beginnings of what adaptive climbing is today is often traced back to his efforts.

Products currently being used on the market for adaptive climbing purposes are being developed by Mark Wellman; an incomplete spinal patient but an avid rock climber before his accident. Even after his injury, he made many accomplishments as an adaptive climber. Now he dedicates his time to showing others that their injury or disability does not define them and that anyone can enjoy what climbing has to offer. Wellman has created a brand of adaptive climbing equipment that makes it so a wide variety of individuals can ascend a rope using a pullup ascender. Other products that Wellman has developed include seat harnesses that provide more support to physically limited individuals (Fengel, 2019).

The benefits of rock climbing for both typical users and those with disabilities has always been noted to be extremely high. For users with physical limitations, the sport is a great representation of the struggles that these users have to face everyday. Engaging in the sport allows them to foster a mindset of solving difficult problems and never giving up. These alone are invaluable to users that have had their life changed due to traumatic injury. In addition to these mental aspects, rock climbing is a great community to join and meet other like-minded individuals providing improved social well-being (XSA, 2017).

Chapter 2 - Research

Interested in learning to rock climb or improve their climbing experience.

Motivated to show that their disability does not define them.

Live a healthy lifestyle and remain social among their friends and community.

15-39

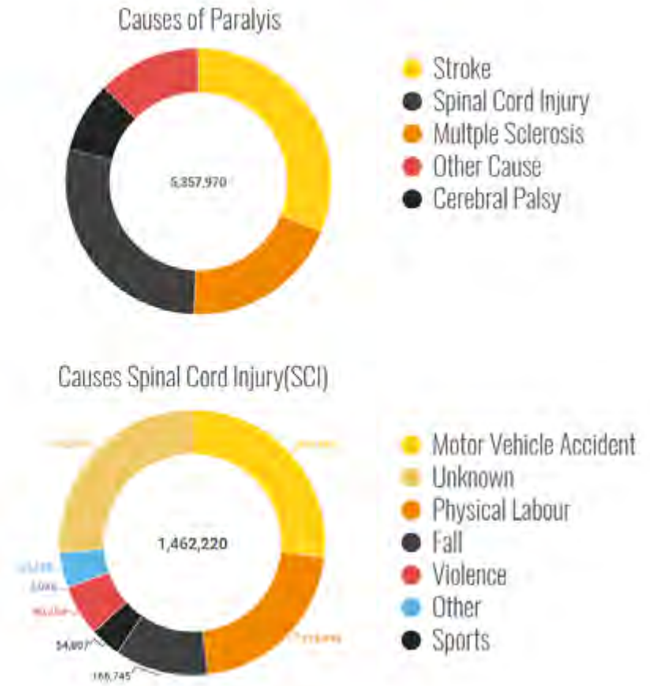
Typical Age Range of New SCI

2:1

Male to Female Ratio of those with traumatic SCI

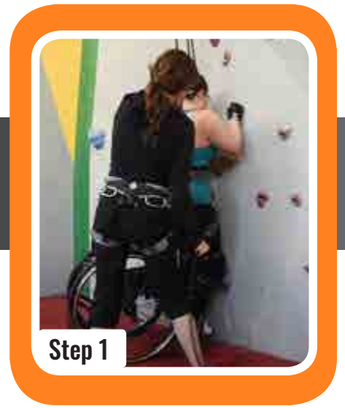
1.7%

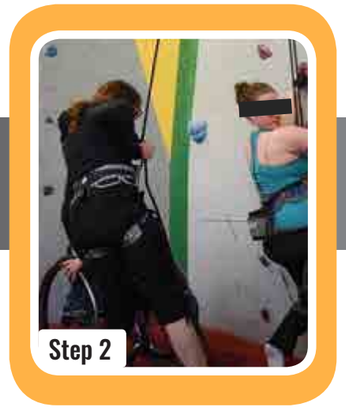
Percentage of those living with some form of paralysis

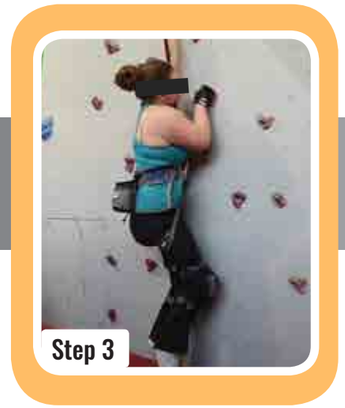


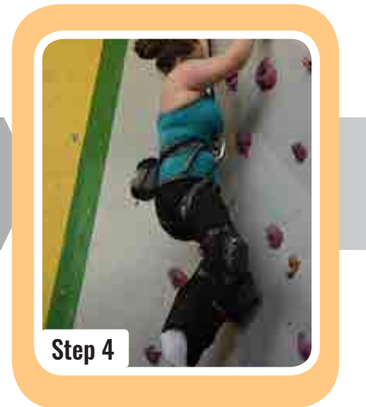
2.1.1 User Profile - Persona

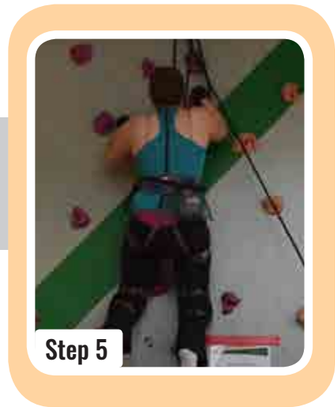
Paralysis is a condition that affects 1.7 percent of the United States population. (Reeve, 2013). The main causes of paralysis are stroke, and spinal cord injury. Focusing in on spinal cord injuries, the main causes are motor vehicle accidents and physical labour (Reeve, 2013). According to World Health Organization, every year between 250, 000 to 500, 000 people suffer from a spinal cord injury (WHO, 2013). Furthermore, the ratio between men and women with spinal cord injury is 2:1 (WHO, 2013). Finally, the average age range for those with spinal cord injury is between 20-29 and older than 70 for men and between 15-19 or older than 60 for women (WHO, 2013). In terms economic factors, households with those living with paralysis are generally lower income. 28 percent of households with a paralyzed individual make less than $15, 000 a year (Reeve, 2013). 15.5 percent of these individuals are employed and 41.8 percent of those with paralysis are unable to work (Reeve, 2013). From the following demographic data, a persona is created attach the solution to a targeted user.











2.1.3 Activity Mapping - Indoor

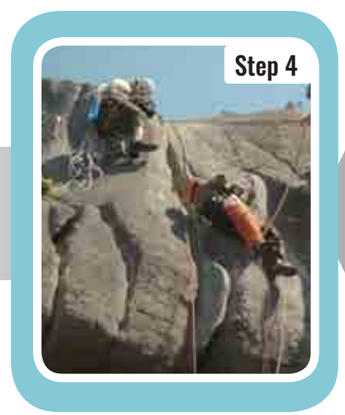
An activity map or journey map is an important tool to empathizing with the target user. and fully understand their journey, pain points, and potential opportunities for design solutions. The steps that the user took in an indoor climbing setting are as follows:

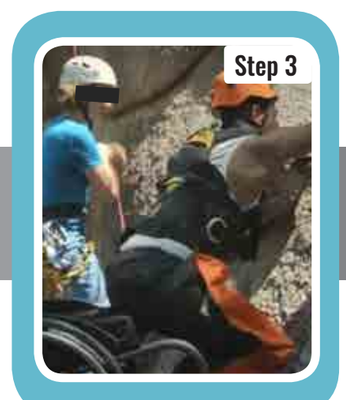
Step 1: User is lifted out of the wheelchair and onto the wall
Step 2: The belayer moves the wheelchair away from the user while holding their weight
Step 3: User begins to climb with a mechanical assistance of thirty percent
Step 4: Full use of the upper body to support their weight and climb
Step 5: User reaches the top using their own body
Step 6: User is lowered onto their wheelchair after finishing their climb

2.1.3 Activity Mapping - Outdoor

The activity map on the bottom shows a user with complete spinal injury climbing outdoors for the first time. It outlines the struggles of climbing without the use of their legs and the struggles that they might experience. The steps of this particular activity mapping are as follows.

Step 1: User puts on a full-body harness and leg chaps for protection from the rocks
Step 2: Another climber situated on the wall is used as a counterbalance
Step 3: User grabs onto the rocks to start climbing
Step 4: Inability to use their legs for balance causes them to spin backwards on the wall
Step 5: After reaching the top, user is in high spirits
Step 6: User is lowered onto their wheelchair after finishing their climb





2.2 Product Research - Adaptive Climbing Products

Below are three different adaptive climbing products currently being used. Each product in this category are generally repurposed products for the specific application of adaptive climbing. Other products benchmarked throughout this section include climbing harnesses and climbing shoes.

Petzl Volt LT
$499.95

- Designed for industrial use
- Commonly used in adaptive climbing applications
- Bulky
- Solid construction
- Unnecessary safety features for adaptive climbing

Wellman Pullup Bar
$350.00

- Adaptive Climbing equipment
- Allows the user to perform pullups to ascend a rope
- Applies to a large range of disabilities
- Takes out the “rock climbing” aspect
- Grip is not very ergonomic
- Not a largely manufactured product

Miasty Mountain ARC Full Harness
$718.00

- Adaptive climbing equipment
- Seated harness that securely straps user
- Provides comfort and support unique to the needs of physically limited users
- Lack of interaction with the wall

2.2.0a Benchmarking - Climbing Harness

Arc'teryx AR 395a
$200.00

Arc'teryx FL 365
$113.93

Black Diamond Zone
$119.95

Petzl Sama
$89.95

2.2.1a Benchmarking Benefits & Features - Harness

The first product of interest is climbing harnesses. The gateway to top rope climbing, climbing harnesses are an important piece of equipment to keeping the user safe. Numerous different climbing harnesses at different price points were examined for their benefits and features. After compiling the product specifications, a list of key words was tabulated to create a word frequency count to highlight common benefits between different harnesses.

The main common benefits for climbing harnesses are: comfort, support, safety, flexibility, durability, and performance. Some of the differences in features between different price points include: more or less gear loops, lighter and thinner material, and brand recognition.

2.2.2a Benchmarking Functionality - Harness

Climbing harness are highly scrutinized for manufacturing quality and safety regulations. Before the time of harnesses, ropes would be tied around the user's waist which evolved into preliminary designs known as the Swami belt. The first harnesses sold roughly fifty years ago. Compared to military and commercial harnesses that are strictly regulated, there is no specific external legislation that regular harnesses must pass. Most climbing brands have developed their own standards that follow the UIAA and EN standard of withstanding 15kN of force (Sanders, 2018).

A climbing harness functions by wrapping fabric around the legs and waist to distribute the weight of the individual when falling from considerable heights. As such, each component must be solid enough to withstand the forces applied to it. In addition to the three loops, the connection point between them and the belay loop must be able to withstand the force of a falling individual. As such key importance is placed in the strength of stitching and the belay loop that connects the main components.

2.2.3a Benchmarking Aesthetics – Harness

Here is a linear scale of climbing harnesses based on their price points from least expensive to the most expensive. The goal is to examine the aesthetic and semantic profile of products currently on the market in order to appeal to different consumer grades. This will help develop the aesthetic approach of the proposed final solution. Harnesses that are below the one-hundred-dollar mark tend to use minimal colouring and accents in their construction. Visually, there are quite a few grey and black harnesses. In addition, material is often limited to a single colour for different components.

As the price increases, especially above the one-hundred-dollar mark, there is a shift in the design language as well as the form. The three main loops of the harness now consider using two tone colour palettes as well as thinner materials to reduce the weight. In addition to the shift in colour, the form of the harness also changes to have more complex geometries. This is meant to conform the user's curves more accurately and provide freedom of movement when climbing. Finally, products that exceed the two-hundred-dollar mark such as the Arc'teryx AR 395a generally incorporate all of the previous changes, however the brand name acts as a premium that is used justify the price difference.

2.2.4a Benchmarking Manufacturing - Harness

Climbing harnesses are made from a mix of textiles, foams, and metals (Dennis, Eco-friendly & sustainable climbing harnesses 2021). Textiles create the outer shell of the harness while the foam is used in the padding of the waist and leg loops. Finally, the metal is used for the buckles that hold the adjustability straps. The load bearing loops of the climbing harness are made from a bonded nylon or a bonded polyester (Sailrite Enterprises, Inc, 2021). Polyester threads are used for more outdoor application due to their strong UV resistance. Nylon is typically used for indoor use due to its increased elastic strength when compared to polyester. The specific stitch patterns used depends on the maximum strength of the material. Generally, the number stitches required will depend on the material used such that the mode of failure happens with the webbing material as opposed to the stitches.

2.2.5a Benchmarking Sustainability - Harness

Bluesign technologies is private company that tracks the supply chain of raw sustainable textiles all the way to the consumer market. It is the number one measure for sustainability of textiles in climbing and outdoor gear. They generate certification and evaluate areas in a manufacturing process that can be improved or should be avoided due to their harmful effects to the environment. The three main certifications of Bluesign technologies are: materials, products, and companies. “A Bluesign material is one that uses nontoxic chemicals and processes in its creation. Meanwhile, a certified Bluesign product contains at least 90 percent Bluesign-certified materials” (Dennis, How green is climbing gear? 2017).

The challenge of creating a sustainable climbing harness comes from the absence of sustainable options. Currently there are over 330 different harnesses, but only about ten of those harnesses are Bluesign certified. Harnesses are made from a combination of textiles, foam, and metal. The foam and metal components found in harnesses currently have no sustainably certified material as a substitute. The first Bluesign certified harness was created by Edelrid shown in Figure 4. Currently, Edelrid is the only brand to continue to strive for Bluesign certified products however other brands such as Black Diamond have incorporated Bluesign material in their product (Dennis, Eco-friendly & sustainable climbing harnesses 2021).

2.2.0b Benchmarking - Climbing Shoes

Scarpa Furia S
$238.95

Scarpa Vapor V
$188.95

La Sportiva Otaki
$219.95

Evolv Geshido
$209.95

2.2.1b Benchmarking Benefits & Features - Shoes

Numerous different climbing shoes at different price points were examined for their benefits and features. Compiling the product specifications into a excel spreadsheet provided the data to do a word frequency analysis. The most common benefits and features among climbing shoes is as follows:

The main common feature for climbing shoes is their downturned profile. The more aggressive the shoe, the higher the performance; a more downturned angle allows for more precise power on small footholds. comfort, support, and the type of material all play a role in the performance of the shoe. Finally, the colour choice as well as the type of lacing system are key features that consumers look at when purchasing a climbing shoe.

2.2.2b Benchmarking Functionality - Shoes

The climbing shoe is a key piece of equipment that can really impact the performance of the user. The sticky rubber provides high levels of traction while climbing rough surfaces. Climbing shoes also tend to fit snugly to the user's foot. This is to provide a greater feel when climbing on uncertain footholds. The variety of climbing shoes varies from brand to brand. Some aspects such as the toebox may be wider for one brand, while narrower for another. Brands with specific technologies may also play a part in boosting performance. Overall, all climbing shoes that are sold to consumers dramatically increase the user's confidence when climbing.

2.2.3b Benchmarking Aesthetics - Shoes

Here is a linear scale showing different climbing shoes at different price points. It is also broken up in to men and women specific shoes. The goal is to examine the aesthetics of climbing shoes and develop a semantic profile that could be used for the proposed design solution.

At lower price points the amount of colourations present is simpler. There are less elements and each shoe generally use two colour accents along with the black from the climbing rubber. As the price increases the number of small details that are added such as accent graphics is more present. Other small details and such as vent holes and more angular lines becomes more apparent. At a higher price point, the aesthetics of the shoe accentuate the aggressive downturned toe along with more intricate strap detail.

2.2.4b Benchmarking Manufacturing - Shoes

Known for their aggressive and tight-fitting reputation, climbing shoes are synonymous with the sport. Anyone who has worn a pair of rental climbing shoes versus a new pair can immediately feel the difference in the performance. There is no question that climbing shoes play an important role in improving an individuals overall climbing performance. Climbing shoes are constructed with a combination of glue, textiles and rubber. Using a unique last specific for climbing, the insole and midsole are constructed as one piece. The rubber is added to the shoe with adhesive and heat in order to mould the shoe into the desired shape. This also helps provides structure to the shoe and improves its performance.

The common types of climbing shoe rubber are made by Vibram and are specifically designed to resist the abrasion of rock while remaining sticky for optimal grip. (Dennis, How climbing shoes are made 2021). After applying the rubber to the sole of the shoe, a craftsman expertly grinds down any excess rubber and shapes the final product. Technology has allowed climbing shoes to become much more elaborate with their designs with the presence of intricate flat patterns for the insoles and 3-D molded rubber to reduce the amount of excess rubber that is removed (Dennis, How climbing shoes are made 2021).

2.2.5b Benchmarking Sustainability - Shoes

The main sustainability initiatives being used in climbing shoe products are: eco-leather, recycled rubber, hemp footbeds, water-based glues, and 3-D moulded rubber components. The main textile of the shoe can be made from recycled fabrics such as repurposed fishing nets. Eco-leather is alternative material used in some climbing shoe uppers; tanned leather without the use of heavy metals. The second major component of sustainability is the rubber. Normally these rubber pieces are stamped from large sheets and the excess is discarded. La Sportiva is using the leftover material to be re-melted and made into FriXion Eco Rubber. One sheet of this Eco rubber can be recaptured from five sheets of Vibram rubber. Even after the climbing shoe has been sold, the consumer is able to resole the rubber, significantly lengthening the lifespan of the shoe (Dennis, Sustainable eco-friendly climbing shoes 2021).

Chapter 2 - Summary

Chapter 2 outlines the preliminary research into the proposed problem definition. The three main categories to consider are: the user, the environment of use, and product benchmarking.

The user defined in this section has three main goals. The first is a passion to enjoy and pursue rock climbing. The second is the drive to become more independent. Finally, wanting to cultivate a fulfilling social experience.

The activity mapping helps outline the entire journey of the user. Both indoor and outdoor scenarios are considered to understand their differences and similarities. Ultimately, the indoor setting was chosen due to its increasing popularity and accessibility to the user.

Product benchmarking of both climbing harnesses, climbing shoes, and adaptive climbing products put the level of detail and design thinking into perspective.

By understanding the user's Interaction points, pain points, and opportunities to improve in addition to the available products and competitors, a new innovative design solution can be achieved.

Chapter 3 - Analysis

3

Maslow's Hierarchy of Needs
Climbing Harness

Product - Seat Harness		
Needs	Benefits and Underlying Needs	Level of Importance
Basic Needs	Physiology (Individual)	Level of Importance
Food, Water, Shelter		
	Sensory	
	Comfortable Material	
Pleasure, Gratification	Feel of the harness when pulled from the belay loop	Moderate
	Addiction	
Security	Safety, securing resources	Level of Importance
State, Group, Individual	Protection of user from falling from significant heights	High
Securing resources	price is not a factor in the overall performance of the product	Low
	Product that allows the user to perform a certain activity	
Control over environment (tasks)	Easy to put on and adjust to fit different size of users	Moderate
Long Term Security/Stability of Group	Form of security for the individual's safety	High
Social Belonging	Effort / resources to belong to a 'tribe'	Level of Importance
	Without this product, the user could be abandoned by those who own the product.	
Fear of Abandonment	Cannot partake in activities that use this product	Moderate
Fear of the enemy	Height/falling risk is greatly minimized	High
Tribal Identity	Associated with climbing culture	High
Behavior cues for survival		
Behavior cues for social interaction of group	Generally be purchased to be used in a group setting	Moderate
Peer Pressure	More experienced climber = personal equipment/harness	Moderate
Esteem	Personal influence in 'tribe'	Level of Importance
Social Status (tangible purchases)	More expensive products provide more clout/performance	Moderate
Social Recogoition	more expensive product is seen as more experienced	Moderate
	brand of product can play a part in appearing more experienced	
Sexual attractiveness	and more stylish	Moderate
Self-Actualization	Needs that are pre-dominantly 'outer cortex'	Level of Importance
	Making the product their own	
Intrinsic pleasure	An extension of their own body much like clothing	Moderate
	Allows the user to express their personality through colour and	
Creative endeavors	brand	Low
Experiential (extrinsic)	This product allows the user to experience rope climbing	High
Experiential (intrinsic)	Challenging experience solving climbing routes	Moderate
Emotional		

3.1.1 Needs/Benefits Not Met By - Harness

The above table corresponds to an evaluation of user needs based on the level of importance according to Maslow's hierarchy of needs around climbing harnesses. This study corresponds to five models of psychological human needs ranging from survival needs to self-actualization.

Comfort/Ergonomics/Aesthetics

The first need that is not completely met with traditional climbing harnesses is the comfort and ergonomics for those without disabilities. The needs of an individual with paraplegia can vary significantly. The types of pressure points and extra support that is required is something that traditional harnesses are not well equipped for. The research advisor for this project has mentioned that the products that they use for harnesses are in fact meant for industrial applications. As such, features that are normally used by construction workers tend to not be useful and provide extra weight to an adaptive climber. In summary, there is a desire for more dedicated adaptive climbing equipment designed for users with physical limitations.

Lack of Independence

The second need that is lacking from climbing harnesses is very similar to the first as it relates to having more dedicated equipment for users without the ability to move their legs. The lack of independence for the user to don and takeoff the product by themselves proves difficult and can have negative impacts to their self-awareness. Rental harnesses are able to accommodate this issue with straps that can be undone, however this poses other challenges. These challenges include: being more of a burden, the time it takes to don a harness increase, and the aesthetic profile of these harnesses being sacrificed as a result.

Climbing Culture

The third need, not met by current adaptive climbing products, is the idea of climbing culture and how current products are marketed and styled. Looking at the aesthetics of different products, climbing equipment is colourful and the style of the equipment tend to be a reflection of the personality or persona that each individual view themselves with. Adaptive equipment currently is still in a phase of function. Often times, equipment used in adaptive climbing is meant for other applications. For example, chainsaw chaps are commonly used as legs chaps for those with paraplegia to prevent skin from scraping the wall. By incorporating stylistic aspects of traditional climbing equipment, the goal is changing the perception on adaptive equipment as simply just a means, but more of a statement of the individual.

Improved Climbing Experience

The final need, not met by current adaptive climbing equipment, is the lack of depth in the experience that a person with paraplegia can partake in. Adaptive climbing equipment currently supports the climber as they ascend, but does nothing in terms of augmenting the experience. Due to the lack of mobility in the user's legs, the contact points that can support them on the wall is limited to two. This aspect severely cripples the type of routes available to them to climb in an indoor setting. The main goal of the proposed design solution is to create this third point of contact to fully enhance and change the way complete spinal injury individuals climb.

3.1.2 Latent Needs

The Latent needs of the primary user are closely related to the needs mentioned previously regarding current product solutions however looking more specifically at the actions that they take to climb. These needs are as follows: Adaptive equipment that can support them, encouragement from others, more interesting climbs, and ergonomic equipment.

Adaptive Climbing Equipment

The first latent need of the user is having access to adaptive climbing equipment. Most climbers with a complete spinal cord injury that would like to partake in rock climbing must do so through organizations that provide services to allow them to rock climb. Comparatively, typical users are able to purchase all their equipment at an athletic co-op store. This gap in climbing products availability is a big part of why those with paraplegia are not often seen in the sport of climbing.

Encouragement while Climbing

The sport of climbing is a fulfilling individual sport that challenges one to push their limits and conquer adversity. Even though climbing is an individual sport, the community and culture has always been about support and inclusivity. As such the second latent need for the primary user is increased amounts of encouragement. Due to their condition, self-esteem and confidence is lower than typical climbers. As such, more encouragement while climbing and especially when they are not climbing can help break the barrier of entry for users with paraplegia.

More Interesting Climbing Routes

This third latent need was discovered through user observations. As an avid climber, the different combinations of moves and body positions that one can maneuver is vast and keeps the sport of climbing very interesting. Due to paraplegia, the primary user is unable to access these types of routes and is generally forced to climb straightforward up and down climbs with large holds. The latent need that these users experience is the hunger for more challenging and interesting climbing routes.

Ergonomic Equipment

The final latent need experience by the user is lack of ergonomic equipment for their specific limitation. Without feeling or movement below the waist, it becomes more important the primary user remains upright. As such full-body harnesses are preferred for these users however, most climbing harness companies do not design or manufacture full-body harnesses. Turning to other harnesses for different applications, this provides a mismatch of features needed for rock climbing.

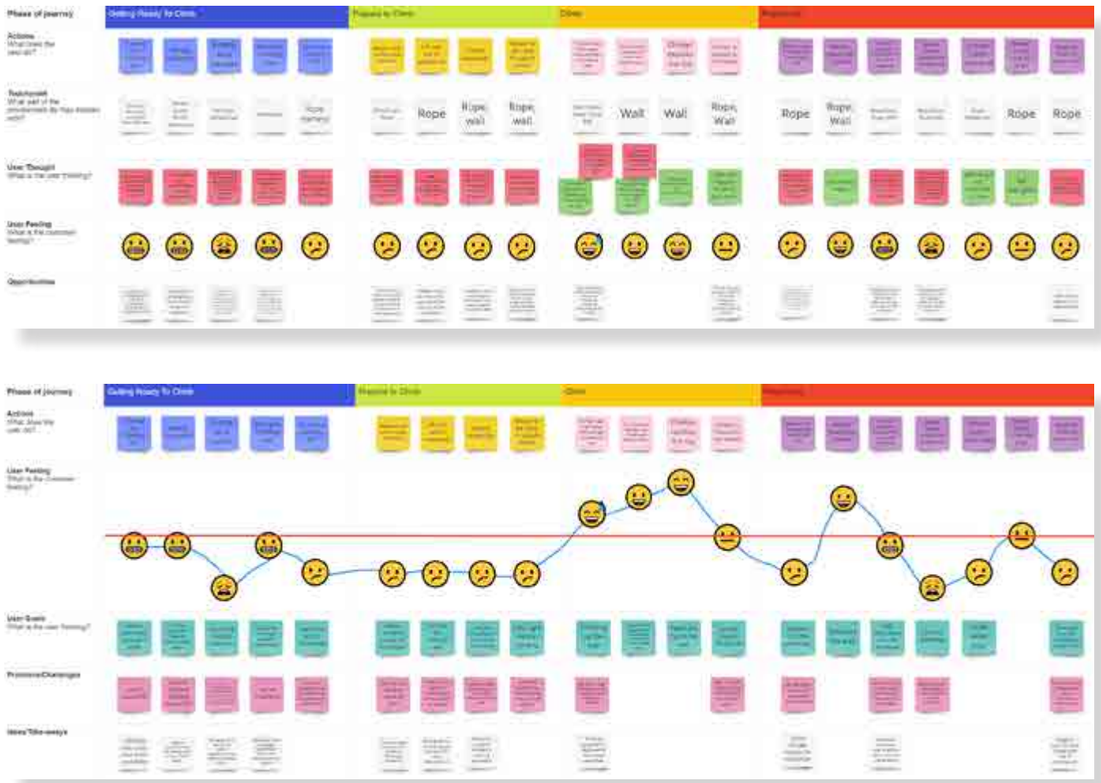
3.1.3 Categorization of Needs

The thesis project is based around the ideas of human-centered design and evidence-based design. The above figure outlines the needs of the user based on the research conducted. It is divided into their immediate needs, latent needs, and wants/wishes.

The immediate needs of the user are accessibility of equipment, increasing their physical strength to compensate for their lack of leg mobility and the assistance they need to put on equipment and maneuvering in and out of the wheelchair.

The latent needs of the user are adaptive tools to support them in climbing, encouragement instead of judging eyes from their peers, and overall, a better climbing experience.

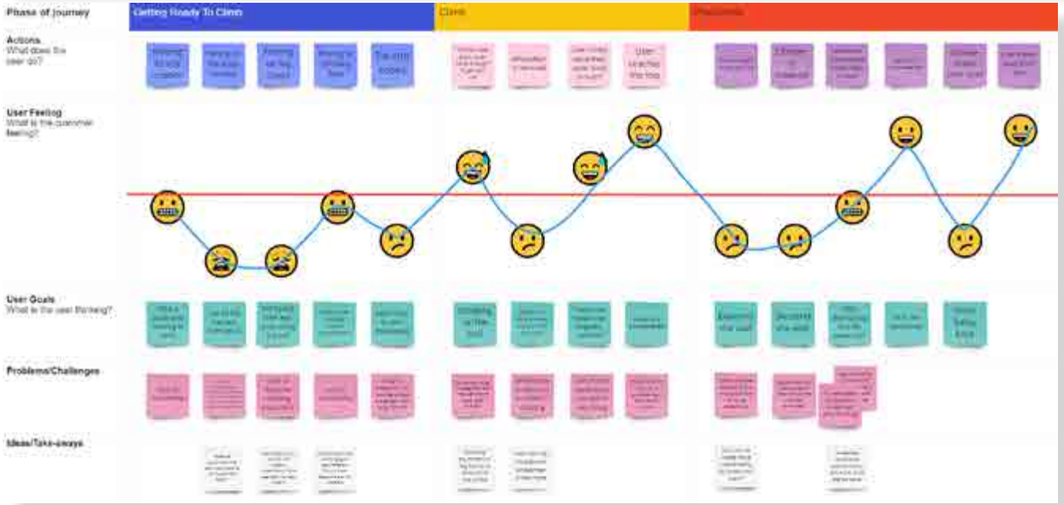
Finally, the wants and wishes of the user are to improve their skills as a climber, physical strength and mental well-being.



3.2.1 Journey Map + User Experience - Indoor

Journey mapping and user experience mapping are key analysis tools for designers that shed understanding on the user and their environment. The journey map and user experience map shown above represents the journey of an indoor climber with paraplegia as they ascend and descend a route. By outlining each action taken by the user in a detailed manner and breaking them down into their core components, new insights can be obtained.

