Athlete Training & Injury Mitigation

By Andrew Chartrand

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Abstract

Athletes have one goal. It is simply to be the best in the world at what they do. Decathlon and Heptathlon must be the best in multiple events if they want to accomplish that goal. This means multi athletes have to spend five to six days a week training. That amount of time working out is very taxing on the body. Because of this, multi athletes have the highest dropout rate (athletes not being able to finish the competition) of any athletic event. In the following document a solution will be developed to help combat these issues.

Keywords: Multi Athlete, Decathlon, Heptathlon, Ergonomics, Human Centered Design, Interaction Design,

Acknowledgements

This project truly pushed me as a designer. Starting with nothing to now a dossier of over 100 pages. This final year at Humber has been amazing! So, thank you to Humber and the Faculty of Applied Science & Technology as well as all the students in the 2023 Batchelor of Industrial Design graduating class.

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CHAPTER 1
Introduction

1.1 Problem Definition

How May We…Mitigate Injuries in Multi Athletes?

The Decathlon is a two day competition encapsulating ten events. Decathlon training is especially hard on the body. This causes a lot of injuries both during practice and competition. This means there is an uncharacteristically high number of dropouts when compared to other events. Most injuries occur during the 100m, 400m, 110m Hurdles, and Long Jump. Most injuries happen on the first day of competition. The most common injury a pulled hamstring (hamstring strain).

I chose muti-event athlete injuries as my first topic as I have already well-established connections within the field (Multiple Coaches, Fellow Athletes, & Medical Staff) as well as personal experience. As I have competed in the decathlon, I also have a strong interest in the field that should last the entire year.

User: Athletes, Coaches, Suppliers/Clubs

Athletes (Primary User) competing in the decathlon at the international level are ages 21 to 32. All decathletes are Male. A decathlete is either both working and training everyday or a full-time athlete and trains 6 days per week. They don’t have much extra time and want to get things done quickly and efficiently.

Coaches (Secondar User) are often (But not always) Retired athletes. Coaches of decathletes are 26+ years old.

Facility suppliers / Club owners (Tertiary Users)

All users (Primary, Secondary, and Tertiary) have a stake in the products used during a decathletes practice or competition. This means the product must fulfill all stakeholders' requirements. The environment for all stakeholders is the same but is for different reasons. The athlete expects equipment to work and do its job flawlessly, a coach expects the product to help aid in the perfection or teaching of a technique, and a facility expects the product to be used and last a long time with repeated use as well as add value to their facility therefore inspiring more people to come to it.

1.1.1. Rational & Significance

The sport of track and field is a large one with many disciplines. The decathlon brings all these disciplines together in one event happening over two days. The decathlon is the ultimate challenge and causes many injuries both in training and competition. Currently there are several injury preventative techniques used by national/International level athletes. Some include Warm-up and Cooldowns, Injury Prevention, Mobility, Strength training, and Physio and Massage Therapies. Athletes also track their progression using technology such as Pressure Plates, Video, and Radar. Many of these technologies aren't available to up-and-coming athletes, often resulting in injury. The thesis research will be done using a combination of user interviews (specific details), surveys (broad picture), and user observation (product interactions). These research methods will provide a clear area of focus as well as define the target users. User testing along with ergonomics studies will validate the functions of the product and whether it fulfills the needs of the user. A solution will be developed that can resolve the issues faced by decathletes and their coaches. The solution will

mitigate decathlete injuries in training and competition as well as be available to early developing athletes.

1.1.2. Background / History / Social Context

History

There have been many forms of muti event competitions when looking through the history of the Olympics. At the 1904 Summer Olympics Men had the first all track combined event. It was a Triathlon and consisted of the Standing Long Jump, Shot Put, and the 100m Dash. 1912 Summer Olympics was the introduction of the modern decathlon. A woman's Pentathlon was introduced to the Olympics in 1964 but changed, including 2 more events in 1984, becoming the modern Heptathlon.

Social Context

Multi Events have changed alongside technology. The technique for events has changed, the implements have changed, your personal equipment has changed, but one thing that has stayed relatively constant is the way athletes are coached. This is important because athletes are starting to train differently. Athletes are training for more hours and there has been an increase in club participation as facility and equipment costs rise. Multi Athletes often train on their own not quite knowing if they are training properly or gaining bad habits.

CHAPTER 2
Research

2.1 User Research

User research is a mandatory part of the design process as it directly contributes to the success of a product. Great user research creates a clear picture of what problems are going to be solved.

Objectives:

1. To find the most common injury (Strained and/or pulled Hamstrings)
2. To identify the Primary, Secondary, & Tertiary users
3. To generate a persona
4. To identify common use methods

2.1.1. User Profile – Persona