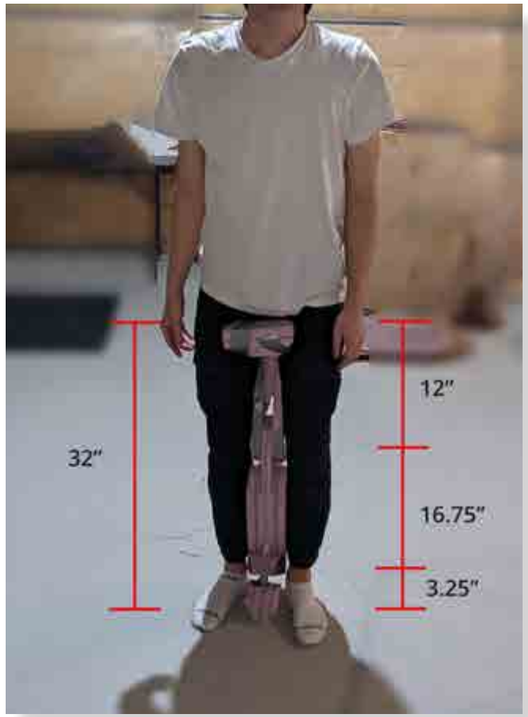
Some of the key takeaways for this journey map and user experience map is how much extra work the belayer is required to do. Furthermore, the amount of extra physical exertion that the climber must exert due to the immobility of their legs. For a new climber, this overexertion can lead to injuries that prevent them from climbing more which can lead to other health complications. Finally, there is a lack of independence with the user which can bring down their self-esteem.

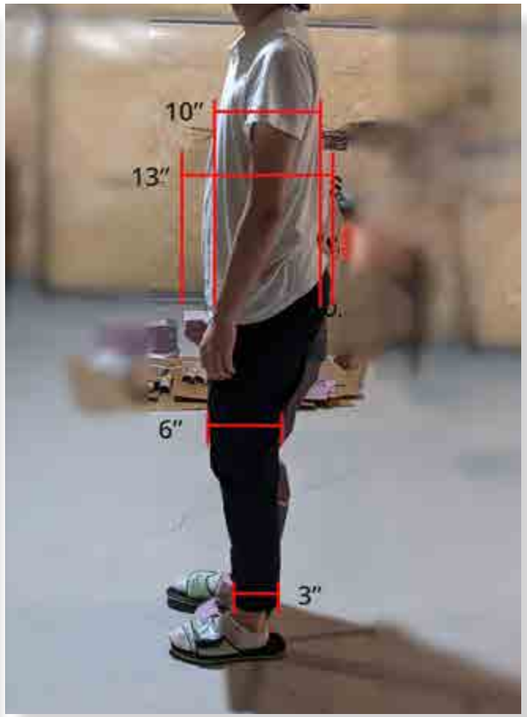


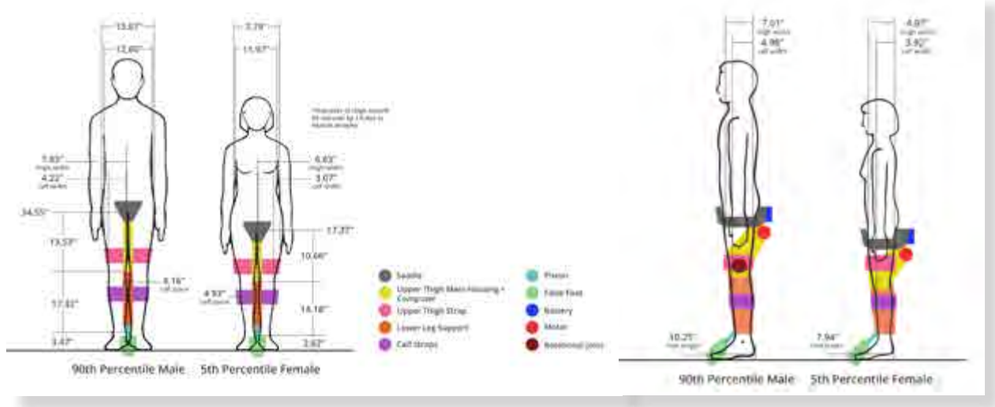
3.2.1 Journey Map + User Experience - Outdoor

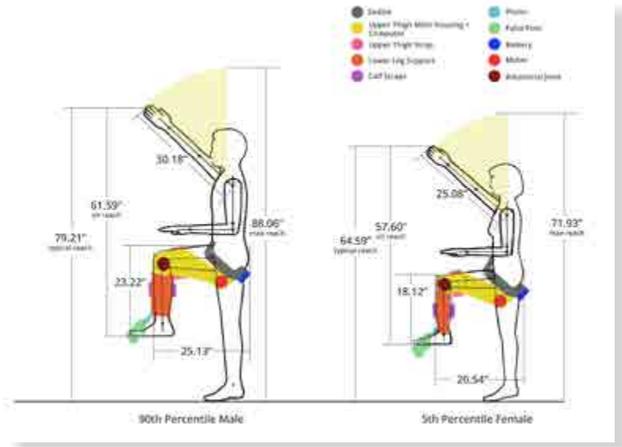
The journey map and user experience shown above represents the journey of an outdoor climber with paraplegia as they ascend and descend a route. Some of the different steps compared to an indoor climbing route include getting to the outdoor location as well as putting on more gear due to difference in infrastructure present.

Some of the key takeaways from an outdoor climbing perspective is how can the setup time as well as the number of individuals helping the user be decreased? Overall, the experience of outdoor climbing has factors such as the environment playing a big role in the user's enjoyment unlike the more controlled space of an indoor gym. Generally speaking, the physicality of indoor and outdoor climbing is very similar and a such the proposed design solution could plausibly work in an outdoor setting.





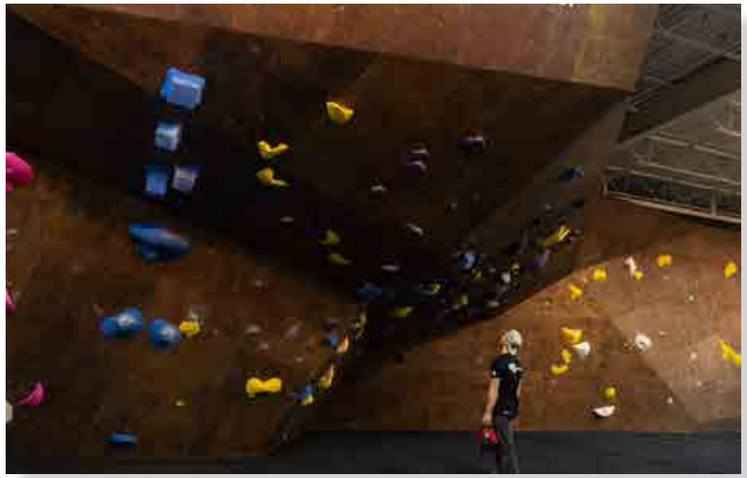


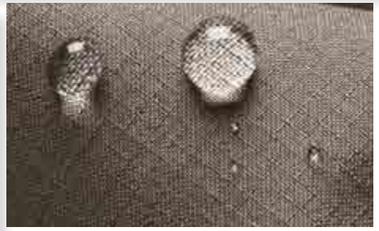


3.3 Ergonomic Profile & Configuration Diagram

The human ergonomic study performed has provided some very key insights into the feasibility of the design as well as the problems that some initial design iterations have. Overall, the learning outcomes from this study created a far better understanding of how the design will move forward. Some key aspects of the design that stemmed from the ergonomic analysis include the major touchpoints of the perineal area and the inner portion of the limbs.

The limitations encountered with this study include the lack of adjustability incorporated into the scale mock-up. Other aspects of the design that were difficult to pin down are the security of the connection to the user. For future human studies, a user more aligned with the end user should be tested to get a better understanding of what they can and cannot feel in terms of how secure the product is attached.














3.4 Aesthetic & Semantic Profile

Climbing culture and the look of what it means to be climber has many different aspects, but its distinguishing features can be seen by anyone. The idea of being a climber or being someone invested in the outdoor field is synonymous with certain brands and a particular look. These collections of images portray the aesthetic profile of what it means to be a climber. The type of gear includes clips, ropes, harnesses, shoes, etc. The specific patterns and colour schemes present within these products is also quite appealing with bright and vibrant colours. The goal of the final design is to create a product that can fit within this aesthetic profile and become part of what represents the aesthetics of climbing.

3.5 Sustainability - Safety, Health and Environment

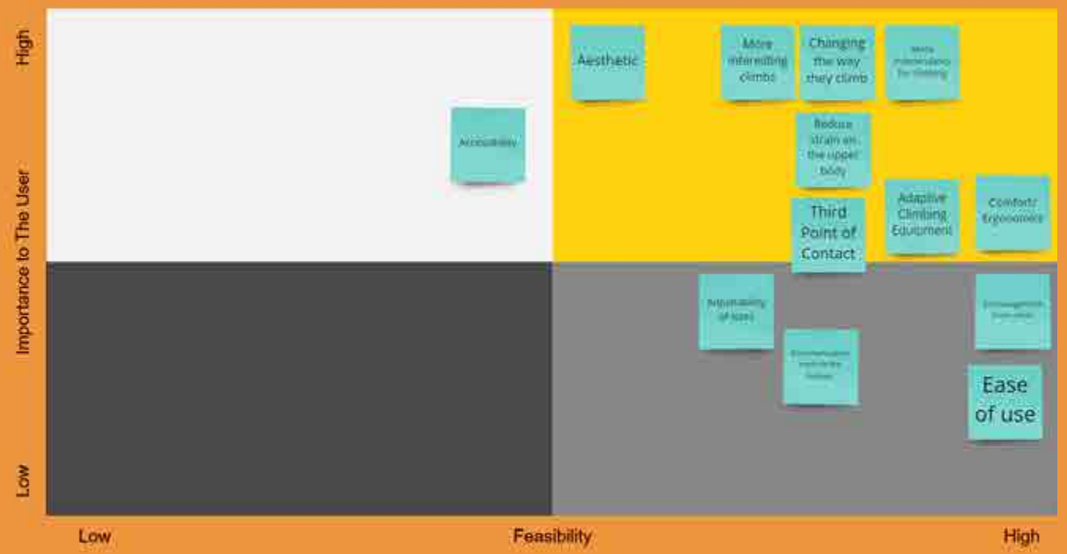
Due to the nature of climbing and application of wearable robotics, safety is a big concern for how the product interacts with the user. With respect to the ergonomic study, the proposed design solution would be a wearable piece of technology that improves the wearer's ability to climb. In this case, the user is an individual that has paraplegia.

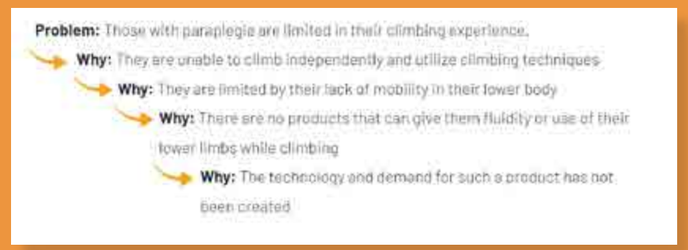
For the proposed design it is crucial that the product does not impede the user or cause injury. This is especially important due to the fact that the user is unable to feel touch or pain in the lower part of their body. In the likely even that the activity must be stopped, the product should remain in a neutral position that does not compromise the user's ability to abort the activity safely. Furthermore, users will typically be wearing other climbing gear. Specifically, climbing harnesses are to be considered in the overall design and as its function must remain uncompromised; The harness' ability to safely support the full weight of the individual.

The user's physical and mental health are also big components to the success of the proposed design. Rock climbing is a very social sport and a has a great community aspect associated with it. Those with disabilities also face a lower mental state as compared to the average individual. As such with regards to the sustainability of the final product, it is important to take the aspects of mental health along with physical considerations. Firstly, the product must be able to enhance, but not take over the user's ability to rock climb. The ultimate goal of the product should not be to make rock climbing easier, but to make it more interesting and enjoyable.

Allowing those with paraplegia the ability to use control a third contact point while on the climbing wall is the short-term goal. With regard to the mental health of the individual, the product should make them feel empowered. Visually, the products should not look out of place, and be seamless in its execution to create exciting conversations, instead of conversations of abnormality.

The final aspect of sustainability is the environmental impact of the product. Overall, the sustainable sourcing of materials and manufacturing processes mentioned in section 2.2.4 and 2.2.5 are perfect examples of incorporated considerations that should be taken into account. Sustainable textile materials and understanding of plastics and their environmental impact are important to consider for the final design.





3.6.1 Innovation Opportunity

The above diagram is of a prioritization grid divided into feasibility and importance to the user. It takes all of the previous insights into the user needs and organizes them according to their priority. The key needs represented in the diagram are in the upper right corner represented by the yellow box. The needs of interest include: improving independency of the user, allowing the user to create more interesting climbs, and adding a third point of contact for users with paraplegia. These specific needs have high value in terms of opportunities for innovative thinking. It also strays away from traditional products and can open up the path to paradigm shifting products.

3.6.2 Desirability, Viability, Feasibility

Following the ideology of IDEO and human-centered design, there are three aspects that direct design thinking and create opportunities for true innovation. These categories are: desirability, feasibility, and viability.

Desirability

Desirability is the part of design that represents what the user needs and wants are. For a product to be desirable it has to fulfill the user's needs. As a commercial product, this is how the decision to purchase or leave behind a product at the store is rationalized by the consumer. The desirability of this project stems from the idea of the unknown and challenges how users understand and participate with adaptive climbing. This is the basis for which the design solution stems from.

Feasibility

Feasibility represents the physical and logistical challenge of creating a functioning product. If a product is not feasible, then it is nothing but a concept or a pipe dream. Feasibility is determined mainly by the comparison of similar products that help prove the concept. Other aspects include the manufacturability of the design and the function of its components. However, the biggest limitation to how feasible a product may be is the technology involved. The more advanced the technology, the greater chance there is for innovation.

Viability

Viability is the final category that defines the business model of the product. How does the product sell, and how what user groups does this product appeal to? These are questions that define a products viability in the market. Furthermore, what type of user is going to use this product? How long is the product going to last? These questions stem from what happens to the product during its lifespan with the user.

Innovation Opportunity

By combining these three aspects, the innovation opportunity for this thesis project comes from a niche market that has seen significant growth in both the popularity of climbing and the increasing number of individuals who experience some form of paralysis. As such, is the hope that with the project and application of innovative thinking that it will inspire others to continue and push the concept of adaptive climbing equipment further.

3.7 Design Brief

The goal of this design thesis it to improve the climbing experience for those living with paraplegia. The design brief will serve as the framework throughout the concept development stages keeping the following ten objectives in mind while consolidating the final design solution.

1. Safety – Must not interfere with existing safety products and regulations
2. Ergonomics – Ergonomic consideration and Human Interaction
3. Intuitive – Indicate feedback between the wall and product
4. Aesthetics – Improve the aesthetic appeal of traditionally designed equipment
5. Versatility – Multiple modes of activation
6. Sustainability – Full product life cycle consideration
7. Comfort – Mitigate stress/anxiety from negative perceptions
8. New Technology – Incorporate or create new applications of technology
9. Experience – Increase the depth of challenging/interesting climbing routes
10. Enhance – Create Opportunity for users to engage in a more active lifestyle

Chapter 4 - Design Developement

4.1.1 Aesthetics, Approach & Semantic Profile

Including the semantic profile developed for the existing products, this mood board of inspiration is meant to provide a starting platform to start from. Taking inspiration from some of these technologies is a great way to move forward and come up with some ideas that could lead to innovative solutions. Some of the important images include the wearable technologies. The mix between textile cushions and hard plastic has a sense of sophistication and technology that would be great to incorporate into the proposed design solution. In addition, the 3D printed technologies and forms help remove any limitations that traditional manufacturing practices may have that could ultimately affect the overall form of the design.

4.1.2 Mind Mapping

The above mind map represents potential areas of interest in terms of product categories, types of actions to achieve, the feeling and thoughts of the user, and current solutions on the market currently.

Writing these down helps organize the thoughts and brainstorm what areas are untouched in terms of current technology and products.

4.1.3 Ideation Sketches

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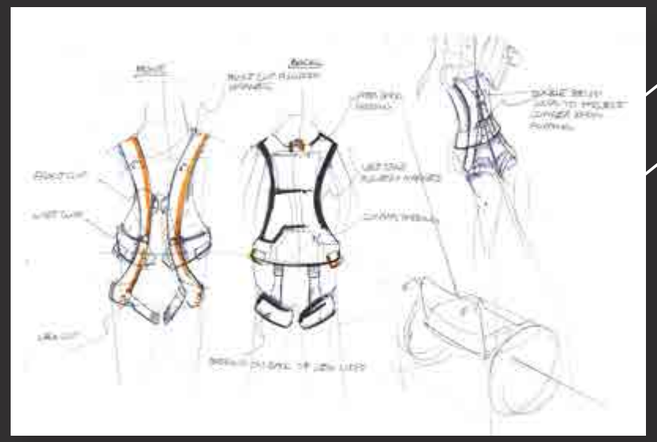

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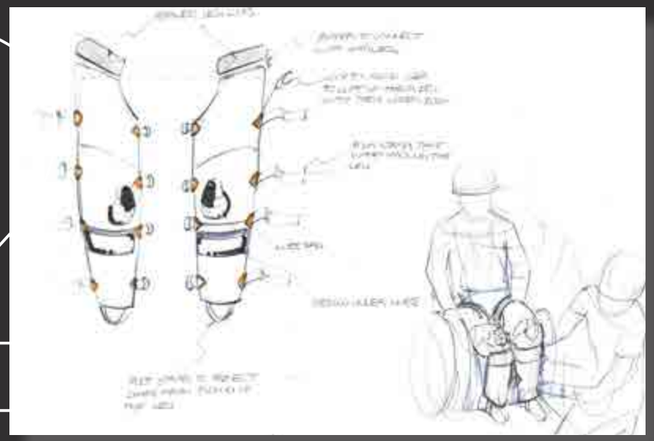

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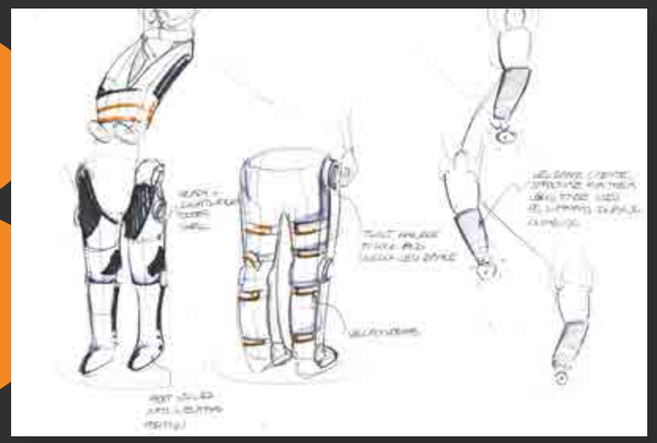

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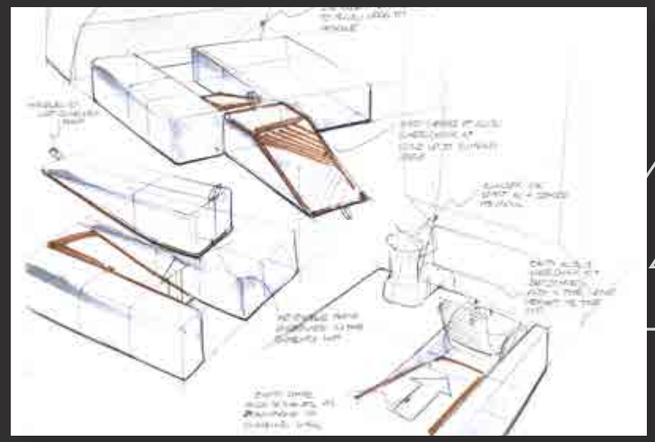

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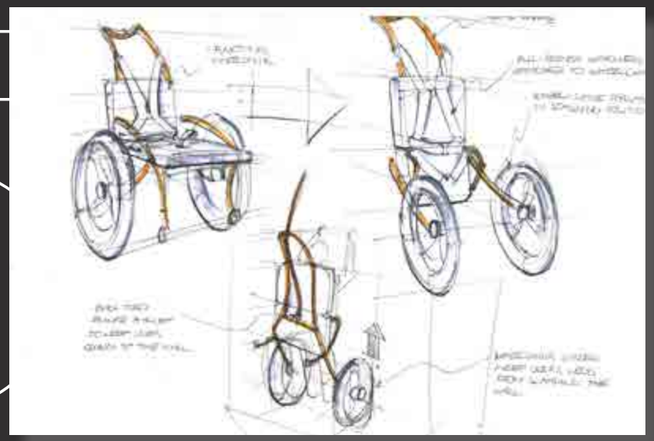

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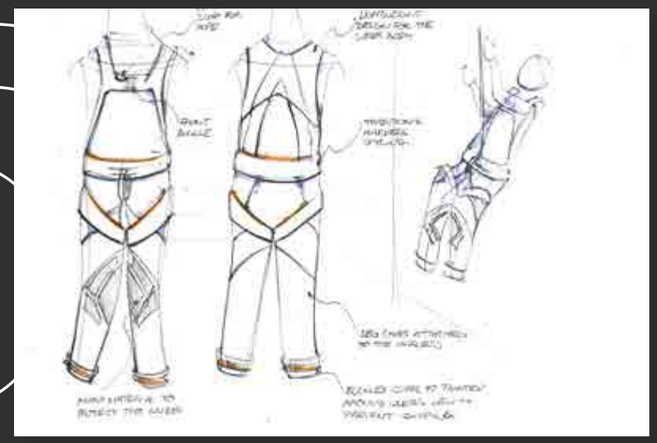

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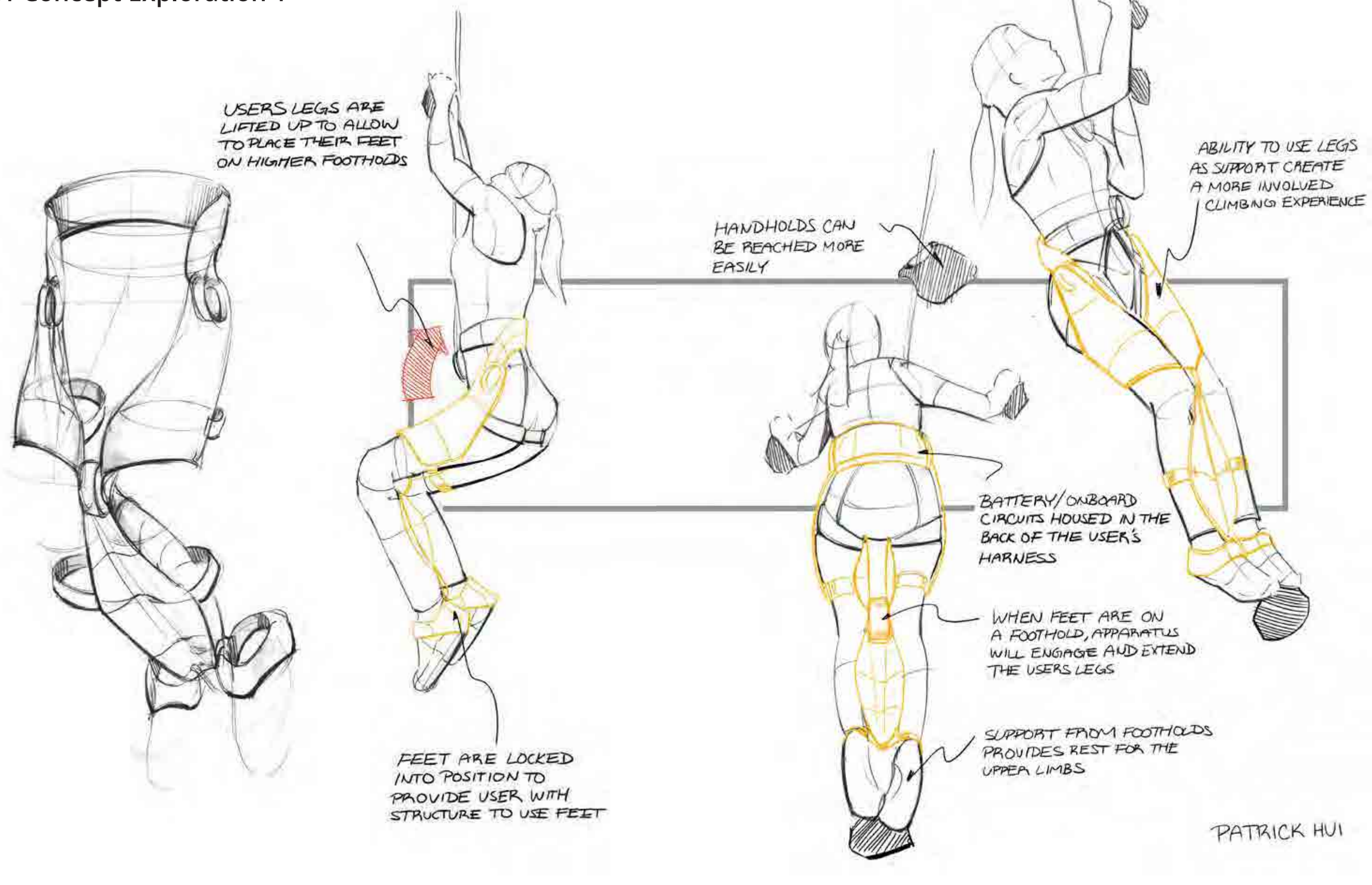

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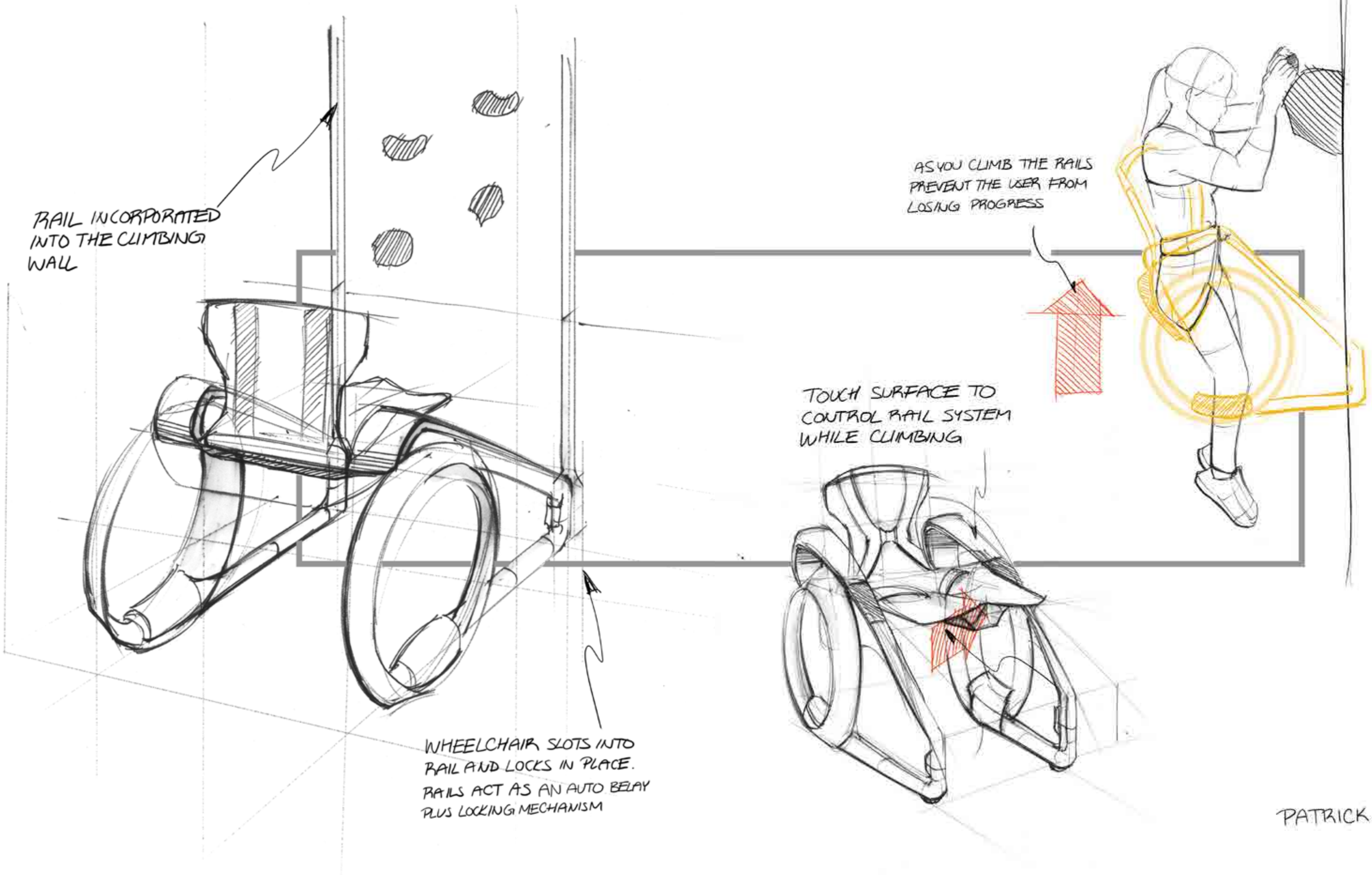

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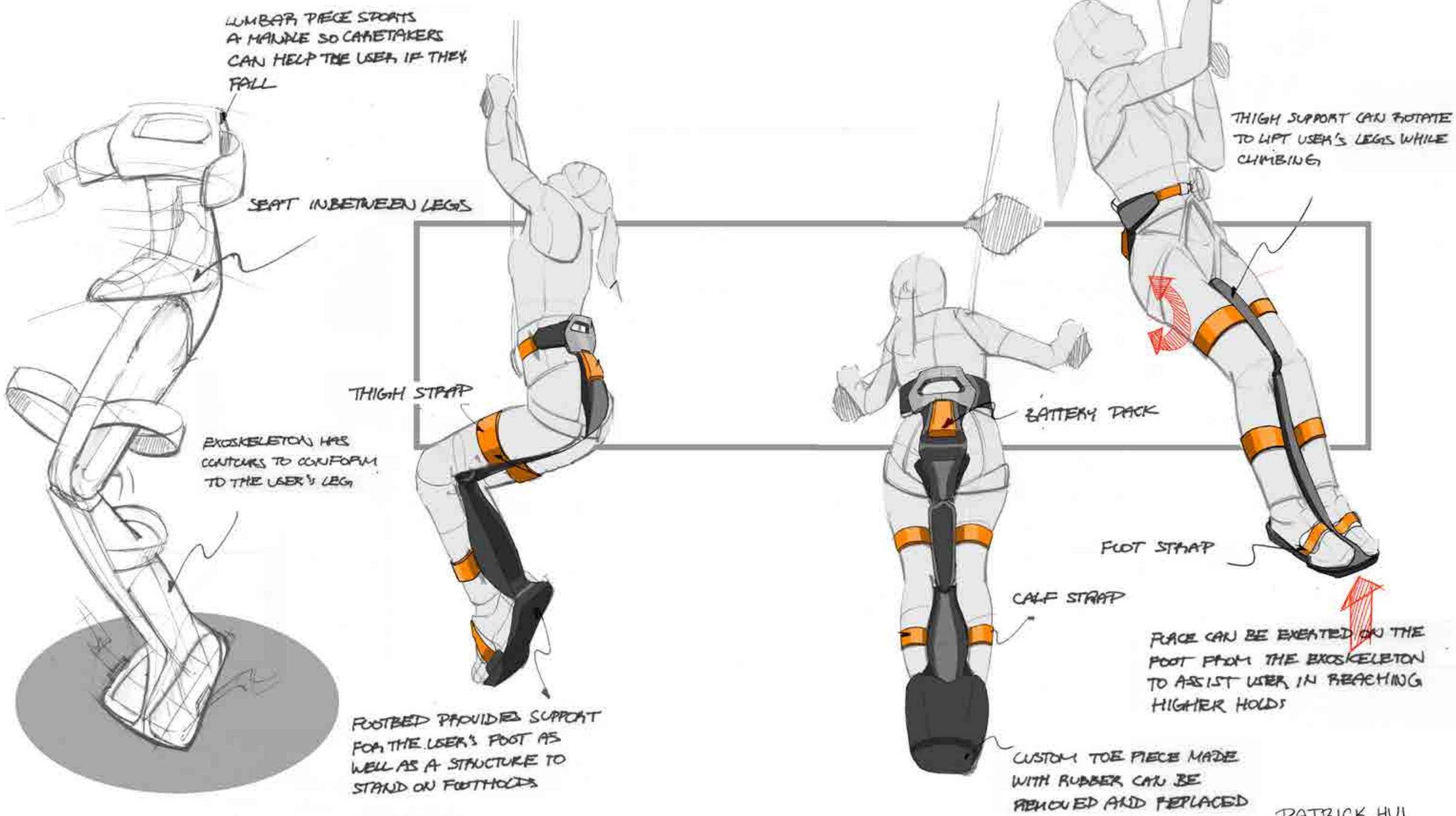
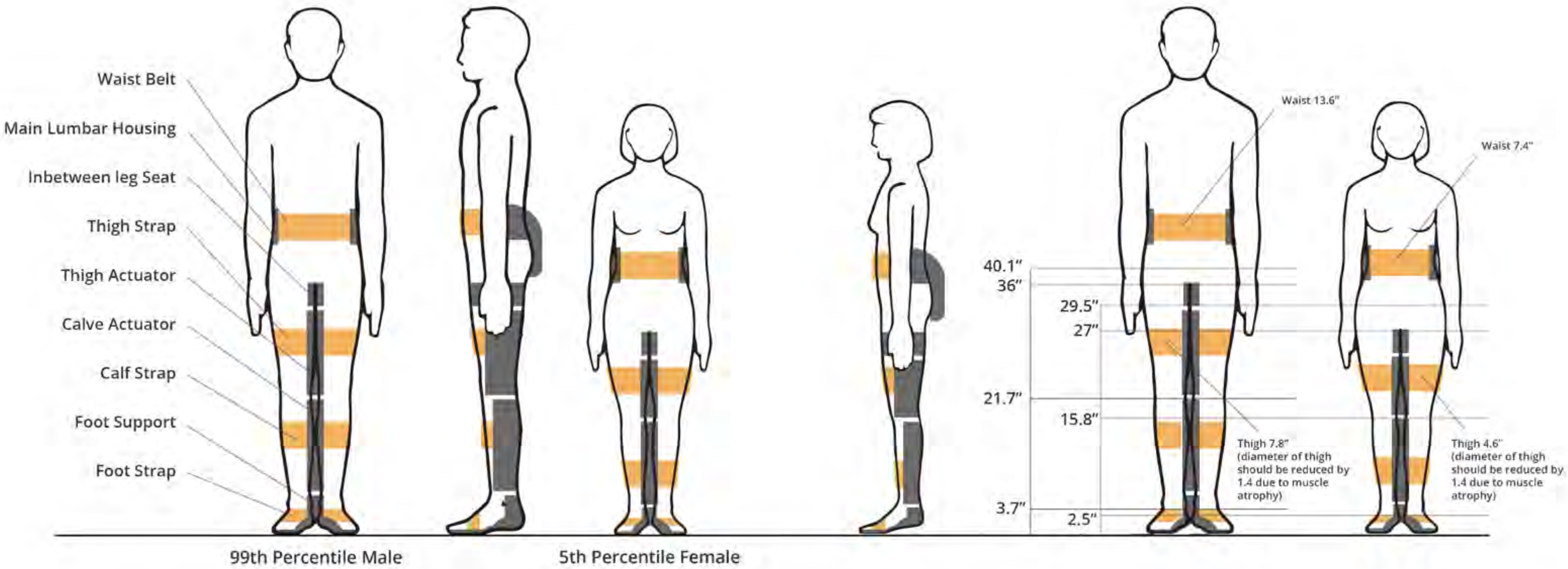


4.3.1 Product Schematic 1



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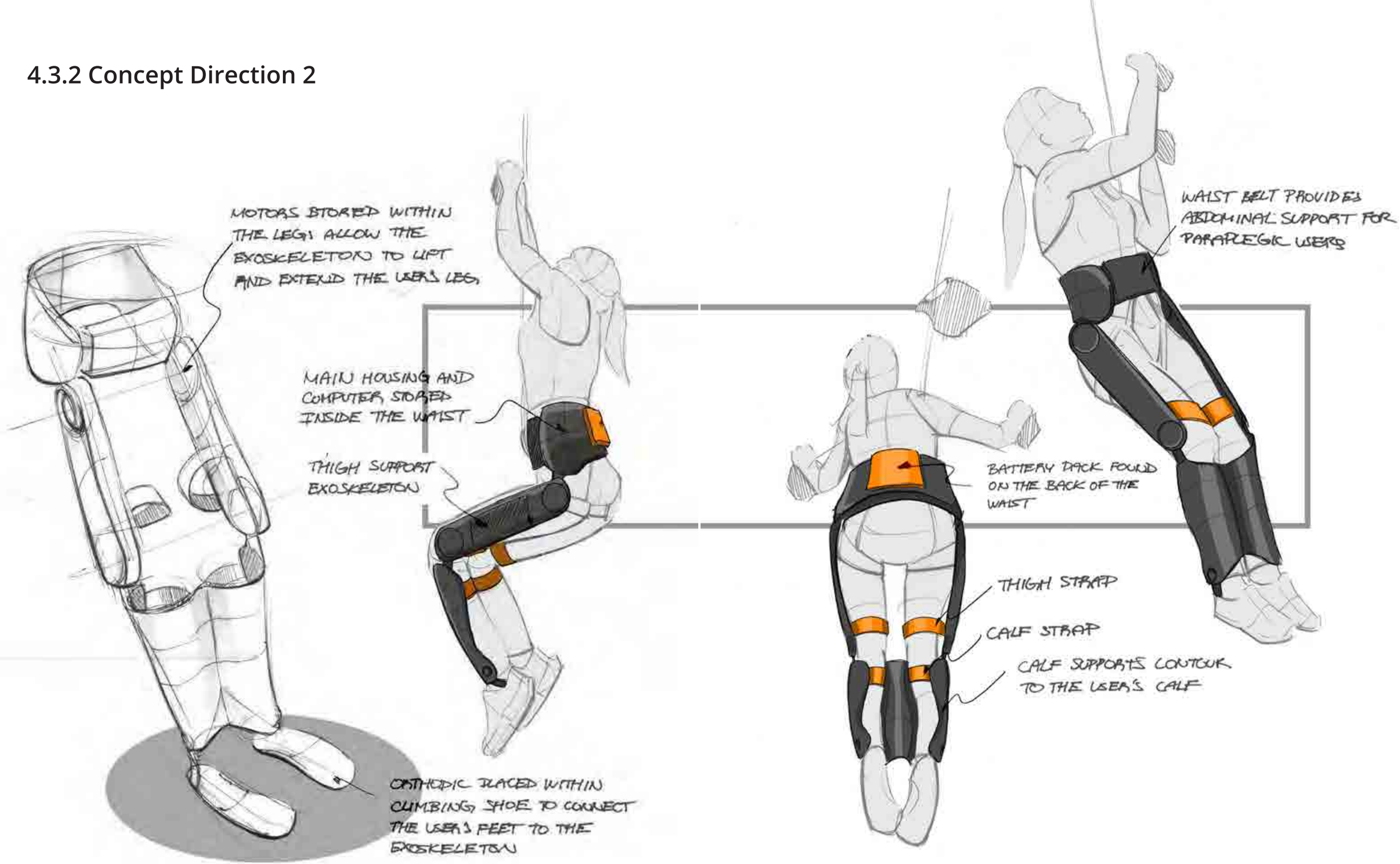

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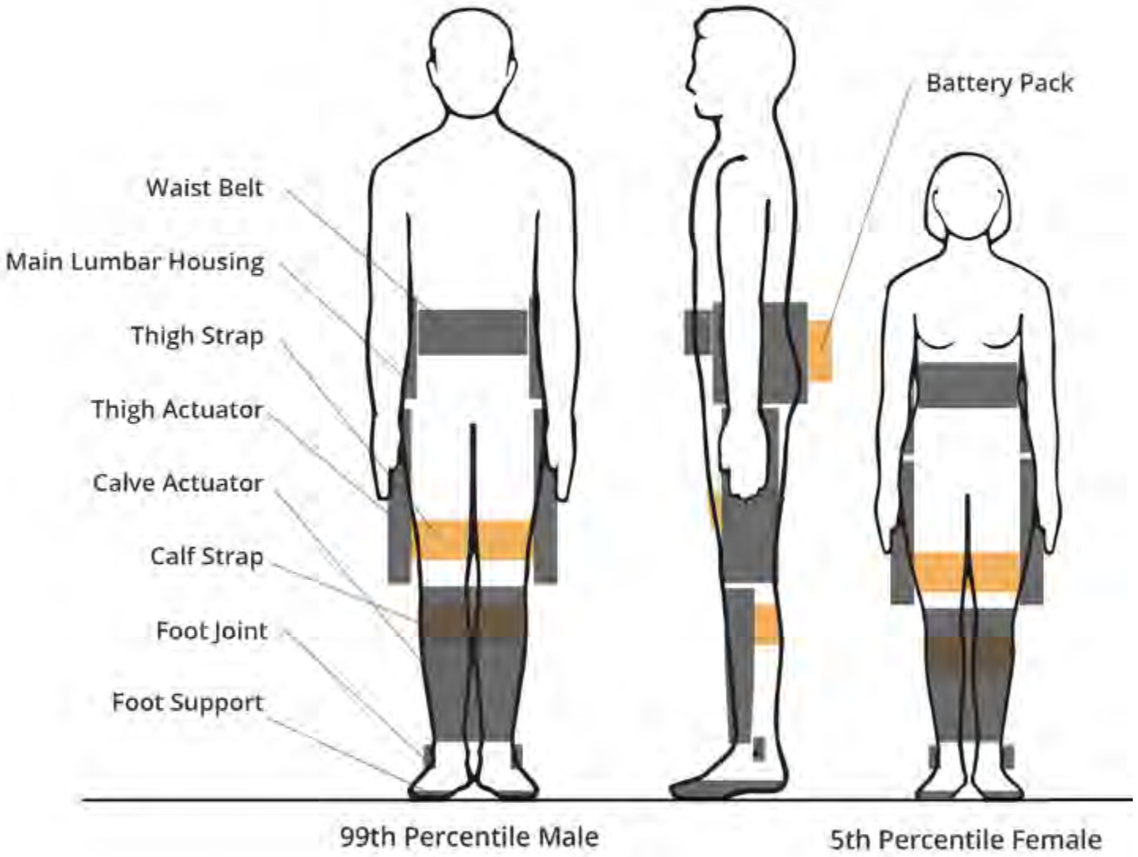
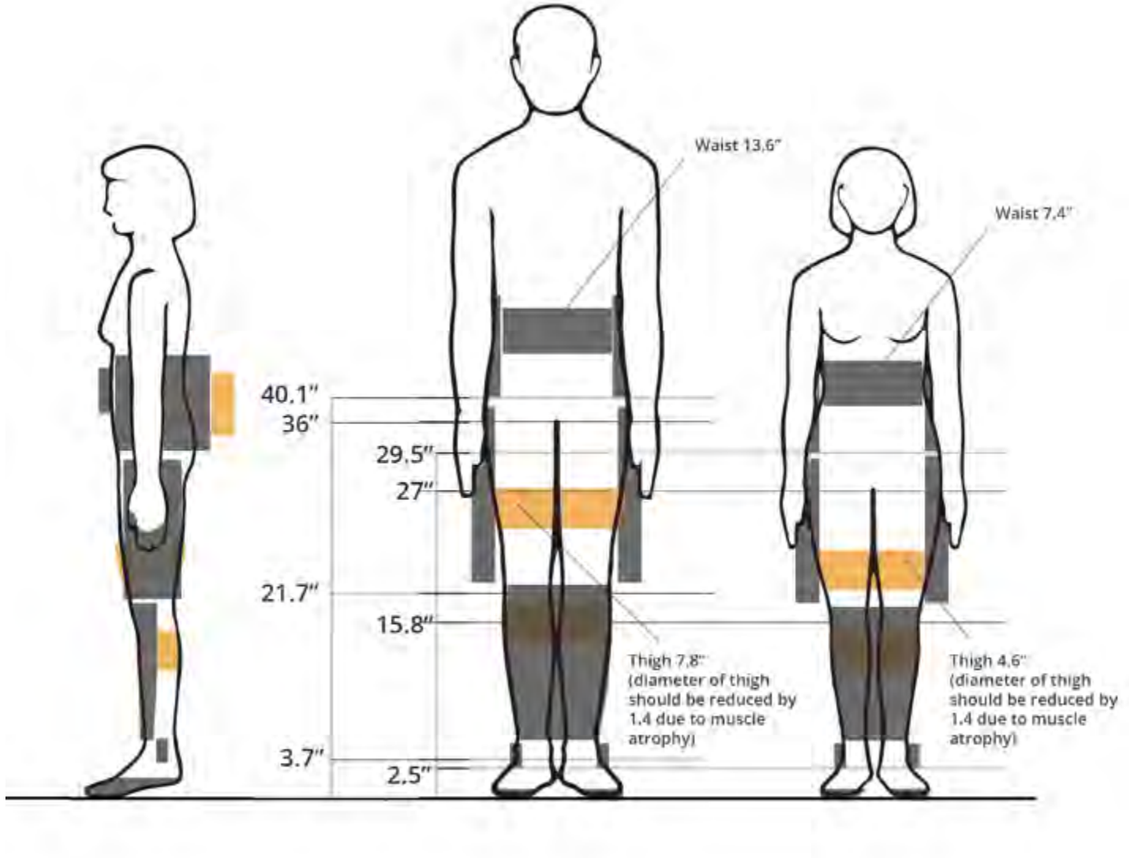
4.3.2 Product Schematic 2





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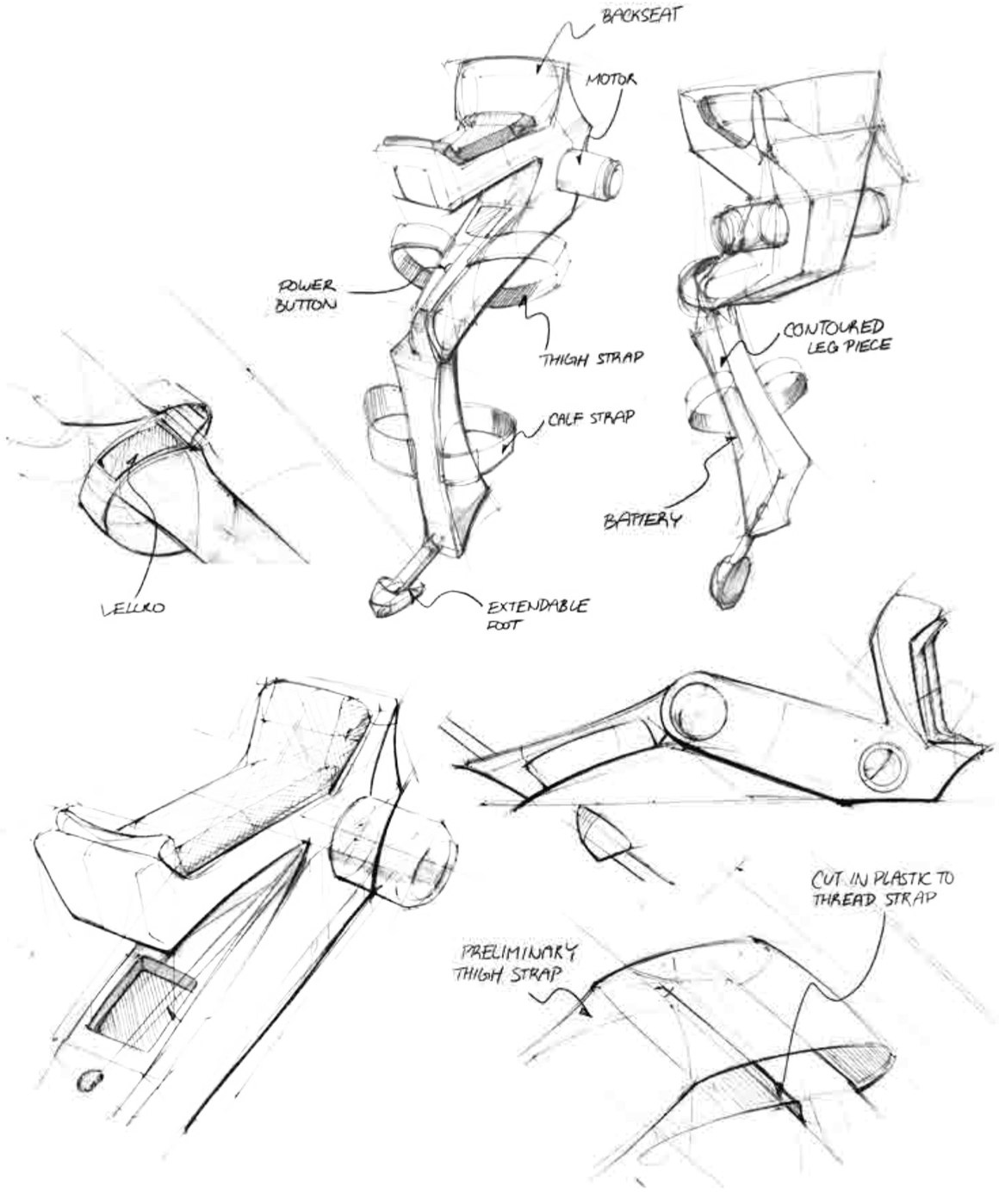

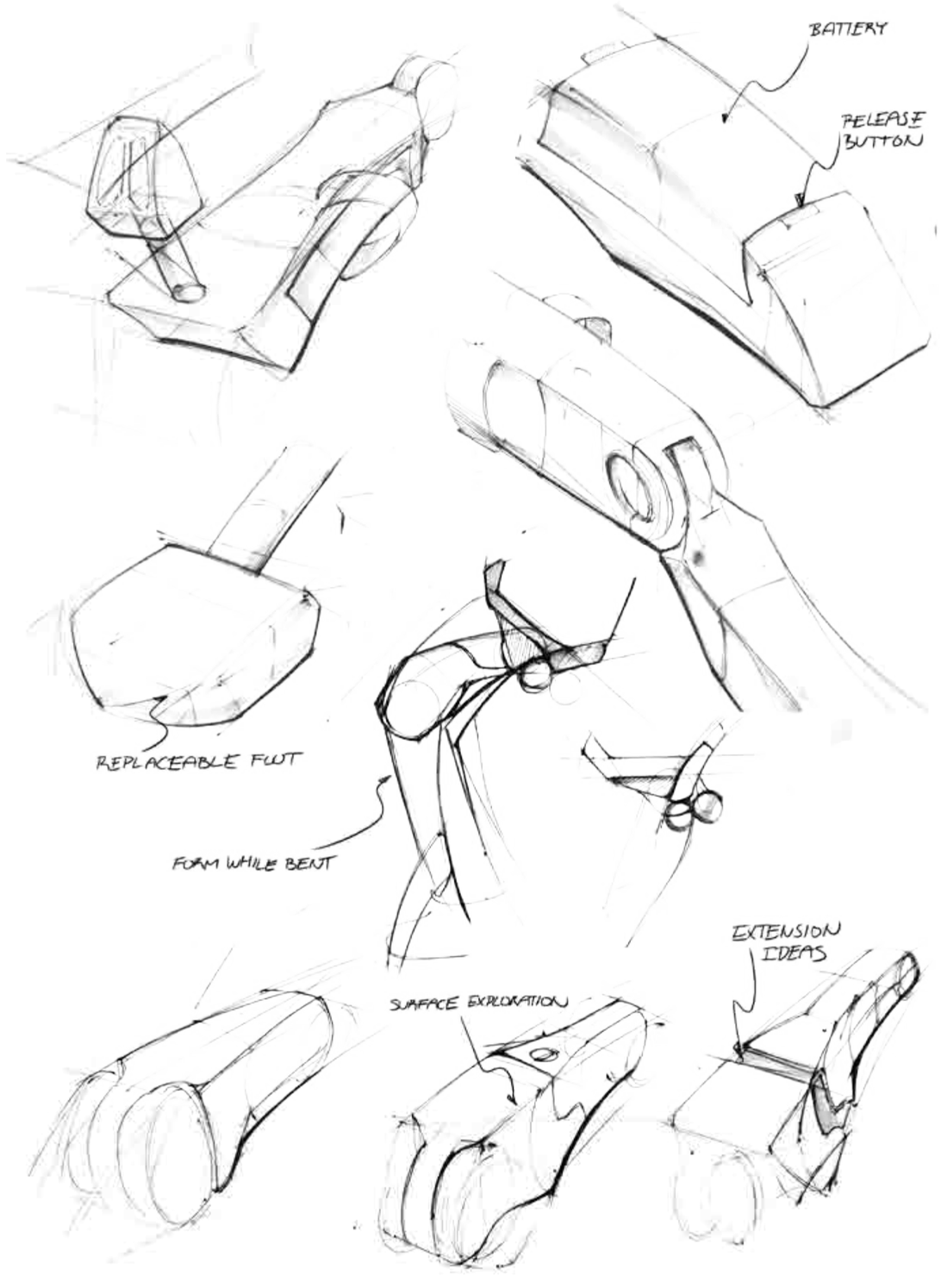

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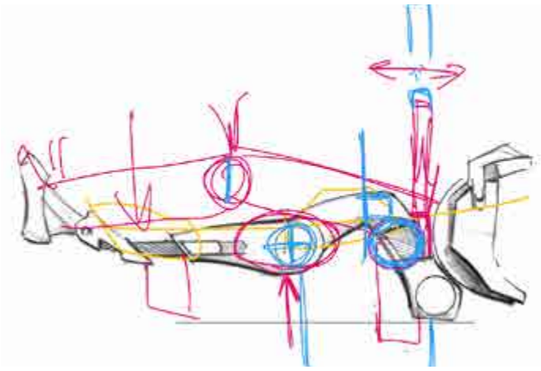
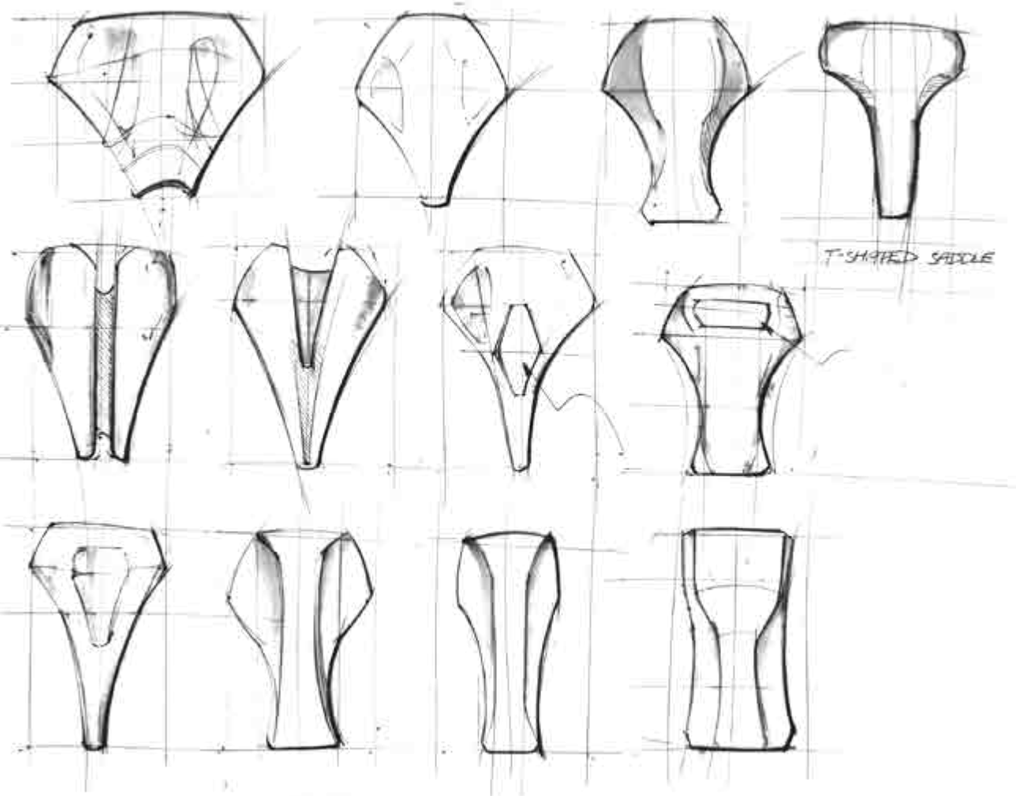
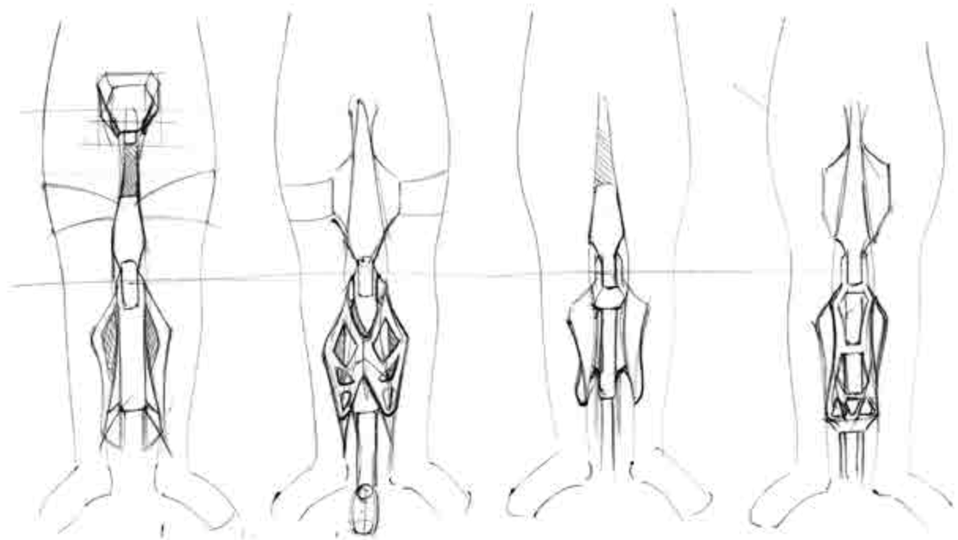
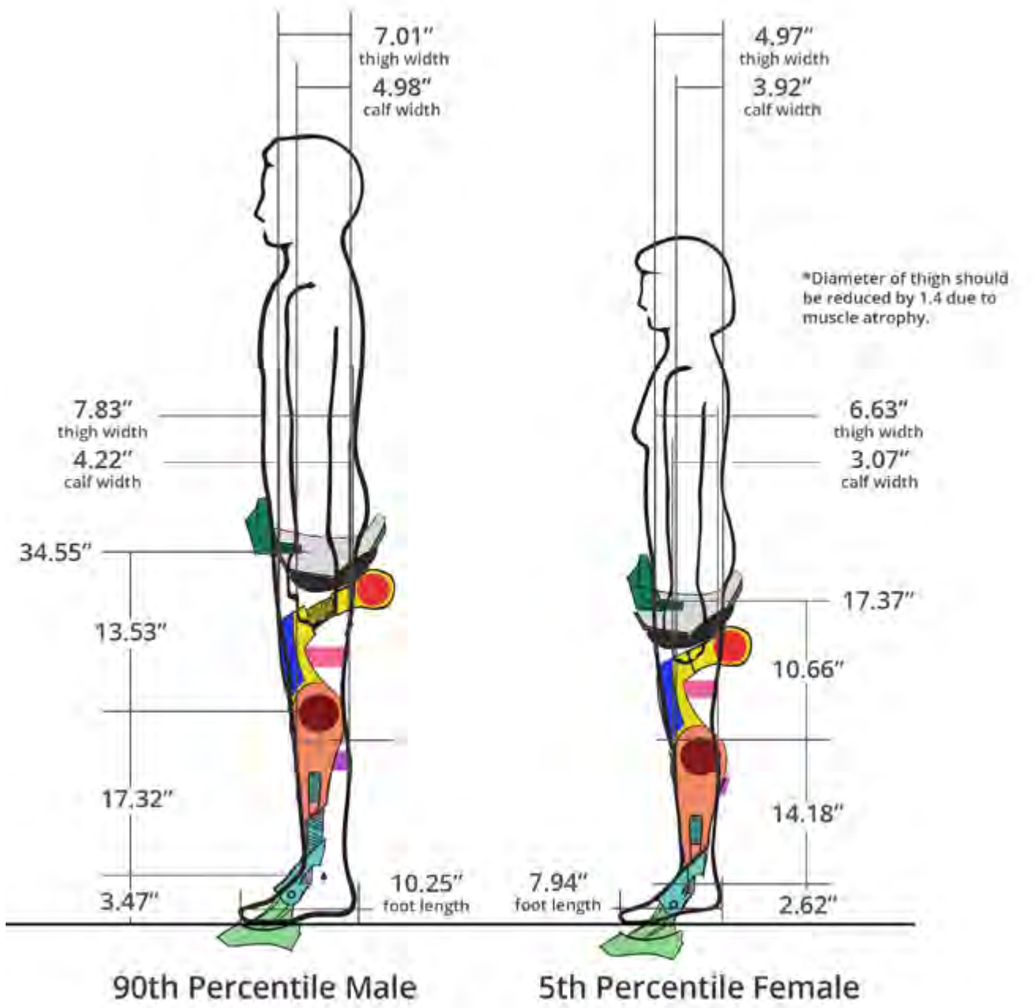
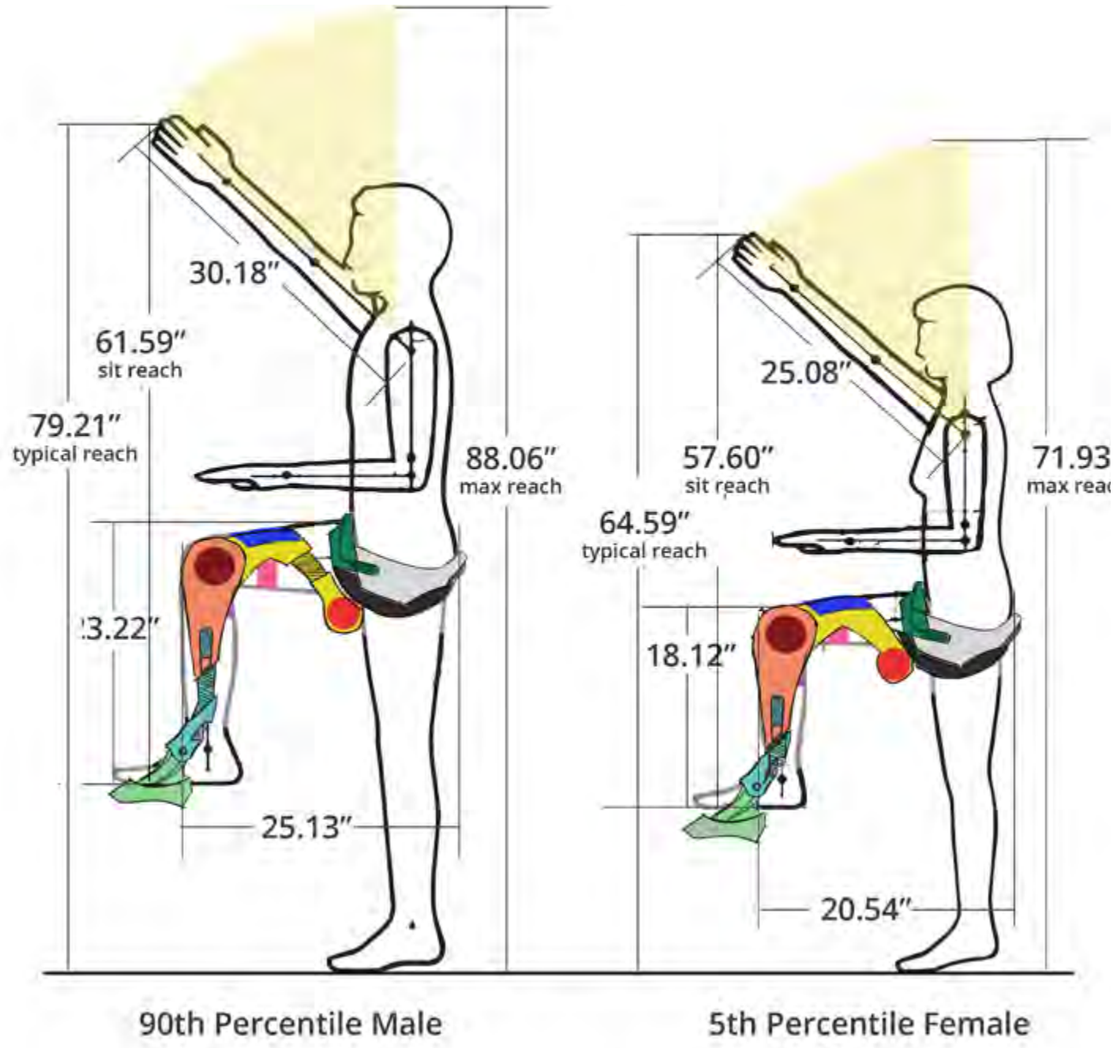




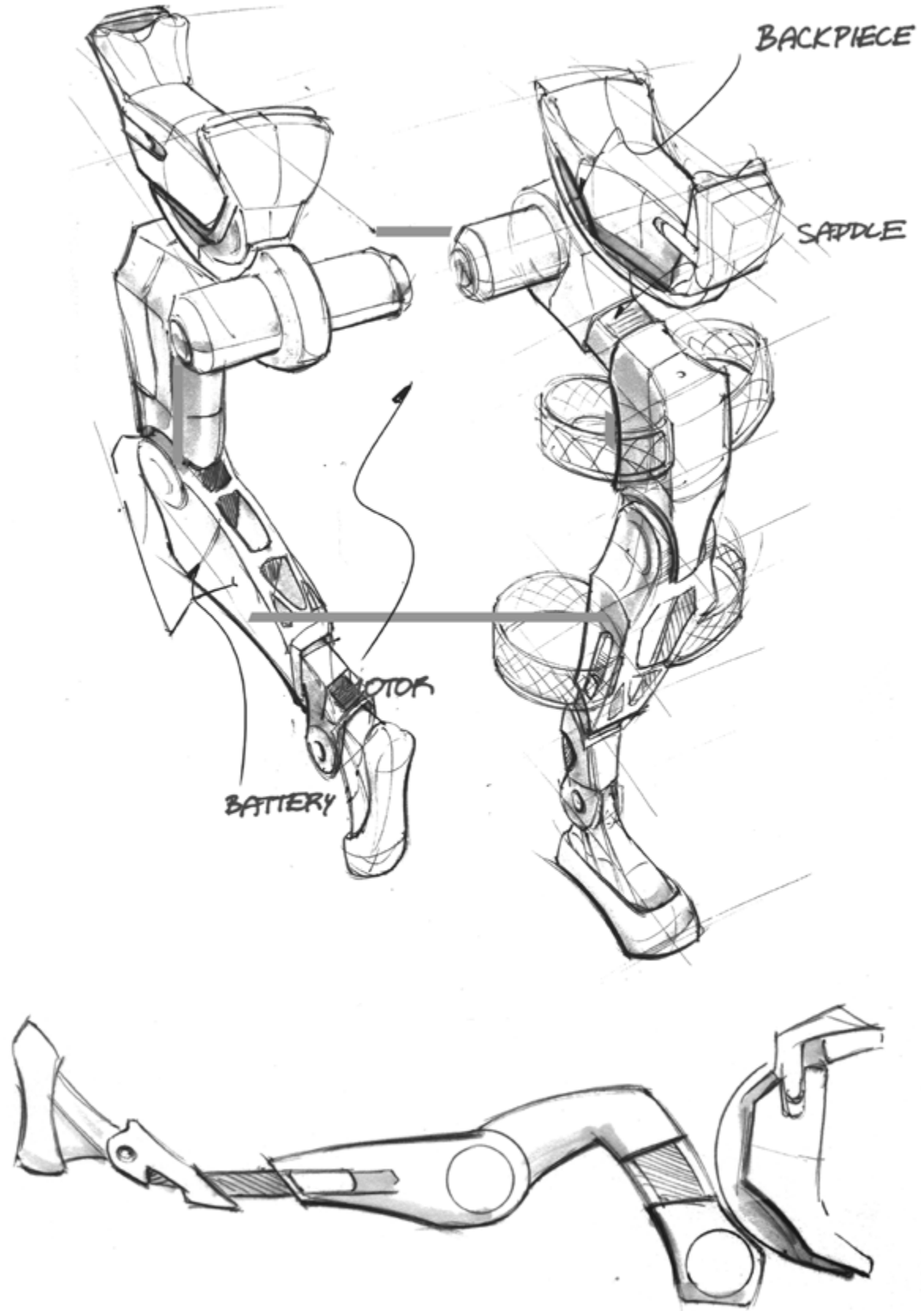


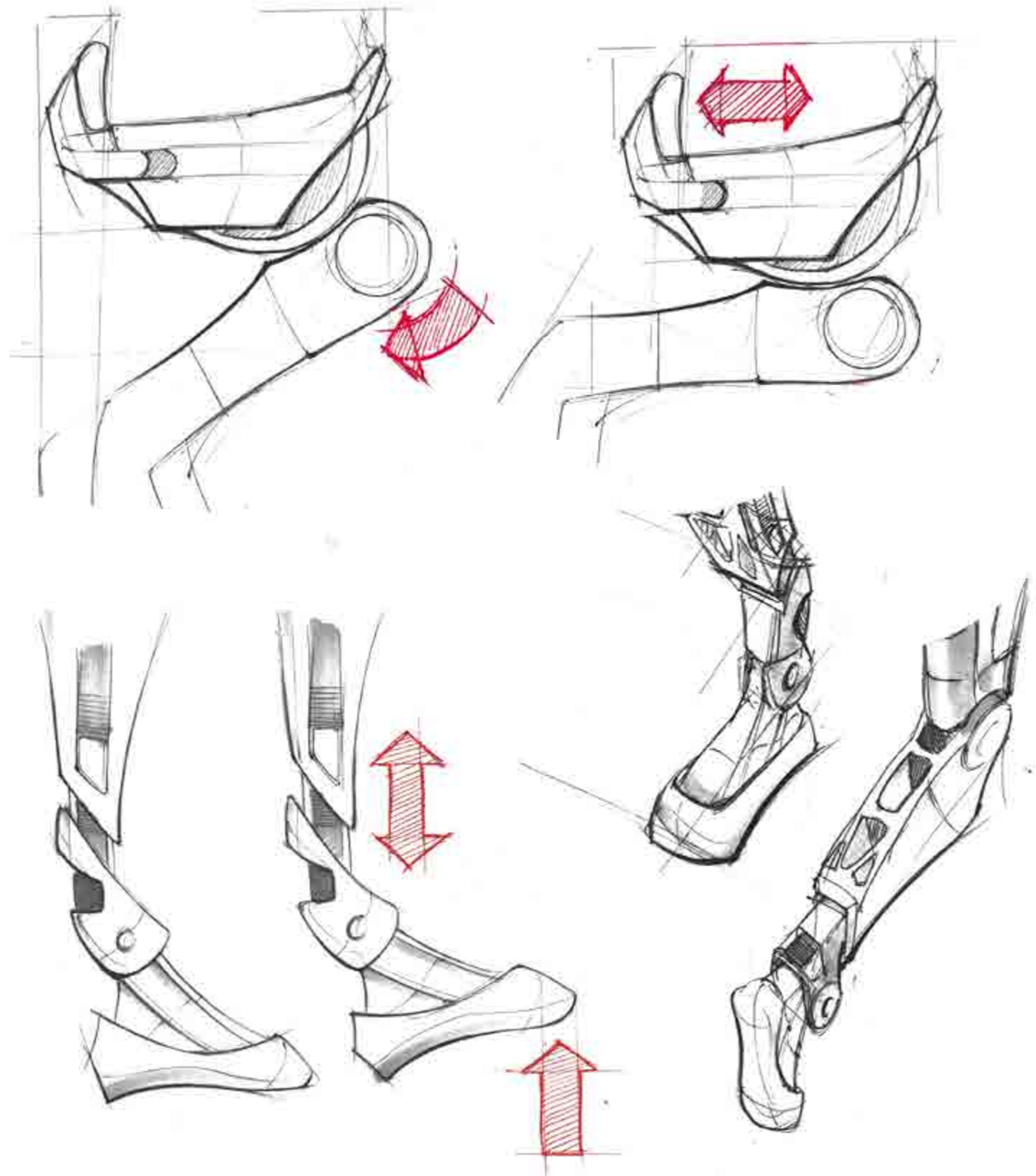
4.4.3 Refined Product Schematic





4.5.1 Design Finalization



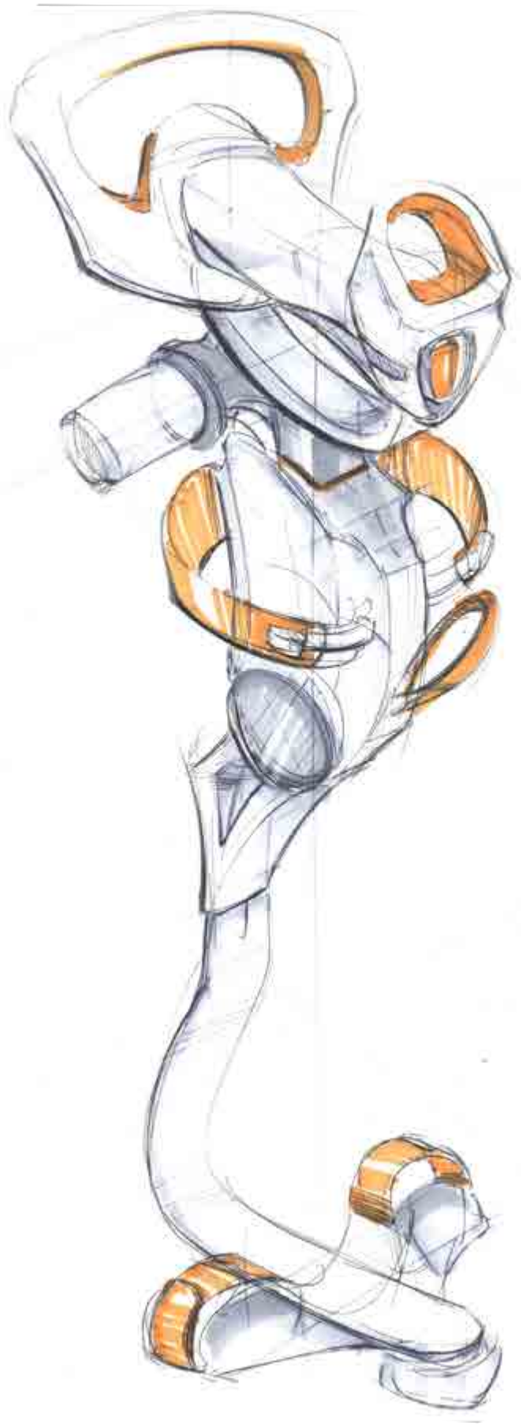


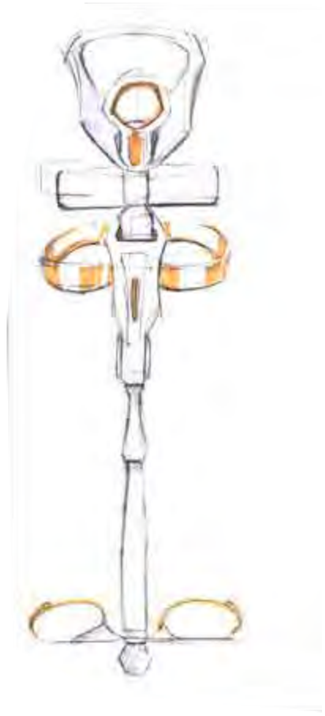
4.5.2 Physical Study Models

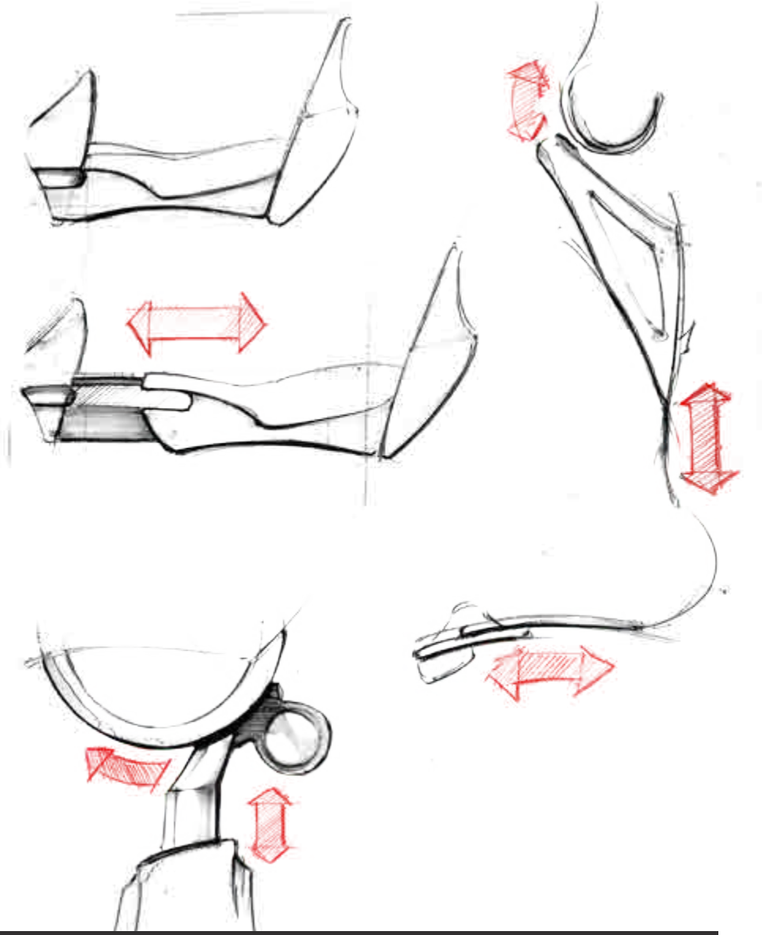
The physical study model is a revised version of the ergonomic study. This model aims to consolidate some of the detail development changes to the original design and bring them into a three-dimensional space before the final design resolution and CAD phase.

This model was made from pink foam and gave a shaped a majority of the details particularly in the upper portion of the design. This model was paramount in understanding the saddle and its position in between the user's legs. Having a 1:1 scale model was also key in understanding the surfaces and form required of the product.

Some of the key takeaways from the model include the overall functionality of the product as well as what works and what does not in terms of design features. For example, the bulkiness of the lower half of the model still requires some thinking to reduce its overall weight in appearance.





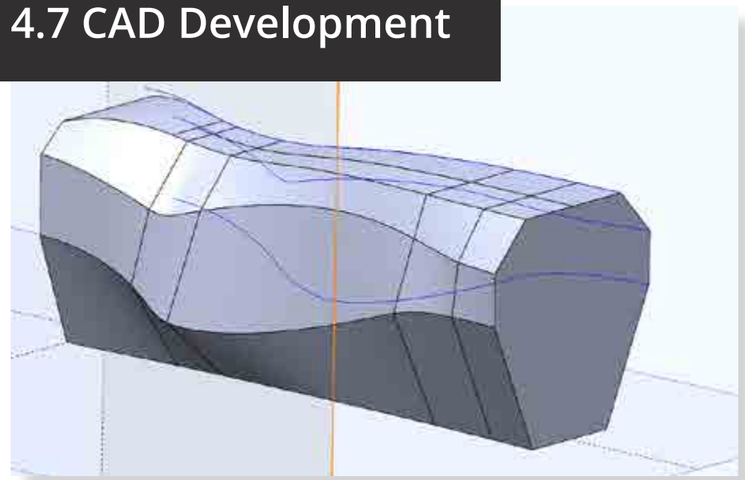


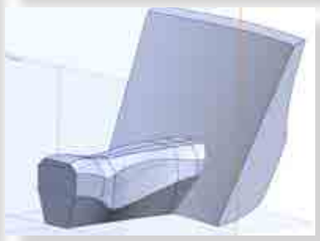
4.6 Design Resolution

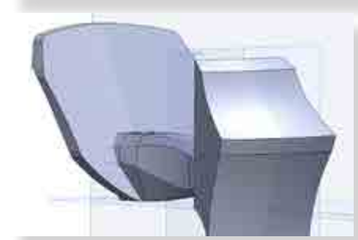
The lower section of the design has gone through many different changes form the previous section. The biggest change in the use of a carbon fibre blade on the lower portion of the product in order to both reduce the weight and simplify the overall design. This removes the need for the design to be attached to the calves and allows for less restriction.

A lot of attention was also made towards the adjustability of the product. An important aspect is its ability to adjust to a variety of dimensions. Understanding the mechanisms while not compromising the overall design aesthetic was very challenging. Overall, the design has some interesting design elements. The more detailed upper portion and the slimmed down lower portion helps provide a tapering effect similar to that of an arm or a leg.

4.7 CAD Development

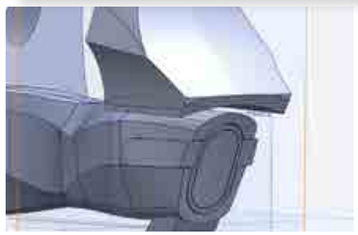


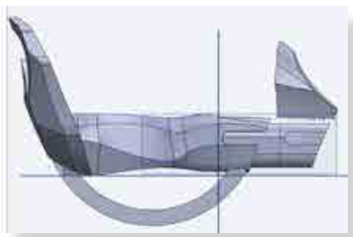


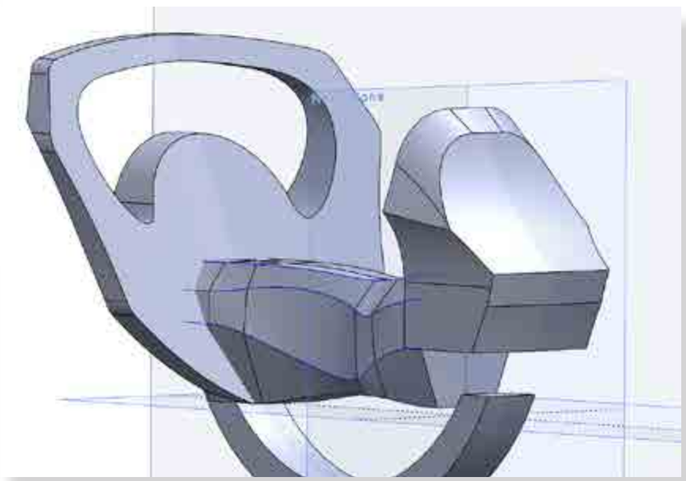


The first stages of the CAD involved modelling the saddle and upper portion of the design. Using projected curves and reference from the physical model study, the overall form was relatively simple to create. Keeping the bodies separate helped ensure that parts would fit together smoothly later on.

1

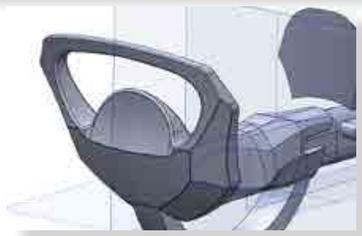


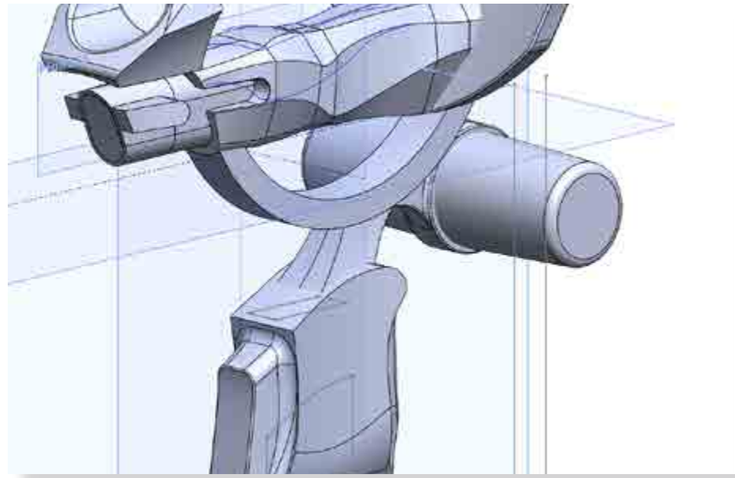


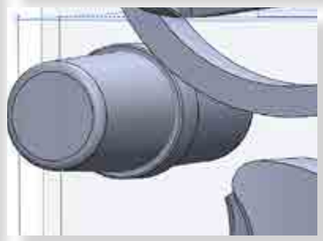


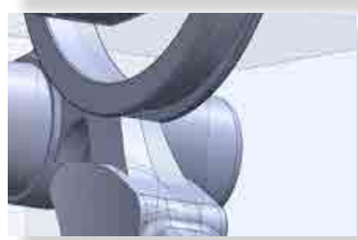
Moving forward with the preliminary blocks, cuts, sweeps, and surfaces were used to shape the form. Aspects such as the handle on the backseat as well as the piston mechanism were also modelled. Filets were also added to help give the form some softness to its edges.

2



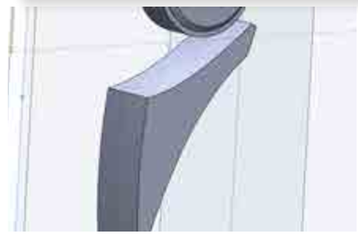


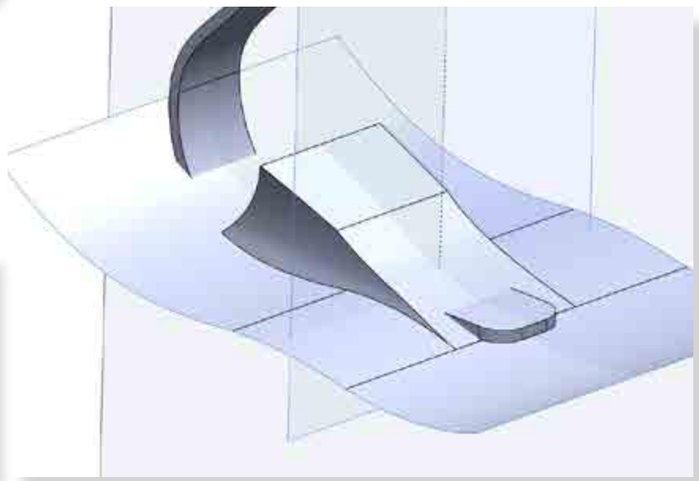




Moving onto the mid section, the body was modelled. Using measurements from the revised product schematic, the bodies were moved into the correct position in the part file. Other parts sections such as the motors, connection points were modelled as well as minor fixes and cleanup of existing parts.

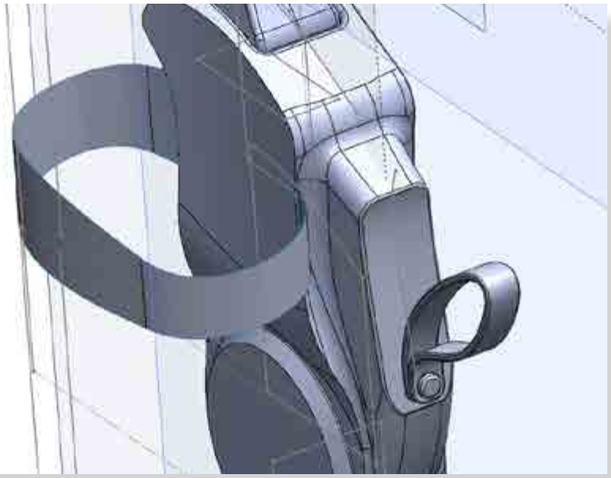
3

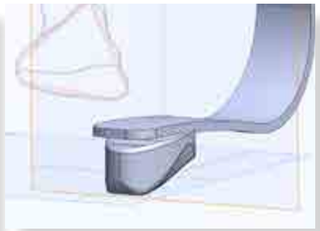


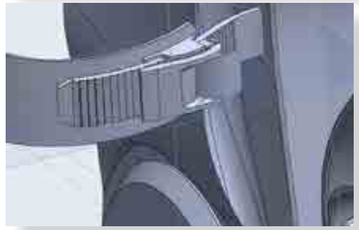


Where simple reference lines are inadequate, reference sketches of the product with human interaction were inserted to help visualize the sizing of certain parts in order to be accurate with respect to anthropometric data. The blade of the model was constructed using surfaces to get the correct profile.

4

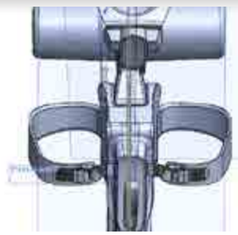


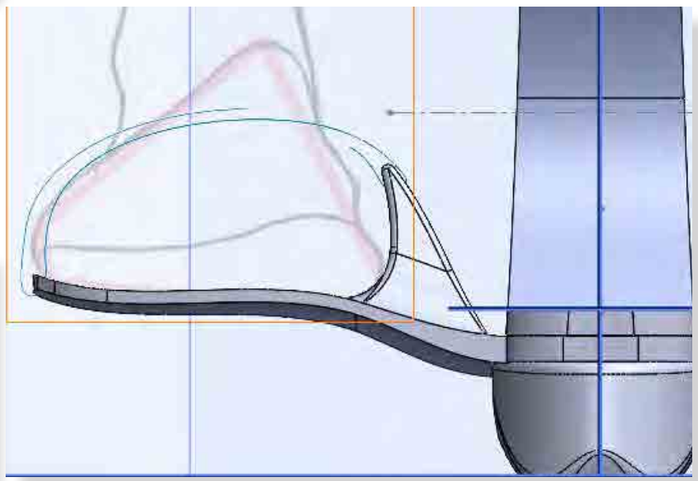




The majority of the pieces are modelled. The next step is to model the smaller pieces such as the straps and the buckles that attach to the user's legs. This is achieved by using surfaces to outline the shape and cut the profile when viewed from different angles. Making sure to keep the bodies separate for 3D printing later on.

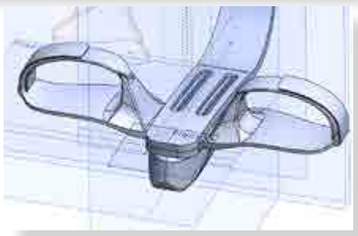
5

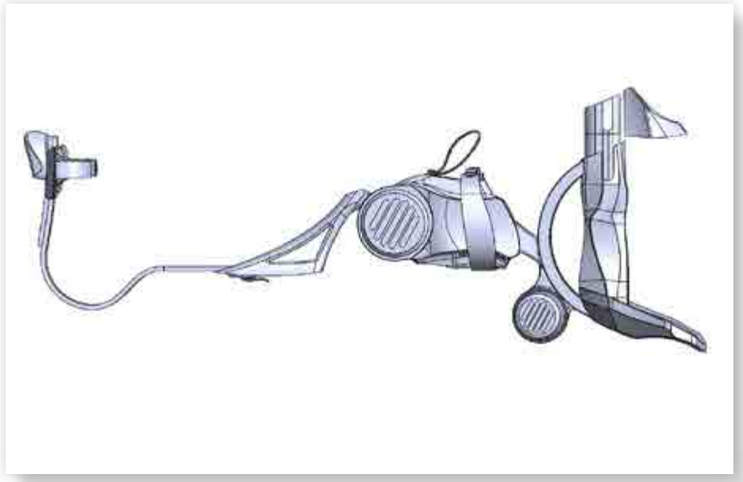


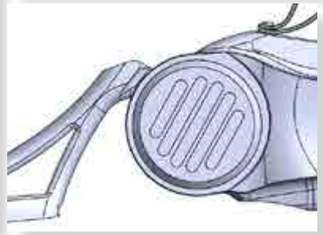


The foot section of the model used a reference sketch to help outline the foot when creating the straps. Additional changes to the lower portion include an extendable foot. In addition to the changes, the overall model was polished for the final assembly.

6





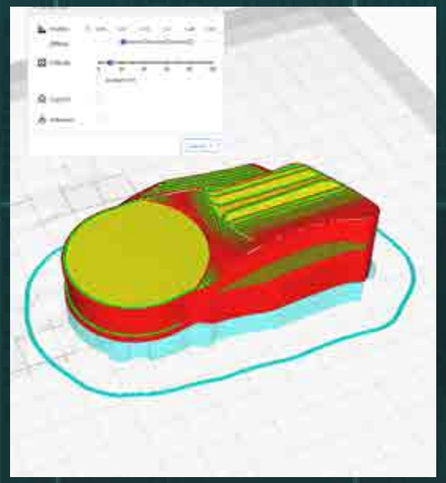


Going back through the model, filets were added to all edges. In addition, key importance was made in the tolerances of meshing parts to make sure that they would fit smoothly. The tolerance added for each part was 0.3mm gaps.

7

The final phase of the CAD model was to import all the solid bodies into separate parts. This is important for being able to print the parts separately. Importing these parts into one assembly file and mating them to their corresponding connection the full model was complete. Appearances were added to the surfaces to prepare for rendering in Keyshot

8



4.8 Physical Model Fabrication

The physical model was created using PLA 3D printed on an Ender 3. The average printing time for each part was between 1-5 hours and the total number of parts printed was twenty-seven (27). Using Bondo and a collection of low to high grit sand paper, the models were smoothed to remove the printing lines and painted with a high-quality filler primer. After which, the part was inspected for hidden imperfections and subsequently sanded again to remove any minor scratches.

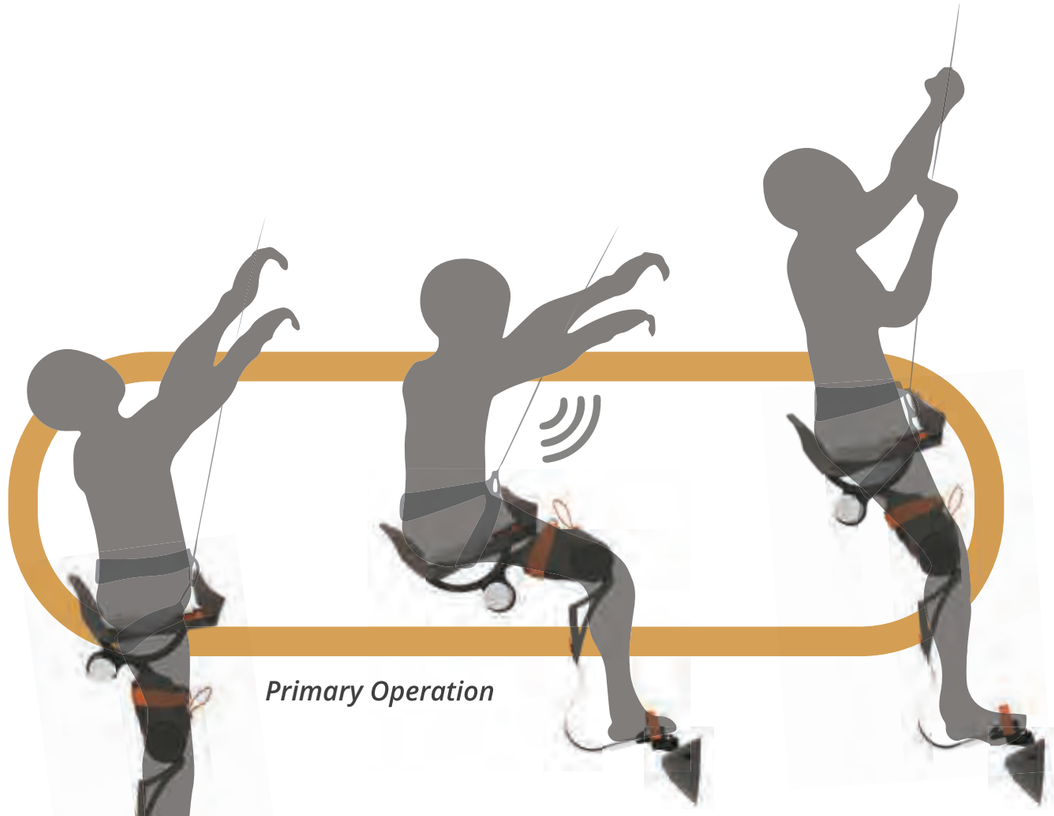
Chapter 5 - Final Design

ZETA

5.1 Summary

ZETA is an original concept aimed at pushing the boundaries of adaptive climbing equipment and accessibility among persons with disabilities. Designed specifically for those with paraplegia, ZETA offers a unique opportunity to create functional mobility in the user's legs in the context of rock climbing. ZETA is a wearable piece of technology that gives those with paraplegia a third point of contact on a climbing wall. This improves the user's balance and strength distribution while climbing.

ZETA blends the distinction between medical device and adaptive sports equipment. Taking inspiration from exoskeletons and climbing gear, ZETA aims to blend aesthetic appeal with functional assistance. The distinctive orange accents represent various touchpoints and moving components.

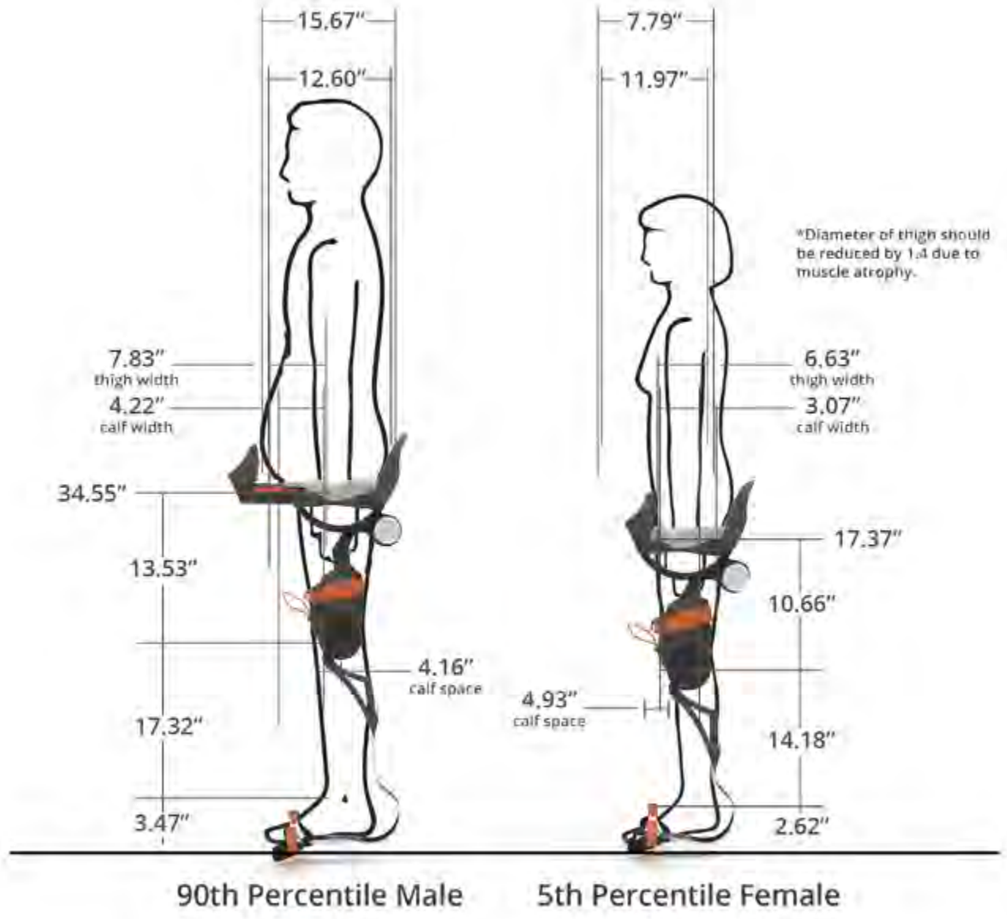


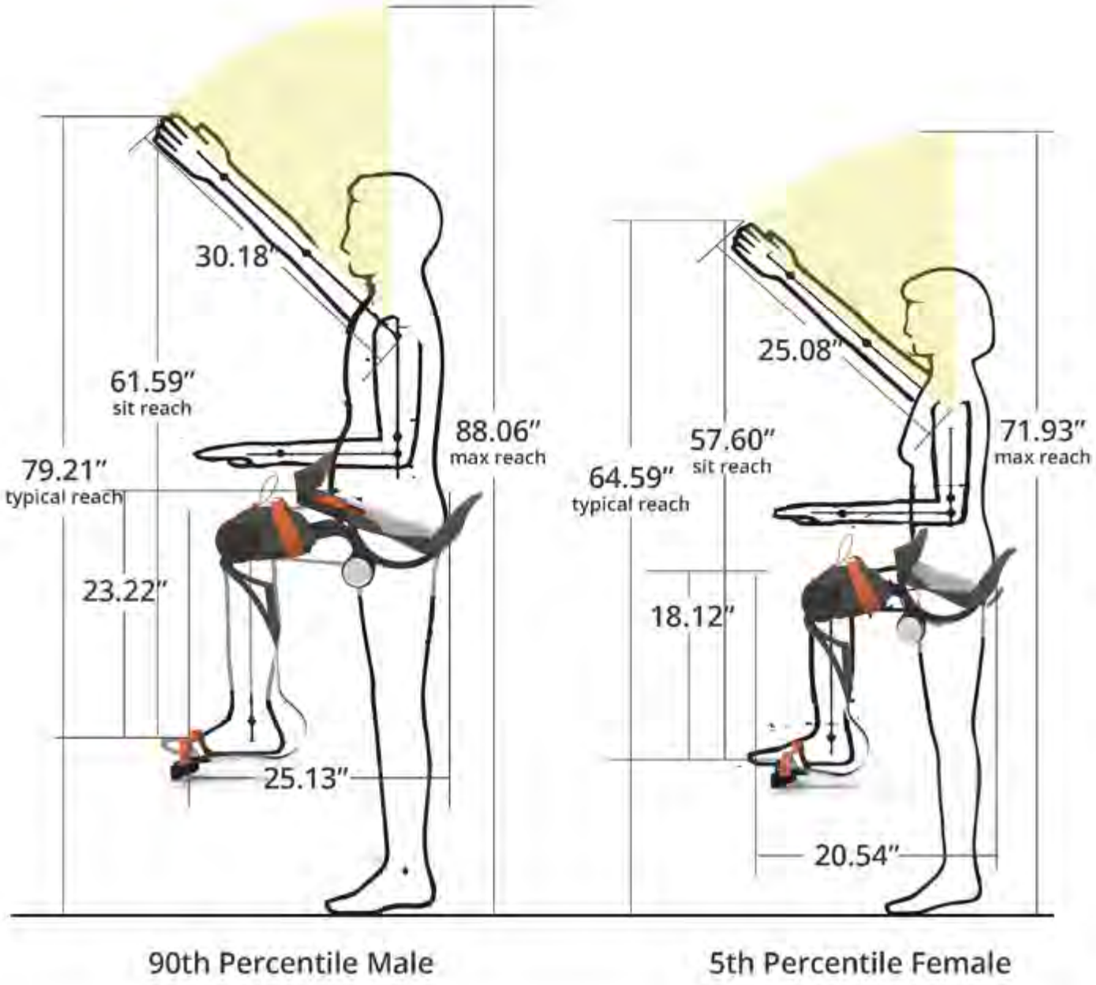
Primary Operation

STEP 1:
The user will begin climbing by positioning their hands on initial starting holds.

STEP 2:
Activating ***ZETA*** through the "***up***" command provides mechanical assistance in lifting the user's legs. Placing the dedicated foot provides support and balance to the user.

STEP 2:
The "***push***" command creates leg drive to otherwise immobile limbs allowing for a more diversified climbing experience.



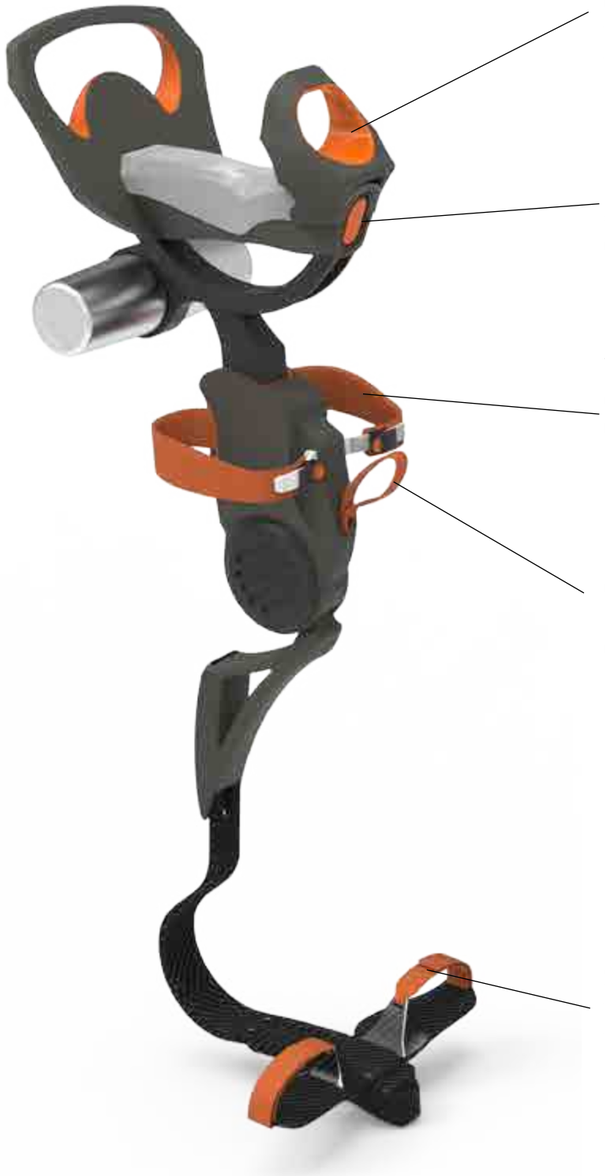


5.2.1 Full Bodied Interaction Design

ZETA features full adjustability for a 5th percentile female all the way to 90th percentile male. The key points of adjustability are in the waist depth, thigh length, calf length, and foot size. Paraplegia is indiscriminatory to whom it affects. As such, filling a large range will help ZETA accommodate any type of user.

Interaction Points

Orange accents on ZETA represent the different touchpoints as well as movement components.



Backseat and Front portion have orange accents to show that the user is able to grasp these touchpoints

Front button unlocks the adjustability of the waist depth slider.

Thigh straps lock the user's thighs to contoured main housing. The straps use a ratchet system to tighten and loosen the with a single hand.

Pull strap allows for manual activation of the product while climbing for more advanced climbers that require quicker more responsive control.

Simple velcro foot straps help keep the user's feet in place preventing them from dangling around.

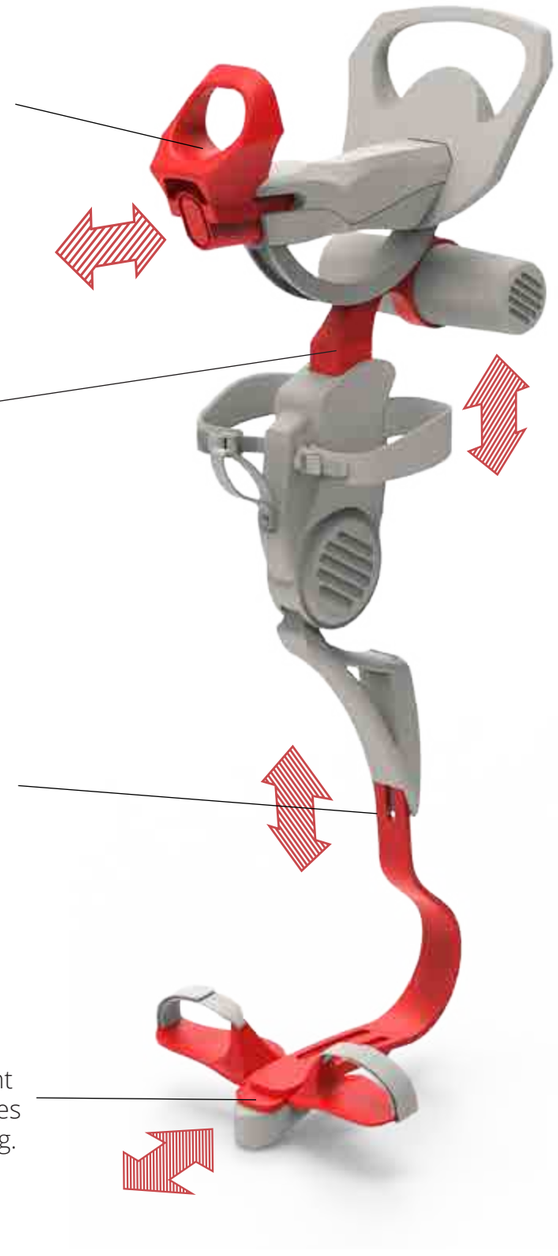
Adjustability

Waist depth can be adjusted via the frontal button. The hand hols allow for easy maneuvering of waist depth position for a snug fit.

Thigh length can be adjusted for taller individuals. This is crucial to keeping the motor placed at the knee for optimal rotation.

Calf length can be extended or retracted to make sure that the foot is placed exactly onto the footrest.

Foot size can be lengthened in order to keep the false foot in line or in front of the user's toes. This helps avoid toes hitting the climbing wall while climbing.



5.5.2 Materials, Proceses and Technology

Saddle is constructed with an injected moulded plastic frame with a thin layer of silicone to provide a small amount of cushioning to the user. Silicone is chosen for its versatility and durability.

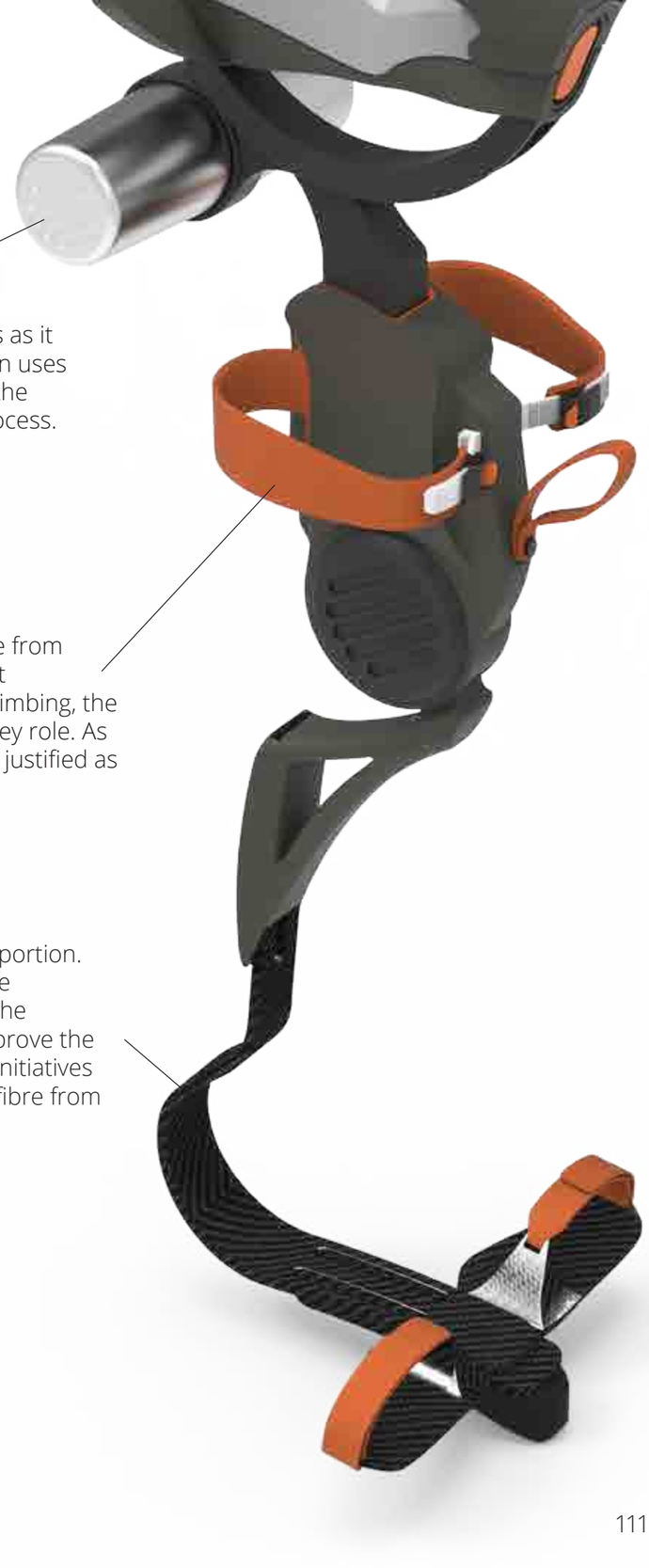
The main bulk of the design is constructed out of injected moulded plastic to have a premium feel while still being strong enough. The specific type of plastic used is HDPE for its high impact resistance and good tolerance.

The small fasteners and buckles are made from thin steel that is stamped to shape. This material and method are chosen for its low cost.

Aluminum is used for the motor covers as it is lightweight and recylable. This section uses stamped blanks which are drawn into the desired shape as its manufacturing process.

All the fabrics on the product are made from recycled nylon. Since the straps are not responsible for any safety aspects of climbing, the strength of the fibres does not play a key role. As such, more sustainable options can be justified as well as lowering the overall cost.

Carbon fibre is used on the lower leg portion. Specifically, the blade and foot rest are comprised of carbon fibre to reduce the weight, increase the strength, and improve the longevity of the product. Sustainable initiatives can include the use of off cut carbon fibre from aerospace or automotive application.



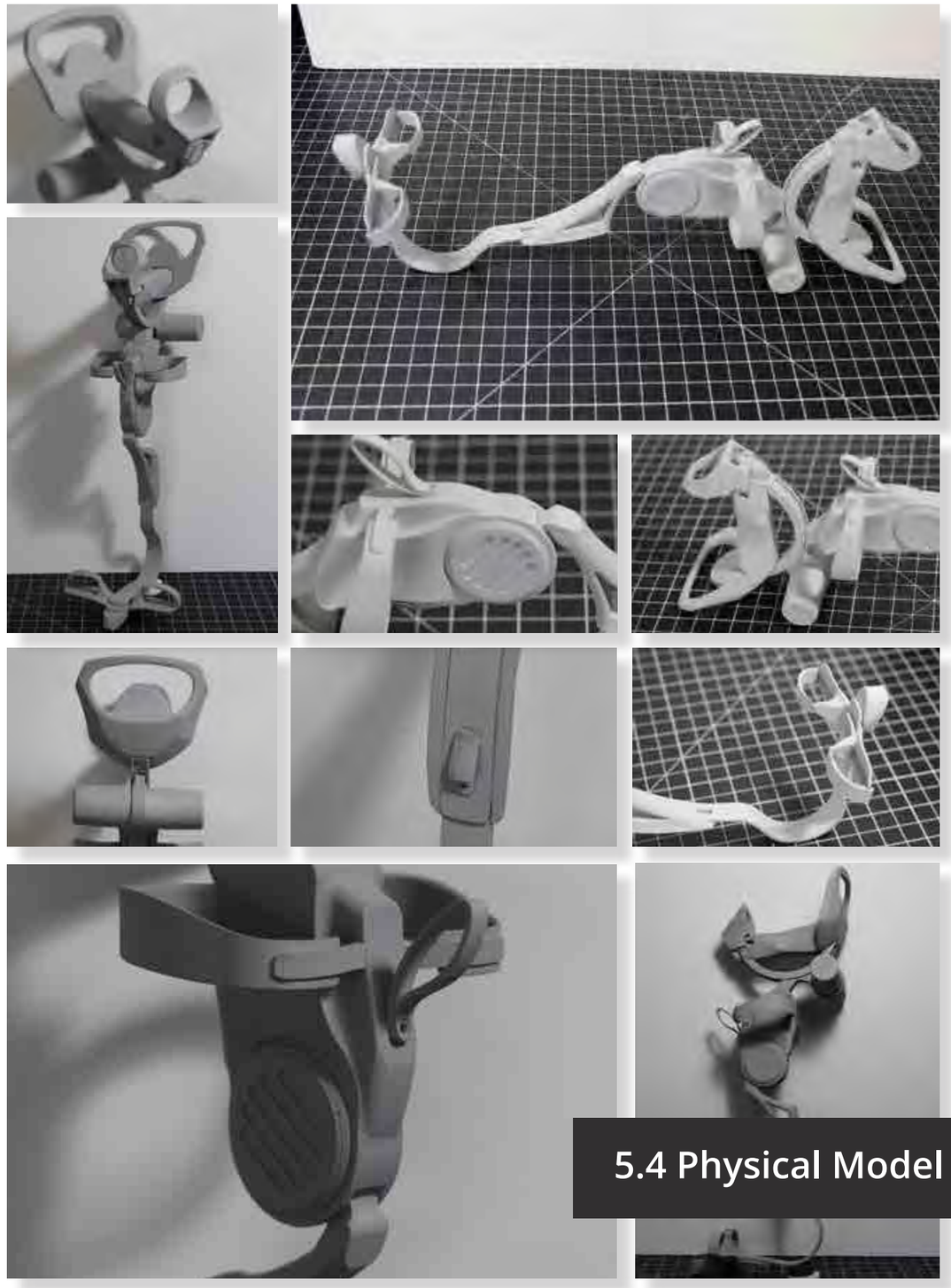
ITEM NO.	PART NUMBER	MATERIAL	MANUFACTURING	Estimate Cost/Each	QTY.
1	Locking Housing	HDPE	Injection Moulding	$ 5.00	1
2	Locking Mechanism	HDPE	Injection Moulding	$ 5.00	1
3	Blade Cover	HDPE	Injection Moulding	$ 8.00	1
4	Blade Housing	HDPE	Injection Moulding	$ 10.00	1
5	Main Housing	HDPE	Injection Moulding	$ 20.00	1
6	Motor Disk	HDPE	Injection Moulding	$ 10.00	2
7	Pull Strap	Nylon	Sewing	$ 2.25	1
8	Backseat	HDPE	Injection Moulding	$ 10.00	1
9	Motor Shroud	Aluminum	Stamped + Drawn	$ 5.00	2
10	Front Seat	HDPE	Injection Moulding	$ 10.00	1
11	Hoop	HDPE	Injection Moulding	$ 10.00	1
12	Hip Motor Mount	HDPE	Injection Moulding	$ 20.00	1
13	Saddle	Silicone	Injection Moulding	$ 5.00	1
14	Piston	HDPE	Injection Moulding	$ 5.00	1
15	Thigh Buckle	Steel	Stamped	$ 2.00	2
16	Thigh Strap	Nylon	Sewing	$ 2.25	1
17	ZigZag Strip	PP	Injection Moulding	$ 1.00	2
18	Rubber Foot	Vibram Rubber	Adhesive + Heat	$ 15.00	1
19	Blade	Carbon Fiber	Epoxy + Heat	$10/lb	1
20	Foot Extension	Carbon Fiber	Epoxy + Heat	$10/lb	1
21	Foot Strap	Nylon	Sewing	$ 2.25	2
22	Pull Strap Fastener	Steel	Aftermarket	$ 2.00	1
23	Thigh Strap Bracket	Aluminum	Stamped	$ 2.00	2

5.5.3 Design Implementation

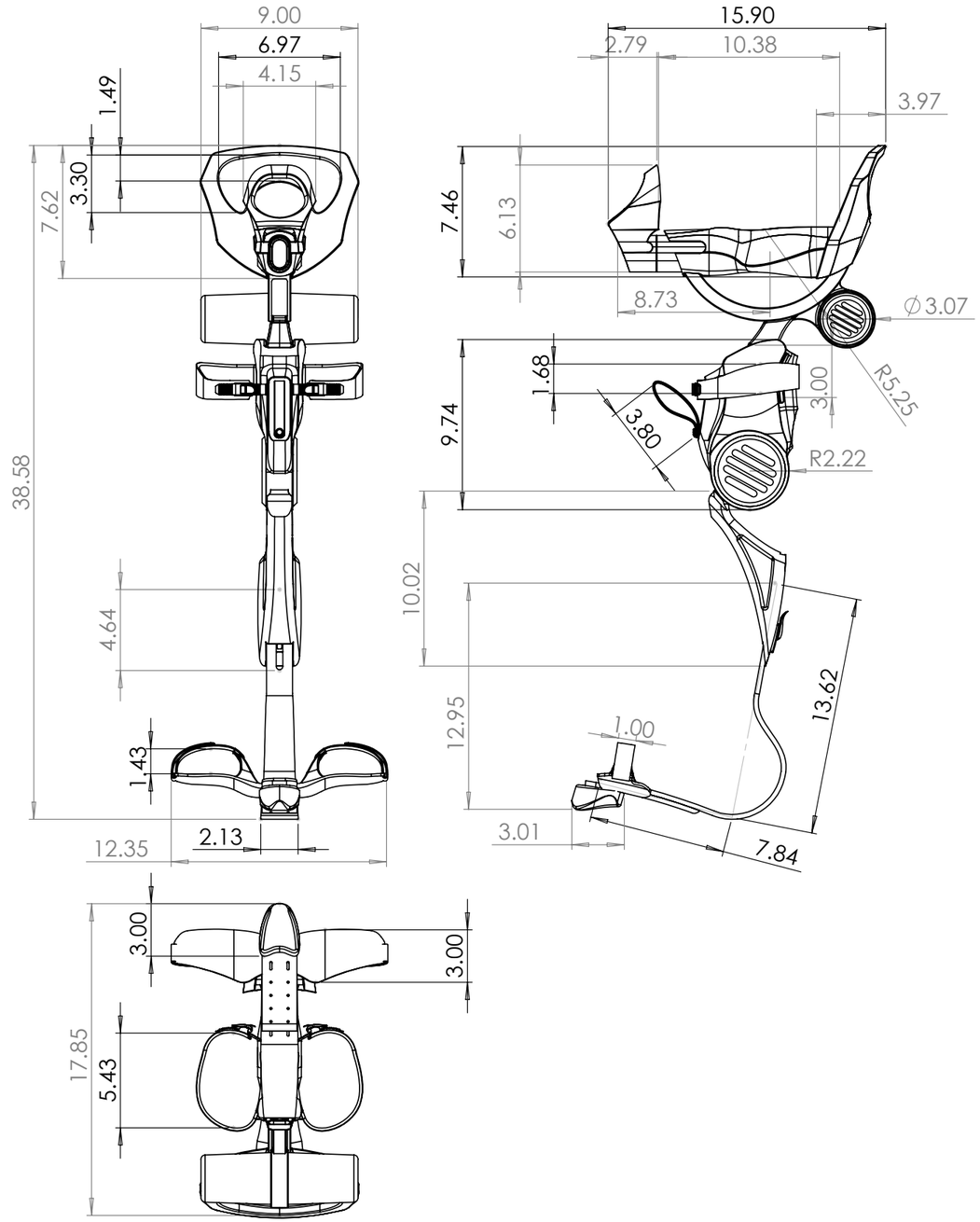
The table above shows a preliminary bill of materials outlining each part in the assembly as well as their material, manufacturing method, quantity, and estimated cost of that part. The biggest factor in the cost of ZETA is the carbon fibre which can be quite pricey. In addition, the large amounts of injection moulding can also add up in terms of price.

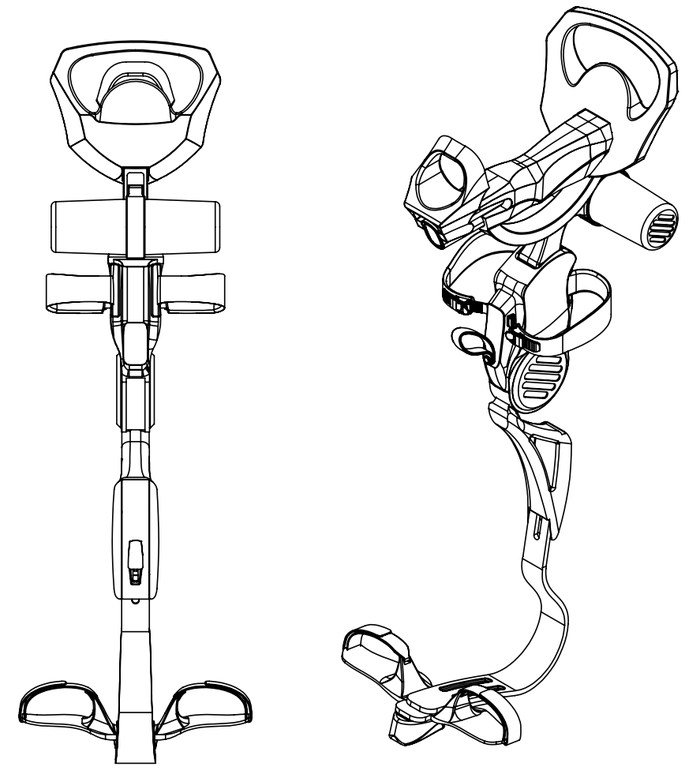
Due to the adjustable nature of the product and its tentative business plan, the price of the product should be justifiable within reason.

5.3 Final CAD Rendering



5.4 Physical Model





	DATE	NAME	SIGNATURE
DRAWN	04/21/22	PH	PH
CHK'D			
APPV'D			

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

TITLE:
ZETA Full Model

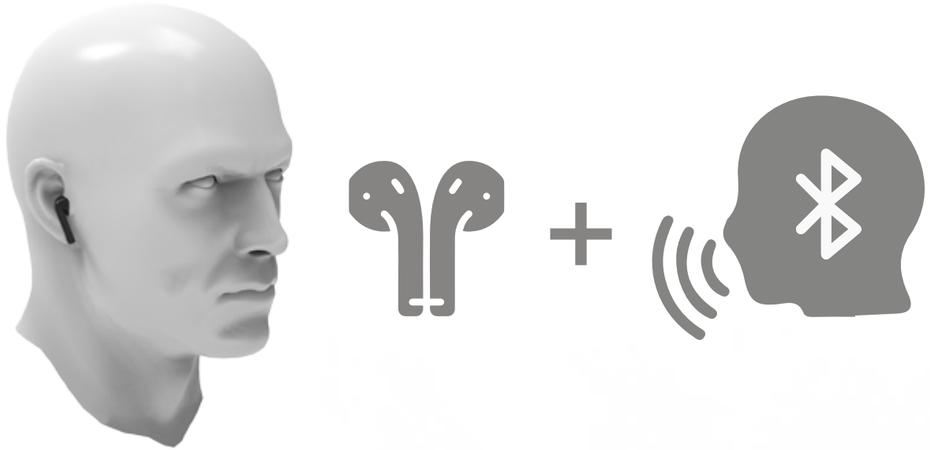
DRW BY:
Patrick Hui

A3

SCALE 1:7

SHEET 1 OF 1

5.5 Technical Drawings



5.6 Sustainability

Sustainability of the final proposed design is considered through three different aspects: business model, material processes, and technology.

Business Model

The business model of the proposed design is a consumer product that affect a very niche market. Those with paraplegia are the main users. As such, the product itself does not cater to the mass market. Instead, its focus is solely on these individuals. Being a small production product, the higher cost of the product can be justified given that its end user sees a complete paradigm shift in the way they rock climb. Furthermore, the longevity of the product would be designed to last to the end of the user's lifespan. Potentially being passed on to a second or even a third user. With this in mind, the design uses modern material and manufacturing processes as well as technology to fully achieve this business model.

Material Processes

The second aspect of the final design's sustainability are the manufacturing processes and materials used. The nature of the product must be able to support the user's weight and be light to not overburden the user. The manufacturing process of the main housing of the product will use additive manufacturing. This allows the reduction of wasted material as well as the opportunity to incorporate recycled material. Carbon fibre infused nylon printed parts are one such example that could be used. Textile fabrics used in the product can be selected from a list of Bluesign certified fabrics. This will mainly be incorporated into the straps that secure the product to the user's legs. Finally, the saddle padding could be 3D moulded silicone for comfort, durability, and flexibility.

Technology

The final aspect of sustainability is the technology incorporated into the product. Given the increase in technologies such as voice activation and AI machine learning, the product will focus on voice activation inputs in order to actuate the device. This will alleviate the need to physical buttons in and touch activation freeing up their hands to focus on rock climbing.

Chapter 6 - Conclusion

ZETA

6.0 Conclusion

ZETA is a unique design that aims to change how adaptive climbing is practiced. Although fairly coherent, the design presented is far from a full consumer product. As a unique concept, there are still many questions left unanswered. The biggest question being, how a working prototype would function and feel? Would it be able to handle the loads associated with a user?

The goal of ZETA as a concept is to inspire others to think in this direction. Pushing the boundaries of what adaptive climbing means, and what a person living with paraplegia is really capable of.

Appendix

References

Dennis, A. (2017, April 14). How green is climbing gear? Climbing. Retrieved February 7, 2022, from https://www.climbing.com/gear/how-green-is-climbing-gear/

Dennis, A. (2021, November 3). How climbing shoes are made. WeighMyRack. Retrieved February 8, 2022, from https://blog.weighmyrack.com/climbing-shoe-construction-how-climbing-shoes-are-made/

Dennis, A. (2021, September 9). Eco-friendly & sustainable climbing harnesses. WeighMyRack. Retrieved February 8, 2022, from https://blog.weighmyrack.com/eco-friendly-sustainable-climbing-harnesses/#:~:text=Summary,standard%20of%20bluesign%C2%AE%20PRODCUT.

Dennis, A. (2021, September 9). Sustainable eco-friendly climbing shoes. WeighMyRack. Retrieved February 8, 2022, from https://blog.weighmyrack.com/sustainable-eco-friendly-rock-climbing-shoes/

Fengel, M. (2019, August 15). Life without limitations: Mark Wellman and the first paraplegic ascent of El Capitan. Climbing. Retrieved December 14, 2021, from https://www.climbing.com/people/life-without-limitations-mark-wellman-and-the-first-paraplegic-ascent-of-el-capitan/

Gardiner, G. (2016, August 4). Composites in exoskeletons. CompositesWorld. Retrieved February 8, 2022, from https://www.compositesworld.com/articles/composites-in-exoskeletons#:~:text=%E2%80%9CWe%20use%20carbon%20fiber%20in,manage%20their%20use%20with%20patients.

Hugh Herr & Jim Gorin: The amazing history of paraclimbers. Moja Gear. (2020, June 19). Retrieved December 14, 2021, from https://mojagear.com/paraclimbers-hugh-herr-jim-gorin/

Kern, H., Hofer, C., Mödlin, M., Mayr, W., Vindigni, V., Zampieri, S., Boncompagni, S., Protasi, F., & Carraro, U. (2007, October 23). Stable muscle atrophy in long-term paraplegics with complete upper motor neuron lesion from 3- to 20-year SCI. Nature News. Retrieved December 14, 2021, from https://www.nature.com/articles/3102131

Kerns, J. (2015, January 15). The rise of the exoskeletons | machine design. Machine Design. Retrieved February 8, 2022, from https://www.machinedesign.com/mechanical-motion-systems/article/21831817/the-rise-of-the-exoskeletons

Kornick, J. (2021, April 26). Living with paraplegia: Recovery, treatments, exercises, and more. Living with Paraplegia: Recovery, Treatments, Exercises, and More. Retrieved December 14, 2021, from https://www.spinalcord.com/paraplegia

Olhorst, T. (2020, April 10). Rock climbing grows in popularity. The National Digest. Retrieved December 14, 2021, from https://thenationaldigest.com/rock-climbing-grows-in-popularity/

Paraplegia. 2011. In Merriam-Webster.com. Retrieved December14, 2021, from https://www.merriam-webster.com/dictionary/paraplegia

The physical, mental and social benefits of rock climbing. XSA Climbing Walls. (2017, July 7). Retrieved December 14, 2021, from http://www.climbingwalls.co.za/index.php/en/xsa-blog/239-the-physical-mental-and-social-benefits-of-rock-climbing

Reeve, C. (2013). Paralysis statistics. Reeve Foundation. Retrieved December 14, 2021, from https://www.christopherreeve.org/living-with-paralysis/stats-about-paralysis

Sailrite Enterprises, Inc. (2021, December). How to sew webbing loops. Sailrite. Retrieved February 8, 2022, from https://www.sailrite.com/How-to-Sew-Webbing-Loops#:~:text=Bonded%20Nylon%20and%20Bonded%20Polyester,we%20recommend%20for%20outdoor%20applications.

Saddle Ergonomics explained. SQlab. (n.d.). Retrieved December 6, 2021, from https://sqlab-usa.com/pages/saddle-ergonomics-explained.

Sanders, S. (2018, October 15). Behind the scenes: How climbing harnesses are designed and tested. Climbing. Retrieved December 14, 2021, from https://www.climbing.com/gear/behind-the-scenes-how-climbing-harnesses-are-designed-and-tested/

Taylor-Smith, K. (2021, January 12). How is 3D printing a sustainable manufacturing method? AZoM.com. Retrieved February 8, 2022, from https://www.azom.com/article.aspx?ArticleID=20017

The Manufacturer. (2021, October 1). Creating a sustainable future for carbon fibre in manufacturing. The Manufacturer. Retrieved February 8, 2022, from https://www.themanufacturer.com/articles/creating-a-sustainable-future-carbon-fibre/#:~:text=Carbon%20fibre%20production%20requires%20significant,to%20create%20the%20fibre%20material.&text=Positive%20progress%20has%20already%20been,of%20sustainability%20and%20mechanical%20performance.

Tilley, A. R. & Dreyfuss, H. (1993). The Measure of Man and Woman. Whitney Library of Design.
Uitti, A. (2019, May 4). Which saddle is right for me? Rivet Cycle Works. Retrieved December 6, 2021,from https://rivetcycleworks.com/which-saddle-is-right-for-me/.

World Health Organization. (2013, November 19). Spinal Cord Injury. World Health Organization. Retrieved December 14, 2021, from https://www.who.int/news-room/fact-sheets/detail/spinal-cord-injury

References (Images)

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https://57hours.com/wp-content/uploads/2020/09/Rock-climbing-Canada.jpg
Page 12/13 (Problem Definition)
https://picography.co/indoor-rock-climber/
Page 14/15 (Background History Social Context)
https://gripped.com/indoor-climbing/11-gold-medals-in-the- paraclimbing-world-championships/
Page 18-19 (User Profile)
https://gripped.com/indoor-climbing/ontario-climbing-gyms-join-together-to-talk-reopening/
https://www.christopherreeve.org/living-with-paralysis/stats-about-paralysis
https://www.newwestmedical.com/power-mobility-custom-wheelchairs
Page 20-21 (Activity Mapping)
https://www.youtube.com/watch?v=_et2t-g3lWU
https://www.youtube.com/watch?v=Gmerle8eE-g
Page 22-23 (Product Benchmarking Adaptive)
https://www.omniprogear.com/Petzl-VOLT-LT-fullbody-harness-p/pc72sfa1u.htm
https://mistymountain.com/shop/adventure/adaptive-gear/wellman-pull-up-bar/
https://challengesunlimited.com/product/misty-mountain-arc-universal-full-body-harness/
Page 24-25 (Product Benchmark Harnesses)
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https://www.mec.ca/en/product/6013-939/Zone-Harness?colour=Sulphur
https://www.outdoorgearlab.com/reviews/climbing/climbing-harness/arcteryx-fl-365
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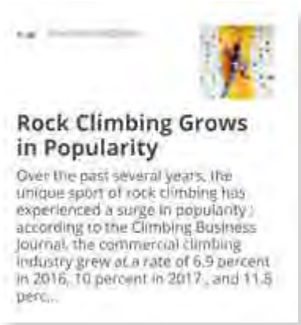
Page 28-29 (Product Benchmark Aesthetics Harnesses)
https://www.mec.ca
Page 30-31 (Product Benchmark Manufacturing Harnesses)
https://www.climbing.com/gear/behind-the-scenes-how-climbing-harnesses-are-designed-and-tested/
Page 32-33 (Product Benchmark Sustainbility Harnesses)
https://terradrift.com/want-a-sustainable-climbing-harness-these-3-are-the-best/
Page 34-35 (Product Benchmark Shoes)
https://www.mec.ca/en/product/5062-822/Vapor-V-Rock-Shoes?colour=OCN18
https://www.mec.ca/en/product/5044-819/Otaki-Rock-Shoes?colour=BLU20
https://www.mec.ca/en/product/6012-914/Geshido-Rock-Shoes?colour=BK293
https://www.mec.ca/en/product/5059-430/Furia-S-Rock-Shoes?colour=PYP00
Page 36-37 (Product Benchmark Functionilty Shoes)
https://blacksheepadventuresports.com/2017/06/01/review-five-ten-quantum-rock-climbing-shoe/
Page 38-39 (Product Benchmark Aesthetics Shoes)
https://www.mec.ca
Page 40-41 (Product Benchmark Manufacturing Shoes)
https://shoedoctor.eu/en/home/
Page 42-43 (Product Benchmark Sustainbility Shoes)
https://www.yankodesign.com/2021/09/27/your-next-climbing-shoe-could-be-completely-3d-printed-according-to-this-dyson-award-winning-footwear-company/
Page 44-45 (Chapter 2 Summary)
https://www.outdoorrackbuilder.com/blog/equipment-for-rock-climbing
Page 48-49 (Needs/Benefits not my by...)
https://i.pinimg.com/originals/b3/68/3f/b3683f71ee8eae878e52516c66f72c99.jpg
Page 50-51 (Latent Needs + Categorization of Needs)
https://commons.wikimedia.org/wiki/File:Gfp-jagged-rock-texture.jpg
Page 56-57 (3.4 Aesthetic & Semantic Profile)
https://sc01.alicdn.com/kf/HTB1gDpeboGF3KVjSZFvq6z_nXXaa/230324620/HTB1gDpeboGF3KVjSZFvq6z_nXXaa.jpg_.webp
https://cdn.shoplightspeed.com/shops/634685/files/31106383/image.jpg
https://gripped.com/wp-content/uploads/2018/02/IMPACT-Climbing-BoulderParc.jpg
https://media.istockphoto.com/photos/carabiner-with-rope-picture-id509476382?k=20&m=509476382&s=170667a&w=0&h=G9XxBoxahV5bjvO1y0CAlpJQDP5UthuIVl20fPujJOI=
https://www.rei.com/dam/kschroeder-_climb_gear.jpg
https://static.dezeen.com/uploads/2018/10/superstar-graphene-wheelchair-kuschall_dezeen_2364_sq-411x411.jpg
https://icdn.digitaltrends.com/image/digitaltrends/pertex-fabrics.jpg
https://www.thebmc.co.uk/Handlers/ArticleImageHandler.ashx?id=7761&index=0&w=605&h=434
https://aarongerrycom.files.wordpress.com/2020/04/hbh_climber.jpg?w=924&h=0&crop=1
https://cdn.shopify.com/s/files/1/0424/1145/products/The-One-Pro-Product_1_800x.jpg?v=1606319800
https://www.paralympicheritage.org.uk/running-blades-and-their-evolution
https://www.cilogear.com/3004.html
https://gearjunkie.com/climbing/gear-list-sport-climbing-essentials
https://www.mountainproject.com/route/107069340/aesthetics
https://www.patagonia.com/stories/climbing/
https://www.paris2024.org/en/sport/sport-climbing/
https://www.tetongravity.com/story/culture/toms-and-so-ill-created-limited-edition-climbing-shoe-line
Page 58-59 (3.5 Sustainabilty)
https://mpora.com/rock-climbing/edelrid-huascan-climbing-harness-review/
Page 62-63 (Design Brief)
https://parthianclimbing.com/harrogate/2020/05/26/the-power-of-planning-route-reading/
Page 66-67 (4.1.1 Aesthetic Profile)
https://www.medgadget.com/2008/11/honda_makes_public_new_robotic_walking_assist_device.html
https://newatlas.com/wearable-chairless-chair-2018/53521/
https://www.plusmedicaot.com/wp-content/uploads/2014/04/perforation2-350.jpg
https://i.all3dp.com/cdn-cgi/image/fit=cover,w=1284,h=722,gravity=0.5x0.5,format=auto/wp-content/uploads/2021/03/17162353/Xkim.jpg
https://www.bostondynamics.com/atlas
https://exoskeletonreport.com/product/indego/
Page 96-97 (Physical Model Fabrication
https://www.architecturelab.net/best-self-healing-cutting-mats/

Appendix A - Discovery



- Rock Climbing popularity has surged in the past couple of years
- Industry grew 6.9% 2016, 10% 2017, 11.8% 2018
- Full-body excercise
- Mental Activity
- Social commitment and teamwork
- Requires knowledge of equipment

- Modern Paraclimbing traced to Hugh Herr 1982
- Developed protheses to climb even harder before amputation
- Height adjustments are some of the benefits that using a prosthetic has provided
- Jim Gorn was the first amputee rock climber

- Mark Wellman, pioneer of adaptive climbing equipment
- Climbing using a pullup mechanism
- First paraplegic ascent of Half Dome
- Runs a company called “No Limits” that supports people with dissabilities
- Ambassador for adaptive athletes

- Physical benefits, full-body workout
- Mental benefits, improved self-esteem and confidence
- Social community and uplifting atmosphere

Appendix B - Contextual Research (User)

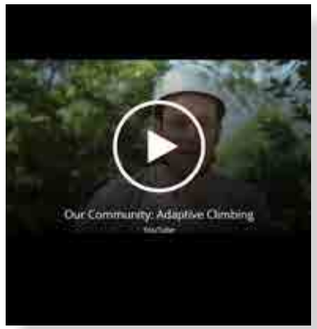
- 250,000 - 500,000 suffer from a spinal cord injury
- Majority of spinal cord injuries are from sudden injury
- Spinal cord injury often requires a person dependent for the rest of their lives
- 20-30% of people with spinal cord injury
- Negativity and physical barriers result in exclusion

- Classification of Paraclimbing categories
- Physical Limitations
- Muscle Deficiencies
- Full medical documentation for all athletes to be reviewed by a panel in order to classify the athlete

- Climbing is not limited by your dissabilities
- Number of climbers with disabilities have gone to achieve qualifications which enable them to lead others
- Supportive community
- Cerebral Palsy

- Adaptive Climbing community based in Vancouver
- Aim to make climbing accessible
- Create opportunities for individuals living with barriers to benefit from climbing

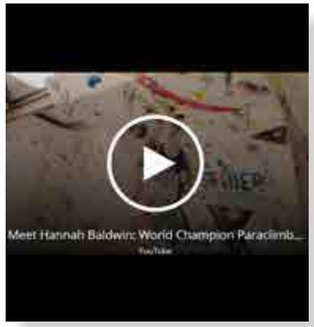
Appendix B - Contextual Research (User)



- Video documents the Canadian Adaptive Climbing Association bringing a couple of new individuals with disabilities to an outdoor climbing route in Squamish BC
- The individual of interest was the one with paraplegia

- Lai Chi-Wai is a paraplegic athlete
- He has won four times in the Asian rock climbing competition
- A traffic accident left him paralyzed from the waist down
- Climbed lion rock with a wheelchair

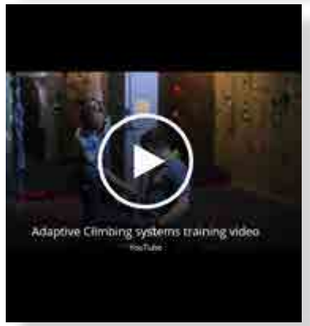
- Video documents Chelsea Donelon, a parplegic climber and their journey of climbing in an indoor route from beginning to end
- Shows the struggles and the challenges faced by both the user and the dependents



- Hanna Baldwin, world champion paraclimber
- Hannah has he ability to use one of her legs
- Video descirbes her journey to climbing and the empowerment and inspiration it provided her with

Appendix C - Field Research (Product)

- Rifton profuct demo of a piece of assistive equipment
- Provides a maneuverability option for moving people in and out of chairs



- Training video on use of adaptive equipment systems
- 5:1 Pulley
- Pullup Ascender
- Wheelchair transfer system
- Products shown are mainly Wellman products

- Wellman Custom ARC 4:1 Climbig system product demo
- Shows all the neccessary components as well as a demonstration of the adaptive climbing equipment
- User is in a floating chair that can ascend via consecutaive pullups

- Introduction video to Mark Wellman
- Pioneer of adaptive climbing equipment
- Goes to local events with a transportable climbing wall to promote rock climbing accessibility

Appendix D - Result Analysis

LINK	https://www.mec.ca/en/product/5045-765/Solution-Harness?colour=ASB02	https://www.mec.ca/en/product/6013-847/Sama-Harness?colour=GRY00	https://www.mec.ca/en/product/6013-939/Zone-Harness?colour=SPR03	https://www.mec.ca/en/product/5039-685/AR-395a-Harness?colour=TAT03	https://vevor.ca/products/safety-climbing-harness-fall-protection-equip-for-rock-climbing-floor-rappelling-1?gclid=Cj0KCQjwwY-LBhD6ARIsACvT72PNse0ygc2zBkLJN8BNiCHTZeuKtqgOHduL8UVagHArvU8nQBaRd8IaAmpkEALw_wcB	https://www.amazon.ca/Rock-Climbing-Harness-Activities-Adjustable/dp/B07LB638BR/ref=asc_df_B07LB638BR/?tag=googleshopc0c-20&linkCode=df0&hvadid=335336138319&hvpos=&hvnetw=g&hvrand=5672882907274933311&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9047850&hvtargid=pla-691772411910&psc=1	https://mistymountain.com/shop/adventure/adaptive-gear/arc-harness/	https://www.nolimitstahoe.com/gear/gear.htm	https://www.gardenmachinesltd.co.uk/treehog-th7000-tree-climbing-seat-harness-53308-p.asp	
PICTURE										
BRAND	Black Diamond	Petzl	Black Diamond	Arc'teryx	VEVOR	ISOP	Mark Wellman	Mark Wellman	Treehog	
NAME	Solution	Sama	Zone	AR 395a	Safety Climbing Harness	Harness	Orion 3	Swami	TH5000	
PRICE	$85	$90	$120	$200	$90	$35	$600	---	---	$332
WEIGHT	330 g	385 g - 475 g	307 g	395 g	2.41 kg	699 g	---	---	---	
TYPE	Seat Harness	Seat Harness	Seat Harness	Seat Harness	Full-body Harness	Seat Harness	Full-Body Harness	Seat Harness	Seat Harness	
BENEFITS	ergonomic	supportive	sleek	all-around	high strength	inexpensive	acessibilty	acessibilty	support	
	comfort	comfort	comfort	performance	durability	durable	comfort	comfort	comfort	
	performance	flexible	versatility	lightweight	safety	adjustability	safety	accomodation	ergonomic	
	cushy	convenience	minimilist	supple	comfort	neccesities	accomodation	safety	protection	
	flexible	organized	flexible	comforms	adjustability	quality	targeted design	support	safety	
	out of the way	snug	soft	comfort	protection	multipurpose	sturdy		durability	
	convenience	durability	powerhouse	compact	ease of use		support			
		breathable	performance	convenient	flexibility					
			lightweight	versatility	reliability					
			breathable							
			low profile							
			support							

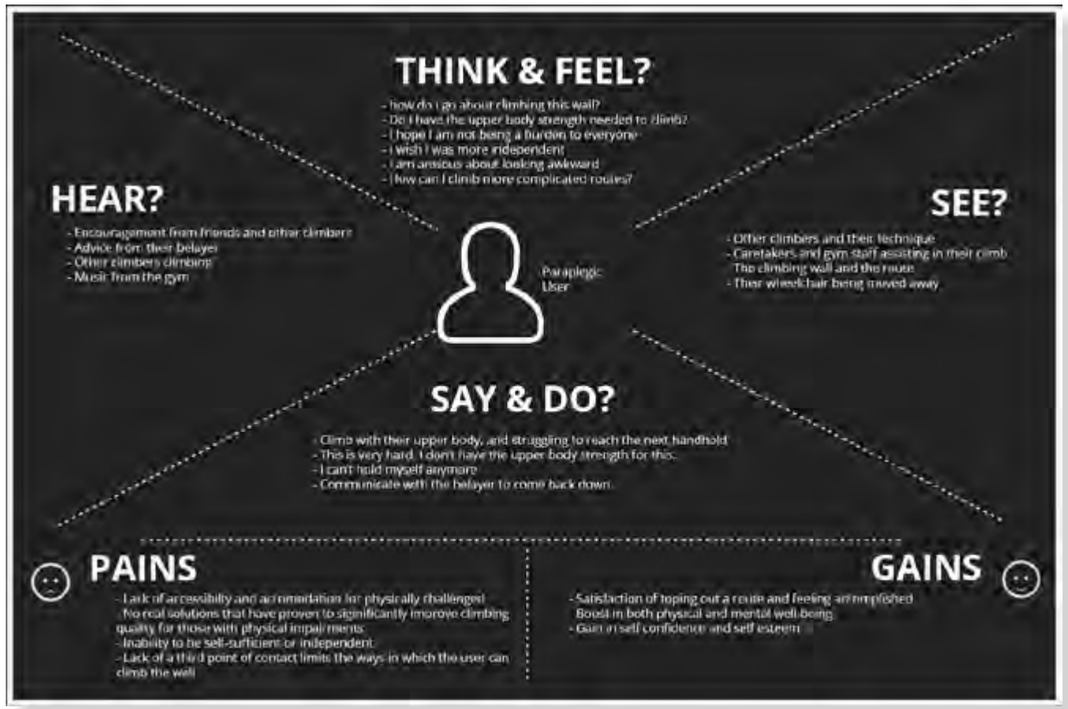
Benchmarking Harnesses

Appendix D - Result Analysis

argonomic	supportive	sleek	all-around	high strength	inexpensive
comfort	comfort	comfort	performance	durability	durable
performance	flexible	versatility	lightweight	safety	adjustability
cushy	convenience	minimalist	supple	comfort	necessities
flexible	organized	flexible	comforms	adjustability	quality
out of the way	snug	soft	comfort	protection	multipurpose
convenience	durability	powerhouse	compact	ease of use	
	breathable	performance	convenient	flexibility	
		lightweight	versatility	reliability	
		breathable			
		low profile			
		support			
Comfort		8			
Support		4			
Safety		4			
Flexible		3			
Durability		3			
Performance		3			

Work Frequency Benefits and Features - Climbing Harness

Empathy Map - Climbing Wall Designer

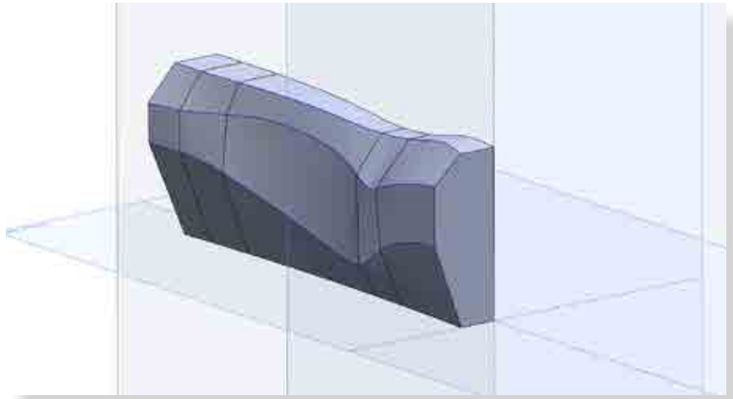


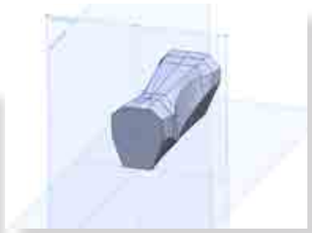
Empathy Map - Individual with Paraplegia

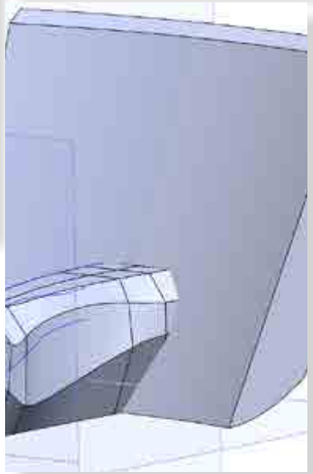
	Male						Female			
	99	50		90			99	50	SD	5
Hipsit	16.9	14.2	1.180721	15.6742			18.3	14.6	1.970714	11.97532
Upper Thigh to Crotch	14.3	12.62	0.72227	13.53728			13.4	11.8	0.687678	10.665
Crotch Height	36	32.8	1.373721	34.54721			33.1	23.9	3.633265	17.37377
Calf Length	18	16.5	0.844804	17.319			16.4	15.1	0.938822	14.17782
Ankle Height	3.7	3.2	0.214781	3.473001			3.3	2.9	0.171202	2.616251
Waist	13.6	11.4	0.934363	12.6012			10.7	9	0.730686	7.794067
Front Thigh Width	8.45	7.1	0.390328	7.837102			8.25	7.3	0.408428	6.626096
Front Calf Width	4.5	3.9	0.237934	4.227601			4.1	3.5	0.237934	3.074377
Space Between Calf	4.3	4	0.128377	4.163801			5.1	5	0.042922	4.929063
Side Thigh Width	7.6	6.3	0.338822	7.009802			7.7	6.1	0.687678	4.965004
Side Calf Width	5.3	4.6	0.300248	4.982201			4.6	4.2	0.171202	3.916251
Foot Length	11.7	8.5	1.373721	10.24721			11.7	9.5	0.94363	7.939381
Knee Height	24.5	21.7	1.203768	23.2288			22.4	19.9	1.074807	18.12657
Knee Buttock Sitting	26.5	23.6	1.246778	25.1834			25.5	22.6	1.246778	20.54282
Rock Climbing Reach Bent Arm Standing	82.87	74.82	3.480877	79.21531			75.55	69.14	2.733604	64.59292
Rock Climbing Reach Sitting	64.47	58.12	2.730003	61.58711			67	61.5	2.304874	57.59845
Rock Climbing Reach Standing	92.1	83.2	3.426311	88.05942			83.9	76.9	3.002436	71.93439
Arm Length	31.5	28.6	1.248778	30.1834			28.5	26.5	0.837649	25.08126
	*all dimensions are in inches									

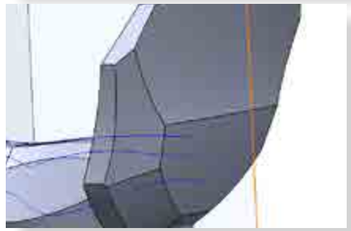
Anthropometric Data Conversion

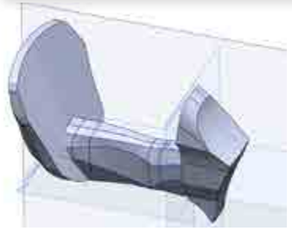
Appendix E - CAD Development

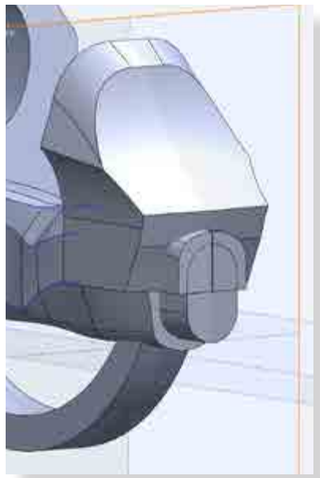


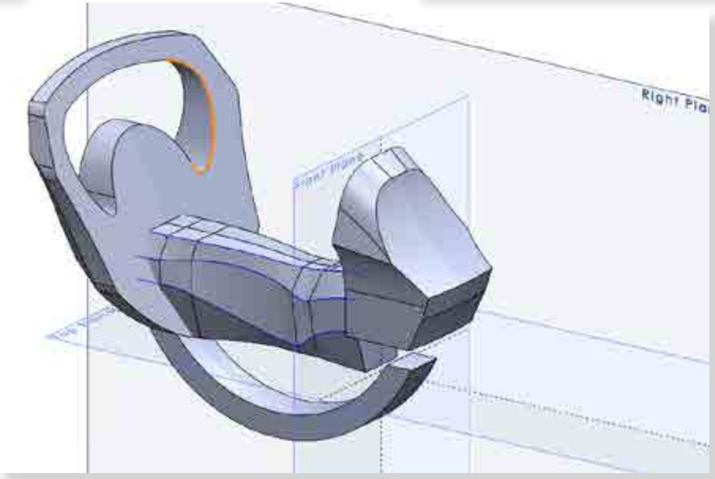


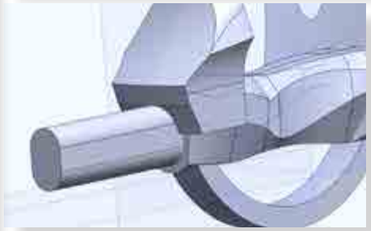


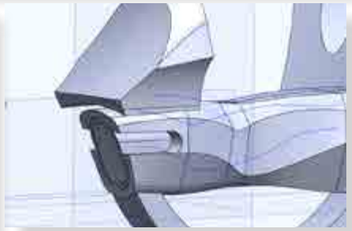


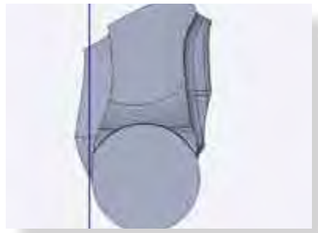


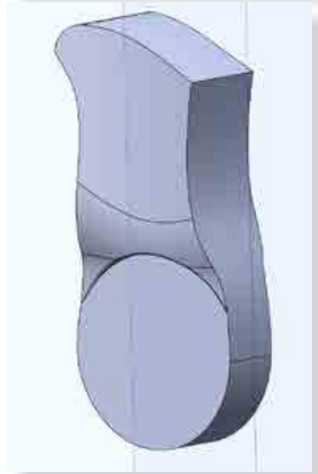


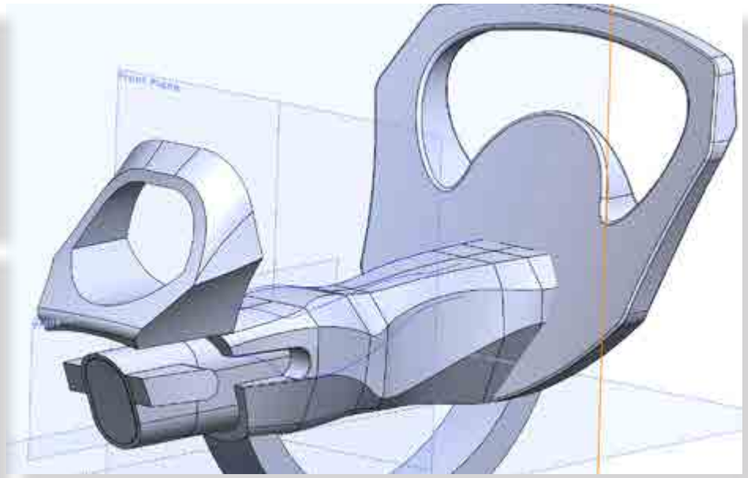


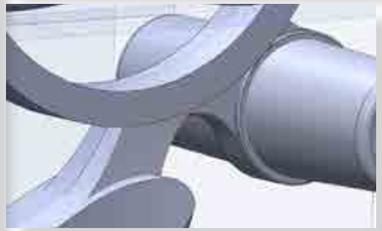


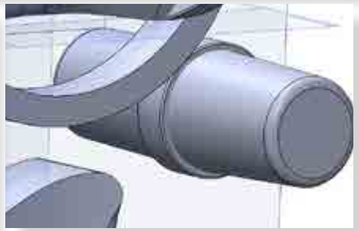


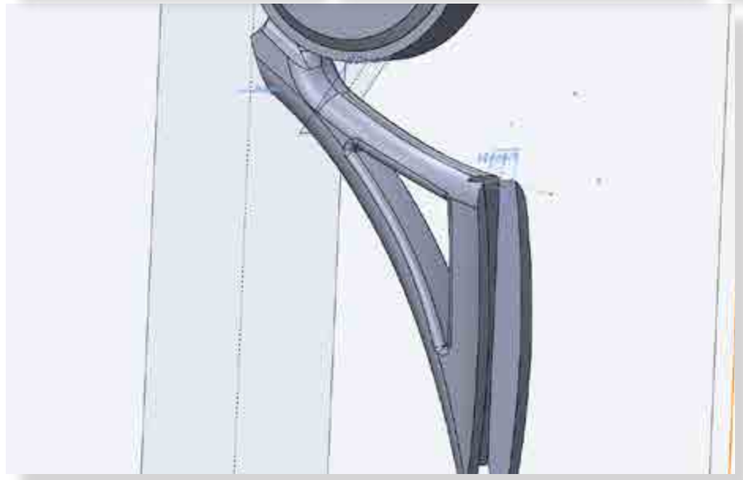


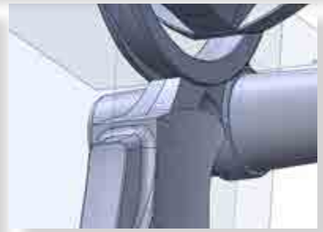


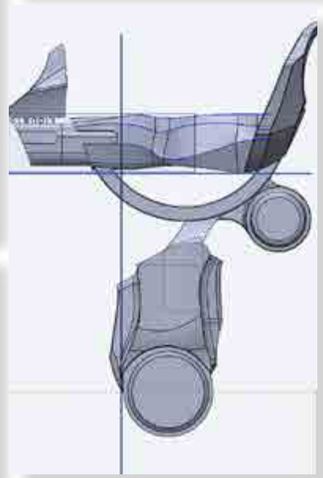


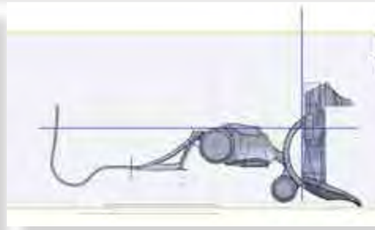




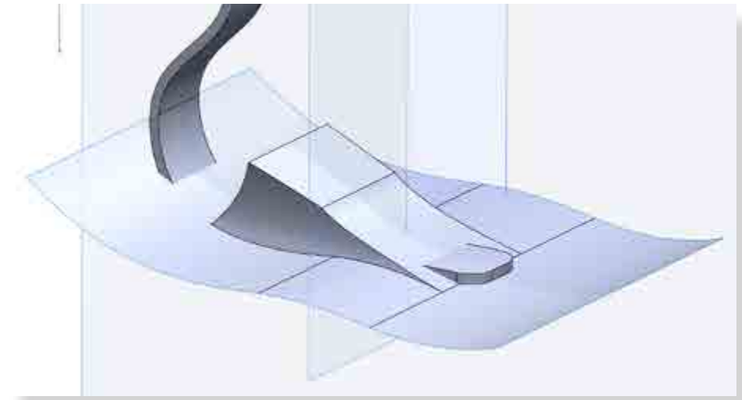


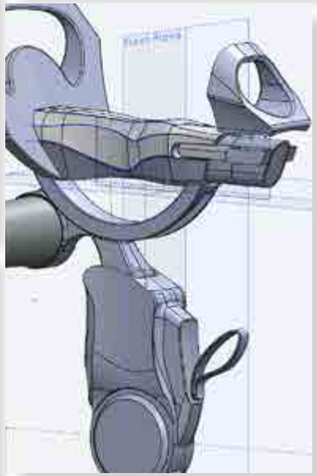
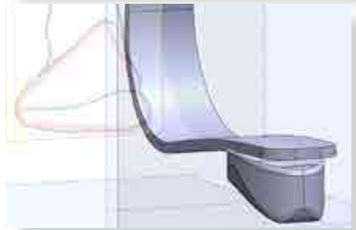


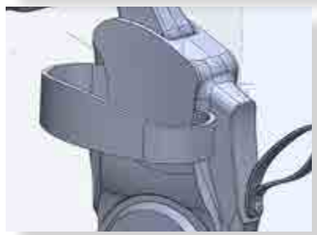
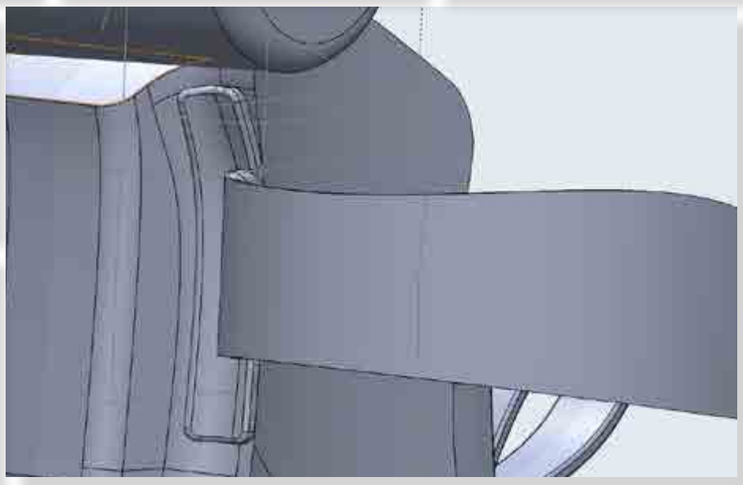
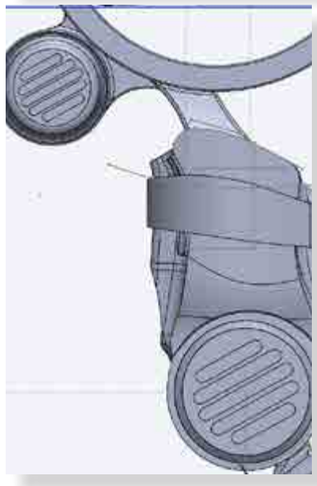
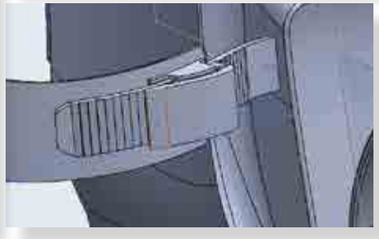
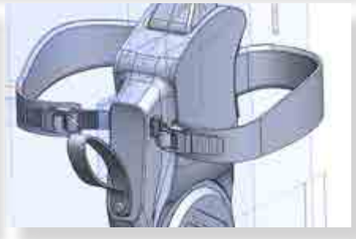


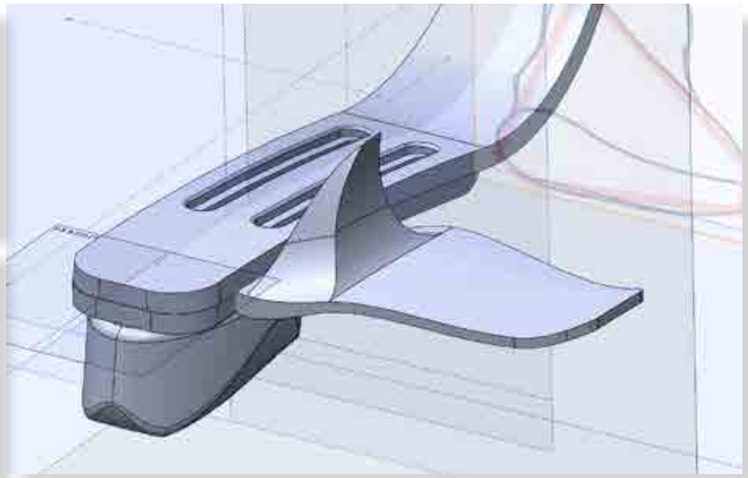
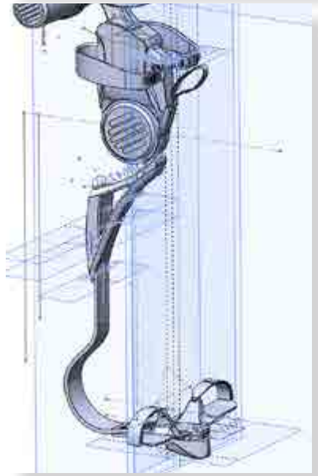
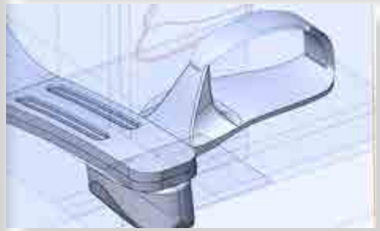
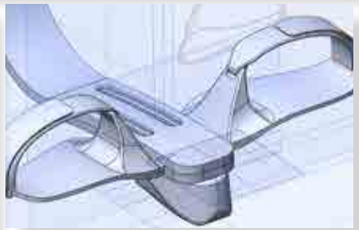


Appendix E - CAD Development






Appendix J - Approval Forms & Plans

IDSN 4002/4502
SENIOR LEVEL THESIS ONE AND TWO

Humber ITAL / Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2021
Catherine Chong / Sandro Zaccolo

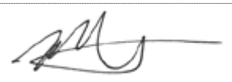
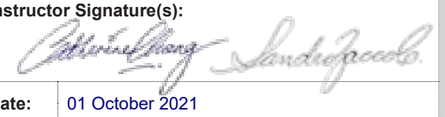
FTA-2 (B) THESIS TOPIC APPROVAL (Preliminary Abstract)

THESIS TOPIC APPROVAL (TOPIC DESCRIPTIVE SUMMARY):

Student Name:	Patrick Hui
Topic / Problem Definition:	How may we enrich the rock-climbing experience for the physically challenged?

Abstract

Rock climbing has become increasingly popular in recent years and has garnered a lot of attention in the media especially after its debut in the Tokyo 2020 Olympics. Climbing as a sport offers full body activation and mental benefits. However, due to the nature of the sport, those with physical impairments are unable to fully experience everything that climbing has to offer. Current products and technologies such as traditional harnesses and climbing walls are primarily targeted for able-bodied users, but there is little innovation towards those with physical disabilities. At its core, climbing is an individual sport. Those with physical impairments lack the ability to be independent. How can we make the climbing experience more independent for these users? Overall, how can we further enhance the sense of accomplishment for those feeling inadequate about their lack of mobility? The goal of this thesis topic is to change the conversation and explore innovative thinking through in-depth user research and a full understanding of the ergonomics of physically challenged individuals. Interviews with primary users who are impaired is crucial to understanding the challenges that they go through and the barriers that they experience as a climber. User research into secondary and tertiary users will also be conducted to get the full picture and scope of the problem. Creating one-to-one models of interaction points will aid in establishing correct full-bodied human interaction and an adherence to appropriate ergonomics. A design solution will be developed for physically challenged individuals to elevate the climbing experience to new heights.

Student Signature(s):		**Instructor Signature(s):**	
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IDSN 4502
SENIOR LEVEL THESIS TWO

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

CRITICAL MILESTONES: APPROVAL FOR CAD DEVELOPMENT & MODEL FABRICATION

Student Name:	Patrick Hui
Topic / Thesis Title:	**ADAPTIVE CLIMBING EQUIPMENT**

THESIS PROJECT – DESIGN APPROVAL FORM

Design is reviewed and approved to proceed for the following:	X	**CAD Design and Development Phase**
Comment:	- Initial CAD started reasonably as of week #7/February 22nd, continue with detailing and refinement. - Refinement and development coming along as of week #8/March 8th. - Need to continue development and refinement for detailing. - Advised completion latest by week #9 (March 17th).	

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

Instructor Signature(s):	
Date:	22nd March, 2022

Appendix J - Approval Forms & Plans

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

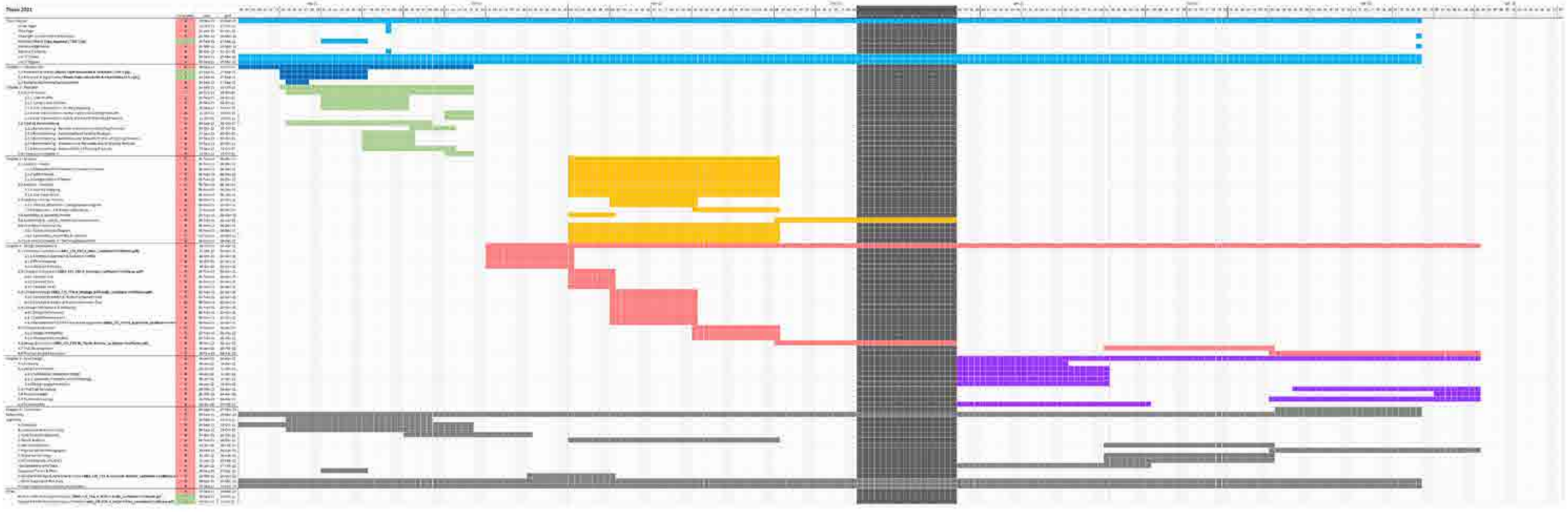
This document certifies that

Patrick Hui

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

n01313382

Date of Issue: **27 September, 2021**



Appendix K - Advisor Agreement Forms

HUMBER

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

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

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.**

Brent Goodman		Monday, November 1, 2021
Participant's Name	Participant's Signature	Date

Project Information

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

Phone: 647 588 8672

Email: Patrick.hui@mail.mcgill.ca

My supervisors are:

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

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

HUMBER

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

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

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: Accessibility in Rock Climbing

Investigator: Patrick Hui – 647 588 8672 – Patrick.hui@mail.mcgill.ca

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

I, Patrick Hui, have carefully read the Information Letter for the project "Accessibility in Rock Climbing", led by Patrick Hui. 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 Patrick Hui at any time during the project.

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

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

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

Privacy

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

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

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca** or Patrick Hui – 647 588 8672 – Patrick.hui@mail.mcgill.ca ».

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.

Brent Goodman		Monday, November 1, 2021
Participant's Name	Participant's Signature	Date

Appendix K - Advisor Meetings

Patrick Hui 0:00
Great. Um, so I guess I'll just, you know, I can introduce sort of what my project is and sort of what I'm trying to do for my thesis. So I am studying industrial design or product design, and if that's what you want to think. And basically, I'm trying to try to enrich sort of the rock climbing experience for those with with physical limitations, pretty much I'm trying to, you know, either design a product that can solve sort of that issue, make it easier for them, or, you know, completely changed the game, basically. And, yeah, I sort of found you on the Adaptive Climbing Canada. I didn't really know about the term Adaptive Climbing until I started this project. So it was really cool to find, oh, there's some certain initiatives that's happening in Canada, as opposed to, you know, somewhere in the states where it's a lot harder for me to contact people.

Brent Goodman 1:02
Do you have any initial ideas based on kind of your initial research? Or are you just kind of, you know, that's why you're reaching out is because you're not really sure what the need is.

Patrick Hui 1:18
I have some ideas, but it's like really like rough ideation, like nothing consult consolidated at all. And I hadn't really been able to speak with anyone who's either either has a limitation or is involved with sort of the people that, that do this kind of stuff. So it's a sort of great to find you. And I'd love to hear your, your experience working with them, and what kind of challenges they might have and what you see as someone who's, you know, involved in that sort of field.

Brent Goodman 1:56
Okay, well, I want to keep it kind of science, because there's so many directions. So I guess, just to clarify, are you are you an engineering? Like? Are you in an engineering school?

Patrick Hui 2:14
It's a it's a design school? So it's, it's, it has, it has similarities, but it's definitely not as you know, it's not meant to be fully, you know, well thought out, like, ready for production kind of thing. It's more of, you know, get the concept and have it, you know, realistic and be tested with, it could be sort of creating idea that could feasibly be be produced, sort of that sort of that direction.

Brent Goodman 2:45
Sorry. And also, do you have? Are you specializing in any particular material? Nope, there's

Patrick Hui 2:53
no, no limit on on that.

Brent Goodman 3:05
So I think, I don't want to like to give you ideas, but I'll kind of give you like, I guess an overview, and then. And then I will kind of share a few things like in terms of tools that we use that we've come up with. That worked for some people, not everyone. But just a quick overview, I kind of started out as kind of identifying a potential linkage between therapeutic climbing, and just the positive effects that I was seeing, having worked in adaptive recreation. We had started a little climbing Friday, climbing thing, Victoria on I work there. Every Friday, I had a really broad group of people, you know, through all the autism Down syndrome, acquired brain injury and all kinds of different situations. Each one kind of requires a different level of care, some more than others. Some were kind of, you know, what we were kind of finding those different situations from those unique narratives. We're gaining different forms of therapy. In terms of, there's four functional domains and kind of therapeutic directors like emotional, social, physical, and cognitive. And so depending on you know, who you are, is what happened earlier in the day. He kind of can end up with different effects, right in terms of what what one of those or more of those might get touched. During a climbing social trend, so everyone seems to be coming out with different, different needs. And leaving it with me as well. So anyway, I started seeing that therapy and climbing and how beneficial it could be. So I started doing research, like you're kind of doing a little bit, there's lots of states, there is some hair climbing. So it is, you know, kind of growing right now, which is pretty cool in terms of competition climbing, but it's still got a long way to go. And anyway, I went to Colorado and I followed around sports. Every single program that they offer, I got to get in on a training that they did at a climbing gym for guys. And I got to see indoor climbing and climbing, which is pretty great. So when I came back, I know, I had a good idea of what what I didn't want to do, from what I saw from sports, I really wanted to make sure that I was trying to build a toolkit that allows for people to actually interact with the rock, and not just end up in a howling situation. When you Google adaptive recreation, or adaptive climbing, a lot of hauling systems where people are basically set up on a static line, and they're in a chair, and they just kind of ascending the rope independently. And I didn't want to be any part of that. So use that tool on a few occasions. But I'm really trying to eliminate that, if at all possible, just to make sure that people are interacting with the rock. So as soon as you start creating a situation where people are kind of potentially dragging their legs across the rock are, you know, trying to hold on to hold when they don't have a lot of good dexterity, or they have arthritis, or you know, bone, bone or ligament issues. There's all kinds of tools that we have to start incorporating in order to take weight,

eliminate strain, and protect their bodies. So we've been kind of working. Since I started on just trying to figure out those three things. And, you know,

really, without a budget, just trying to you know, it's been, it was really effective living in Squamish because I'm surrounded by a really nice climbing community. And a lot of those climbers also work like an industrial rigging, and search and rescue. So I have had access to all these great people who work with ropes for a living in various ways, either in recreational or otherwise, so. So we've kind of incorporated into a lot of people to quantity. But the missing pieces became evident in terms of, you know, eliminating strain from muscles, ligaments, and you know, those kinds of things to small muscles in your hand and shoulder and wrist. There's a lot of strain involved. If you're, you know, you can't stand on your feet. So that was the thing that we've kind of continued to work on. And then the other piece, of course is like protecting the body. Especially outdoor climbing, protecting the body from from skin damage, basically. So the project that you might have seen on the website with Hannah, last year was to design like a technical pants that would kind of provide protection for mostly chair chair users. But it will definitely come in handy in lots of different use cases because because we put padding kind of a key area like on the knees, in various places where we saw lots of wear points. We were using chainsaw chaps before that, and they work and they definitely they do the trick but they really ugly and so eventually, I can lose you and I was just gonna say I'll leave you in. If this kind of is something there's something that resonates you know. Kevin is here in Exeter, who kind of helped me he kind of took me under his mind. Kind of a better design of the chainsaw chops and kind of made a custom version with more early material climbing rubber, if they're pretty hands actually. And then Canada kind of took that design in her consideration of her own design of a path. So we've been kind of going through all kinds of experiments, it's always room for improvement, because I think one of the things that I've noticed that, you know, every person is slightly different. And I think that's where the issue might might arise for you is like trying to come up with something that is universal, pretty difficult, is taking a lot of effort to come up with something like, the pants, for example. That might work for a broad range of people, you know, because almost like, each person might need a custom design of a pan, like in terms of length or have like how high it fits on the body, or what kind of needs it might need, like, we're hoping that she comes up with kind of a couple of different iterations in the past. So it'll kind of meet different needs in terms of like, whether it's full spinal cord, impairment, like full, full impairment, or if it's partial, because we have like, great. Some people can utilize sort of like, so like, for example, using Kevin, Kevin can stand on his feet. He has, he has use of his legs to a certain extent. Whereas Paulo, some of the photos on the website, like he doesn't have any uses, it's like, he can't, he can't, he can't wrap the body on his way. And also, the difference between how Kevin uses a pair of pants as designed, and Paulo is totally different. Like he needs, he needs them to stay. You know, for example, a quick example would be like, under the bottom of the, of the path, there's the I can't remember the right terminology, but like, it's like a little band that you put kind of under your foot to kind of keep,

keep the pants like in place. Because when Paulo climbs, as soon as he's like, lifting himself up with his upper body, the pants tend to he'll move around in his heart. And then the pencil will kind of drip some fillet. If he doesn't have that. Whatever it's called. And, whereas Kevin, Kevin can, like reach down and adjust those hands, so it's not like not as important because he's actually like, every now and then standing on Steam, and then it kind of it still is an issue, but it's not as big of an issue. So these little details, you know, can really make a difference. One thing I was just thinking, though, is like one thing that we played around with photos, I can send you as well as we've come up with like a solution for people who don't have dexterity or fine motor skills.

We utilize this. It's actually like a weightlifting wristband that goes around the wrist and it has like a hook. And what it does is it allows for people who maybe have maybe they had a stroke, or do they have good, good, fine motor skills in their, in their one hand, but not less, for example, like one, right? Oh, totally fine. And there's a left hand, like Virgina here in Vancouver, and she has that where she has one good hand, and then the left end, just because of her sort of Republic, she can really do a lot more effort to open the hand, it's almost always clenched. So sometimes, depending on the client, she can wear that wrist.

And they're not really perfect. You know, you can look online at them. They're kind of like weightless.

Strap things or whatever. I don't know what they're called. Find a link. But that will keep in mind when you were kind of describing what kind of what kind of course you're doing and stuff like that. The materials involved to make something work for that will be fairly straightforward. It's just a matter of keeping. One of the things we find is the material on the arrow. won't, they're usually like a flat surface, as opposed to maybe being like concave. And, and the hook itself doesn't always stay in position. And also the risks, the risks have kind of moved on person to risk, so it doesn't stay in place very well. So sometimes it works, and sometimes it doesn't. And balance came to mind, because that could hurt, you know, quite a few people, that tool has become really, really key. The reason it's really amazing is because if you have, say, only one, one, the use of one arm, in one side of your body, like the stroke victim, or something, where you have good use of one side of your body, but not the other, you end up in a climbing position where you're always kind of leaning to one side, kind of like you're kind of you're not valid. The key to to, like good climbing form is to always be kind of like facing the wall, you know, especially with the hardest ones that we use, we try really hard to use, like industrial artists to the key people in an upright position. So they have to, if they're in a tough position, they're kind of like square to the climbing holes, then, then they're going to have much more success, they're going to be able to reach fire, they're going to be able to stay with their body kind of close into the wall. So they're programmed to be a lot better, a lot faster, and they're going to have more enjoyment. So for those situations, when they are kind of imbalanced, so to speak, like that little one tool can be a real game changer from like their ability to make progress. So I was wanting that project could easily be pulled off, I'd say fairly quickly.

Patrick Hui 17:19
Yeah, it's interesting to hear some of these these projects that you've been, you've been describing this, it's good to know that, you know, I am thinking sort of similar pathways. So it's, it's nice to see that a monkey dilemma alone. And that's different, it's a little hard because, um, our specific thesis, there, there are a couple of limitations that make it much more difficult than I would say other other schools with similar programs. One of those is being sort of full by design. So the idea that it has to, it has to touch at least three different touch points of the human body. So whether it be you know, head, like, waist or something, for example, then, you know, it's not just limited to smaller products, you know, it can be a whole system designed together, it could be the wall itself can also be part of the whole project. So that's also sort of some of the directions of magnitude. I'm also really interested in the people that you've mentioned, Paulo was one. And also Kevin, who, you know, that I'm assuming they have some either incomplete or complete spinal injury on the lower half of their body. And just the idea of someone who's having to use a wheelchair and sort of that aspect of, you know, the frustration of going to injure climbing gym and having to deal with that wheelchair, sort of one of the areas that I was I was looking towards. So I mean, if you have any experiences or you know, stuff that you could tell me about working with someone who's got incomplete or complete spinal injury, I'd love to hear about that.

Brent Goodman 19:15
Mostly what we're focused on, right, we're focused on more physical and cognitive injuries, because I kind of made a decision early on that, like, the tools require basically like, the kind of this decision was like, Okay, if we can get people with like, complete spinal cord injuries, cerebral palsy, visual impairment, like those kinds of more challenging, you know, parameters, we could get them on a wall and climate successfully, then everything else can be super easy, right? Like every, all the other kinds of like, leg amputations or what Ever, like, those are all pretty easy comparisons, who cares, right? Like, they almost don't even need us. You know, they can just show up like their, their level of accessibility and inclusion, there's quite a lot easier, in my opinion versus someone in a power chair, coming to a rock climbing champion. So definitely like, you know, your perspective of accessibility is really a big part of why why we're still trying to do this thing, because there's a lot of work still to be done, right. Like in terms of in terms of, like a training that we do at a climbing gym, for example, a big part of it is doing like accessibility audits, you know, walking around the gym, looking, making the managers aware of things that they might want to consider, you know, thinking about in the future, right? how the entrance looks

like how easy it is for public transit? How hard is it to open the front door? Is there stairs, up the door, you know, up to the door? Like, how hard is the door to open? Like, you know, when you come to the desk? Like how, like, how much in a way, is someone in a wheelchair? You know, is there enough room for them to roll over to the change room in the changing room big enough? Like? Do they have accessible bathrooms? And then like, when you actually come on to the climbing area, you know, is there stairs going down into the climbing area, or how soft is the mat and it's even possible to get onto the mat and the mat, like, you know, can you roll on the mat, like, there's so many pieces to it, like we had a gym and dirt that we went to. And to get people in the gym, we had to lift. First of all, they had used the back door, because the desk is actually up a set of stairs. And then to go back to the gym is down a set of stairs the back door. And we use like a shitty old table. Like an old like table if they probably used to like parties or something, we use that as a ramp. And we put like a yoga mat down and then the power chair users would like roll up the friggin old table into the back door. And then when we wanted to get the end of the climbing area, there was a stakeholder in that and we had to get a bunch of people to help us list up this old. It's like never been moved for like 20 years. And we have to lift it up so that they could roll through into the into the gym. But you know, like Henry was willing to a lot of fun there for free. So it's like, Okay, well we're going to use but, you know, it was like 20 years and stuff underneath that. And people had it. Right, we were like well so yeah, I think some potential solutions to I mean, obviously there's routes, like here in BC and and Ontario. More specifically, there are lots of, you know, accessibility audits available. We haven't really utilized those too much in Ontario and like reaching out to a third party to ask for assistance in terms of an accessibility audit like Rick Hansen Foundation, for example, here in BC those really good accessibility audits. There are groups in Ontario that do do kind of accessibility audits but specifically to climbing and get some of the solutions. I can just touch on a few other examples downtown Toronto I know that there was a guy that was still so base camp

in con Medina or whatever strict that is they there's a there was a dude that walked around door to door and was selling ramps that are ever seen that there's little ramps that people have at their front door because the all the entrances have a little step off the sidewalk. And so he went around and sold these little ramps and he built like custom for each each little step and they just keep them by the door and that's like a great example of a small little accessibility solution. So Basecamp actually has one of those little Medina location Martin says right at the door so someone could knock on the window and come out with a little ramp and people become and it's pretty sweet so like little ramps are kind of a key solution actually inside the gym as well. You know some gyms have and some some gyms have thought about some gyms. They haven't at all, you know like the boulders mento because they definitely have thought about those times. Snakes are really good

people, we mostly work with true north. And I don't actually know what's part of true north climbing. And you know, we've worked with them for like, three or four years now. So they're definitely on top of things. I'm not sure how you know how accessible the play is, in comparison to others, I

know that the folders in Soho is probably the best one that I've seen in terms of good accessibility. But I think thinking about those things is, might be a great way to approach this in terms of hitting all the points that you're describing. Because, you know, simple solution, like building a ramp, or, you know, getting actually onto the floor, for example, to get to the ropes is a pretty easy thing that will hit a bunch of points. And the other thing that is a potential solution I've seen in the past, for example, or some older Tim's like the default product, where we actually had to bring like, like, we had to bring, like, we had to pull plywood out. In order for the power chair users to get across the map, because the maps were so soft, that they just, they stopped. So we have to create like, like basically like, like a toadstool type, like, we have to build basically like a road across the mat to get to the spot where we have to climb setup, and we had to have a ramp onto is just like a total disaster, because the masks are so soft. In order to get people actually on, we had to like stack to fly with that wouldn't break under the weight of our chair. So you know, just thinking that out loud, right? I'm wondering if there's a way to come up with some solution for specific gym that

has an issue, but they want to address it, it might be some kind of industrial outlook on a solution that is, you know, maybe not permanent.

But allows, allows the gym staff to quickly and easily kind of, you know, roll it out or whatever the case is. But other than that, I mean, without going into details on the artists, which I think might be, you know, a real, like, I wanted to work with our parents on designing

basically like a harness that is specific for what we're doing. You know, without going into those kinds of details, like

you know, if I, if I said you were in Vancouver, I would say that would be the project that I would want to focus on. That's those next, like, we actually have kind of gotten a job with our tariffs, I'm really hoping that we speak in there in the next year, and start working on a prototype design for a Technical Harness that isn't so ridiculously heavy and early, because we're tech, we're using a pestle industrial work harness. And it's an amazing part is that petal has, I just noticed this, in the last six months, they've changed the design of the one that finally was amazing for our use, but it's still very, you know, quite heavy and a little bit too over the top. And it would be really amazing the design of harvest specific to,

to kind of what I think is, you know, three sizes or four sides, we can come up with a harness that kind of low,

low weight, lightweight, versatile and does all the things that we needed to do. But I think that might be a good project to take on, I'm not sure.

Patrick Hui 29:26
I would say it's too big, just it's not it's obviously wouldn't be able to, you know, go into the most technical of, you know, safety requirements with a harness and you know, kind of testing that kind of stuff. But in terms of you know, creating a design or being thinking about the user and understanding what their issues are and creating something that works is within the realm of the scope of the project.

Brent Goodman 29:56
I would be keen on the design for sure

Patrick Hui 29:59
enough And you said with the harness there were there were some, I think, like features, I guess, with the pencil thing that that worked for your your specific needs as as you know, adaptive climbing equipment, could you go into more detail? What do you mean by what what features it has that works for you? The other computer, yeah.

Brent Goodman 30:26
So there's two sections. There's the sport and then the professional

Nubian vault,

the vault. So a standard climbing harness, right. And two leg lifts, and they're connected by one. One control little belay loop, they call it the issue with these harnesses, even see, in these professional grade ones, they're big and thick in the way, the ones that say, they're full body harnesses, like just do it. By themselves, it's a big, something to be worn all day, hung in for long periods of time, right? People are sitting in their furnace, you know, for four hours, five hours at a time, right? So they have to be they have to be, there can't be any pressure points. You know, so that's why there's so in the, in the legs, especially around so they can be worn all day long. There's lots of, there's lots of padding. But in addition to that, like in the work part, there's, there's a deal with time points, right. And that's, that's designed for longevity, because you're working in lots of different scenarios, right, you might be in an acidic environment or you might be in like confined space, or you might be you know, in various locations where these hard like I work for the rope act like these guys have come back the furnaces of the freaking destroyed after like, you know, say a hydro inspection or some kind of confined space where they just got the hardest destroyed from like, maybe an iron ore, all or something. So you can see the harness, really early metal clients in various places. One, like the two on the shoulders is the full body one, and then one, two in the front, usually one of the chaps one of the steps. And then there's also two sides one side for your, for your loss or clause that attach really fast. So there's a lot of different weird specific time points and we don't need any of them. We don't need like all we need basically is an equivalent of a basically the design of a phone. And the design is a new set of both made and you can see like the specifics of the different videos capsules all over the website. They will show you like specifically why they're built where they are. The one thing that stands out between Sport harness and a professional artists is that when you fall, you fall on an upgrade. And especially so in the bullpen the bullpen is built to be worn for people who are doing maintenance or whatever on on wind turbine. So on a wind turbine, you're in a very small state. Sometimes you can climb up through the two there's like a ladder in the center. And so for people climbing up that too, they fall, they don't have a lot of space to fall.

So that's the hardest is actually built so that you fall, kind of not in a sitting position, like you would in a climbing harness but you fall into kind of a upgrade, so to speak. And we've tested these harnesses and it's absolutely true. You just don't, your knees don't lift when you fall, you kind of stays the kind of stay in like standing position so to speak, you actually have to make an effort to to sit in a sitting position. So I really like that design. And it's a real game changer, because what it does is one, it eliminates the potential for people that fall sideways, or backwards, because you have a full, you have that full support. But you also for someone away from the wall when they fall, so we have three normally climbing on a static rope. And there's sometimes there's, you know, there's a counterweight system attached, taking like, say a third of their weight away. So when they fall, they don't lose progress. So wherever they fall is where they fall, they don't like there's not a rope stretch involved. So they're not losing like two inches or three inches or whatever.

They're not falling technically away from the wall, when they fall, they kind of fall like kind of where they are, and they don't get kicked back. So when someone has mobility issues, they're trying to reach forward with their knees in front of them. And they're trying to reach for the wall. And they have limited mobility. That's like really frustrating, right, so but if you're falling in an upright position, you're kind of all ready to go. But you can just grab the hole that's right in front of and then you know, get your feedback on something and start over again, it's a, it's been a real game changer. The only limitation is that the new harnesses change the previous version, or sorry, of the vaults, the previous version of the old was actually like a, it was more like a bat. So as opposed to the one you're looking at now it's almost three straps, right? Like the back strap to shoulder strap, but the previous version one, and you can probably see the previous versions that are more like lower profile. And it's an amazing artist, there's nothing else like it on the market that works for what we're trying to accomplish. So I want to build basically a full party. So without all of the work. Except, you know, all the extra pieces that are involved, right, I want to make it a low profile,

I don't want it to be flashy, I don't want any pressure points, I still want it to be in a status or in a standing position. I still need those two tie points on one of the one of the hips and then one of the chest. And then

and then possibly fold string. tie in point is behind, like kind of the small of the back on the heart. But other than that, I think you know, everything else will be pretty much the same the paddy within the same park terrace house. You know, they are inbuilt harnesses. So, in order to make one, it wouldn't be that much of a stretch for them, they already have the technical material is just a matter of design, it's a matter of just designing something based on the whole and how it functions.

And I'll just share one final thing, the reason I came up with it came about from lots of different services that we you know, we experimented with just the normal, you know, we're you know, just like without a chest or without a,

it's not a full body, right, just like just the normal one. Like a single hip one with a chest harness attached and those are just so uncomfortable and just knocking it they don't cut it for most people. They're to the infrastructure to and you're comfortable. And they just they're not comfortable. They're really, really uncomfortable. And then we tried a I got my hands on a zipline partner. And we've ever done any ziplining but the zipline harnesses has this like It's like basically like fabric seats. Because I can show you a picture I think I think it's actually still in Ontario somewhere. Figure out where it is, but I think it's still I think last time it was a big camp I'm not sure exactly where it is. But on my tablet anyways basically has these like if you Google like unzip lanterns I don't even know what company was coming In California that makes these awesome supplies harnesses, but they basically like old fabric, all over the hips, under the bomb, under the leg, and the strap kind of comes up and over the back from the back of the play clips, you know, so it's like, you actually are sitting down fully, it's really, really comfortable, harder, it's got a full chest comes over, to basically goes on like, like, you know, you put your leg, you put your arms in the front, and then and then there's like, you know, you kind of sit in, kind of like, from the back to the front flips on, like the three clips. And just a quick aside, you can see these work harnesses they can play on. So you can do it while you're you can do it while you're standing, right, you don't have to actually like, put it on your leg, you can just like, put it over your shoulders, and then click on the on the leg. That's a key feature of the tricep harness, the problem that I came was, the difference was that the people would get, like I was mentioning earlier, people would get socks off the wall in that same position, and then they couldn't get back on. They hadn't, it was too much of a seated position, even though in all the parameters of eliminating pressure points. And being really comfortable, it was easy to get on and off, you know, from a wheelchair user, right, you have to lift someone up and put it underneath them that that hardest

was perfect. And we have still use it in like extreme cases, because it is very comfortable. And it's easy to get on. But the trade off is that people are very much in a seated position. So it limits the potential it would be, it's almost like the perfect scenario harness for when we're hauling someone up. Like when they can't, when they have almost no mobility. And they're in a situation where they just have such a limited capacity to lift themselves up that part is does work really well. So that's why we've kept it. But it's a very rare situation when we're actually hauling so much. So that's why I went to the artists afterwards, I bought one, we experimented, it was like holy shit, this thing's totally amazing. It's way better than way lighter. It's definitely the best one out there.

Patrick Hui 42:47
For like good information. Now it's especially the hardest thing I guess it's nice to hear what what you're using in the industry and using it for your own purposes, sort of, you know, taking something that's not really meant for this, but it works for it. Definitely a lot of areas to to, you know, work with in terms of you know, working with design and that kind of stuff.

Brent Goodman 43:17
For you to collaborate on this project, like in terms of, like, I got you in, you know, with various people, like some of our climbers, as well as Hannah, I'm not sure, like, Anna has the capacity right now to like, potentially collaborate with you on the design, but that's something that could be reduced.

Patrick Hui 43:39
I think for this project or for the thesis in general, it's, it's more of individual design thinking as opposed to you know, being influenced by by others. And then, you know, at that point, it doesn't become your project at that point. So in that sense, I can see why why the collaboration would be really, really good. And, you know, if that wasn't an issue for the criteria of my project, I'd probably be totally cool with that.

Brent Goodman 44:14
But the only the only reason I'm mentioning your design, say it was the designer was like holy cow. Okay,

this is gonna work like, you know, you all in that side. Right. So, moving forward. You know, for our parents, for example, who want to get involved. We have to have some kind of an agreement, right or like a legal agreement. Moving forward, right to actually take that implement design into a prototype. Right.

Patrick Hui 44:52
Yeah, that's something I have to really discuss the my process because I have no idea to be honest about all of that kind of have implications and stuff. And I think I think the project as a whole at the end sort of belongs to the school.

Brent Goodman 45:12
Which, you know, it's, it's, it's a bit weird in that sense to,

Patrick Hui 45:18
I'm sure, though I'm sure there have been pieces projects that have done some collaboration and could have potentially gone to some sort of market at some point. But I'm not too sure about that aspect. So I'd have to get back with you in that.

Brent Goodman 45:38
Yeah, I would, I would. I just based on my experience with working with Hannah, she went to school here, she did a technical apparel, through KPU, the Wilson schools design. And we had to come up because Kevin's initial design iteration, we actually came up with a three way, basically a four way agreement that was signed by myself and Kevin and Hannah and the school. It's a fairly technical document saying who has who has the rights of design, right. In the end, you know, Kevin maintains his design for his, you know, the initial design that we came up with, Hannah maintains the design of the pants that she came up with, with the agreement from the EU that she can hold that, you know, design moving forward. So there's definitely legal, you know, parameters that would be important, I think, for me, having learned through that experience, because, you know, my end game is to make a harness, that is going to work. So if you end up with a situation where you actually work on that, and you come up with a design that actually makes sense, that would work, then I would want to make sure that we can move forward. Because like, for example, I'm currently working on turtles. If I get charitable status,

there's going to be it's going to be way easier to fundraise for say, Hey, we're going to build this prototype, with our characters, our characters on board, we're going to put in $20,000, you know, there's going to be an opportunity there moving forward. And I would hate for it to be stuck in the legal. Black Hole.

Patrick Hui 47:36
Yeah, for sure. I understand where you're coming from.

Brent Goodman 47:42
Especially seeing that the old terms have changed design.

Patrick Hui 47:50
Yeah, for sure.

Brent Goodman 47:56
You can look into it. I mean, obviously a legally binding document, that I could share the documents that, you know, when it comes to that I can definitely share the documents that we all signed here. If they're like, Oh, we've never had that situation before I can, you know, I can share with whoever it is a copy of the signed documents, just to kind of give them context for how an agreement could work. Yeah.

Patrick Hui 48:32
It's also very dependent on whether or not like, the harnesses the way that that that the end, the end goal becomes just, you know, there are other opportunities to explore. And that's also dependent on how my profs feel about it. But yeah, for sure if it if it does sort of go in that direction.

Brent Goodman 49:00
I just wanted to say, like, just come and surprise, like, I'm gonna do, and then I'm like, well, we're not doing it.

And then it might just talk about it now, because I'm learning each, each project is so unique, right? Like we worked with OT, like, our last project was with occupational therapists up, you know, in that situation, it's so much simpler. She just joined you know, does some research comes to our programs, you know, it's not as, not as evolved as something like what we work with Hannah, right? Like she actually came up with a design iteration. That is hugely scalable, right, like, we could show up to all the carrot climbing competitions over the next five years, and she could sell those people, you know, so like, all over the world, like it's actually a scalable product of the real We'll work on together. So now that I saw that in, I see like where she is headed. You know, I kind of see the potential now for a hardest for us, that is totally game changing in mind. So, if you're, if that's the project that you want to pursue, you know, I just want to make sure that, you know, I'm definitely a disrupter, as you might

hear. And I don't want any, like, I wouldn't want any legality to slow down the disruption, you know?

Patrick Hui 50:37
Yeah, for sure. I totally, I totally get it.

Brent Goodman 50:43
I've already, I'm actually dealing right now. Totally off topic, but I'm dealing with the county's issue that I didn't even know was an accounting issue. The account that I was using from 2018 totally screwed us over for the last three years. And, like, I'm now paying another account to fix all the problems that the guy created, specifically with the CRA. And so now, I'm just like, I'm a little bit on their heads, you know? Like, what the hell, like he didn't submit T to first season T submitted name correctly do into those names. As a for profit, instead of a nonprofit. And then, because of that, apparently, we owed money. But then I wasn't ever informed. I never looked at the theory accounts we had. We had an accountant who was doing it for me. And then he didn't submit to iTunes for the next previous two years, even though he told me so now, so now, I hope I Oh, series three, T two. And apparently money. Like, oh my God, but so anybody that counts on it is like way too much money, but I'm learning now in my older age is like, there's a fine balance between disruption. And like, you know? Any other anything I can send? Like, to give you more information.

Patrick Hui 52:38
Yeah, I would love to, I would love to speak with Kevin or Apollo, those who seem pretty good insights in terms

of just the users themselves and just unseeing the perspective from from their side of the story.

Photos are, um, and I guess like, if you have any locations in Toronto that I could visit that unless unless there's no like real sort of office in a terminal that you have it just more like an organization thing that just you go to the specific gyms you have, or any people in Toronto, I think, on their website, there's Cade. I would love to. Yeah, I would love to speak with her as well, that that'd be really awesome. So like, mostly contacts with people is great, because I've been struggling to find contacts.

And I mean, I guess the last thing, I guess, is really cool talking to you. Do you think you'd be willing to become sort of an advisor for our project? It doesn't require any time commitment at all, it's all you basically need to do is just answer any questions that I might have. And fill out sort of as participation consent.

Brent Goodman 54:14
Ya know, for sure. Yeah. And yeah, of course, and, you know, my focus is on the equipment side of things. They have Kate, Kate is really she's definitely not as technical. Like she's trained as a guide and, like, I trust her 100%. But her focus is not necessarily on the system. But you know, because she's in Toronto, if that becomes an issue, for whatever reason, because I'm in BC, and you need to advise her that in Ontario, because I have had that situation before. Yeah, of course, would be your go to person. So maybe just clarify that before. Before that comes

Appendix M - Topic Specific Data


www.nature.com

Stable muscle atrophy in long-term paraplegics with complete upper motor neuron lesion from 3- to 20-year SCI - Spinal Cord

Unrandomized trial. To investigate the structural and functional relationships and the progression of muscle atrophy up to 20 years of

- Study on muscle atrophy in long-term paraplegics
- Long-term patients force and size of thigh muscles were slightly different compared to mid-term patients
- Muscle fibres mainained striated appearance of normal skeletal fibers
- Up to 40% of muscle loss in the first three years

Paralysis statistics

In 2013, the Christopher & Dana Reeve Foundation unveiled staggering statistics based on research into the prevalence of paralysis across the U.S. According to the study, there are nearly 1 in 50 people living with paralysis - approximately 5.4 million ...

- Study on muscle atrophy in long-term paraplegics
- Long-term patients force and size of thigh muscles were slightly different compared to mid-term patients
- Muscle fibres mainained striated appearance of normal skeletal fibers
- Up to 40% of muscle loss in the first three years

About Spinal Cord Injury - Spinal Cord Injury BC

The spinal cord which is made of nerve cells and nerve fibres, resembles a cable about the size of your little finger. Approximately 21 inches (52.5cm) in length, it begins at the base of your brain and passes through the interior of each of your cervic...

- Anatomy of the spine
- Definitions of Paraplegia and Quadriplegia
- Different vertebrae that affect the parts of the body
- causes of spinal cord injury
- Is there a cure?

Living with Paraplegia: Recovery, Treatments, Exercises, and More

Paraplegia is almost always the result of damage to the brain, spinal cord, or both. In most cases, spinal cord injuries to the thoracic, lumbar, or sacral spinal cord are to blame. When these injuries occur, signals cannot travel to and from the lower ...

- Paraplegia is almost always the result of damage to brain, sprinal cord, or both
- Incomplete paraplegia
- complete paraplegia
- Hereditary or Spastic Paraplegia

Appendix M - Topic Specific Data

Saddle Ergonomics Explained

The Pelvic Bone When sitting normally, the sit bones (red highlighted areas) support the body's weight and have the capability to withstand high pressure. This should also be the case when riding a bicycle.

- When sitting normally, the sit bones support the body's weight
- Dynamic riding positions change the contact point slightly along the sit bone
- Pressure maps of differnt types of saddles
- Large blood vessels and nerves travel through the perenial region

Why Are Bike Seats so Uncomfortable? - eBike Pursuits

When I got my first bike, I couldn't understand why the seats were so hard and skinny. They were uncomfortable and were really difficult to sit on for a long time. I

- Bike seats are saddles, not seats
- Saddle is not meant to carry your full weight
- Narrow nose allows for clearance of the movement of a rider's thighs
- Harder, firmer seats are designed for experienced rider's because they are able to hold proper riding form for longer

Bicycle saddle fit [03] Saddle shape | BikeGremlin

This post, third in the series about bicycle saddles, explains what kinds of saddle shapes there are and which to choose according to one's needs and riding style. Previous two posts explain bicycle saddle material and ... While the next post will explain...

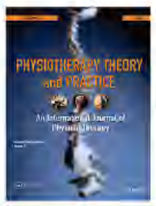
- Flat saddles are good for upright riding postures
- Waved saddles are good for leaned forward riders with minimal flexibility
- Moderately waved saddles is a mixture between flat and waved
- Convexity dissallows sliding from left to right
- T-shaped has more comfort while pear-shaped provide more support while the body moves

AASQ #77: Time to saddle up? SQLabs, WTB & Fabric discuss saddle fit, rail types, cut-outs and more!

We know, there's no such thing as a stupid question. But there are some questions you might not want to ask your local shop or riding buddies. AASQ is our weekly series where we get to the bottom of your questions serious or otherwise. This one is Abo...

- Pointy noses help the rider steer the bicycle
- Design also plays a factor into the design of the nose of the saddle
- Rider's who ride on steep terrain will use the front of the saddle more often
- Rails can be made from steel, titanium, carbon fibre

Appendix M - Topic Papers



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Outcomes following an adaptive rock climbing program in a person with an incomplete spinal cord injury: A case report

Brittany DelGrande, Carrin LaCoppola, Gabriele Moriello & Kerrianne Sanicola

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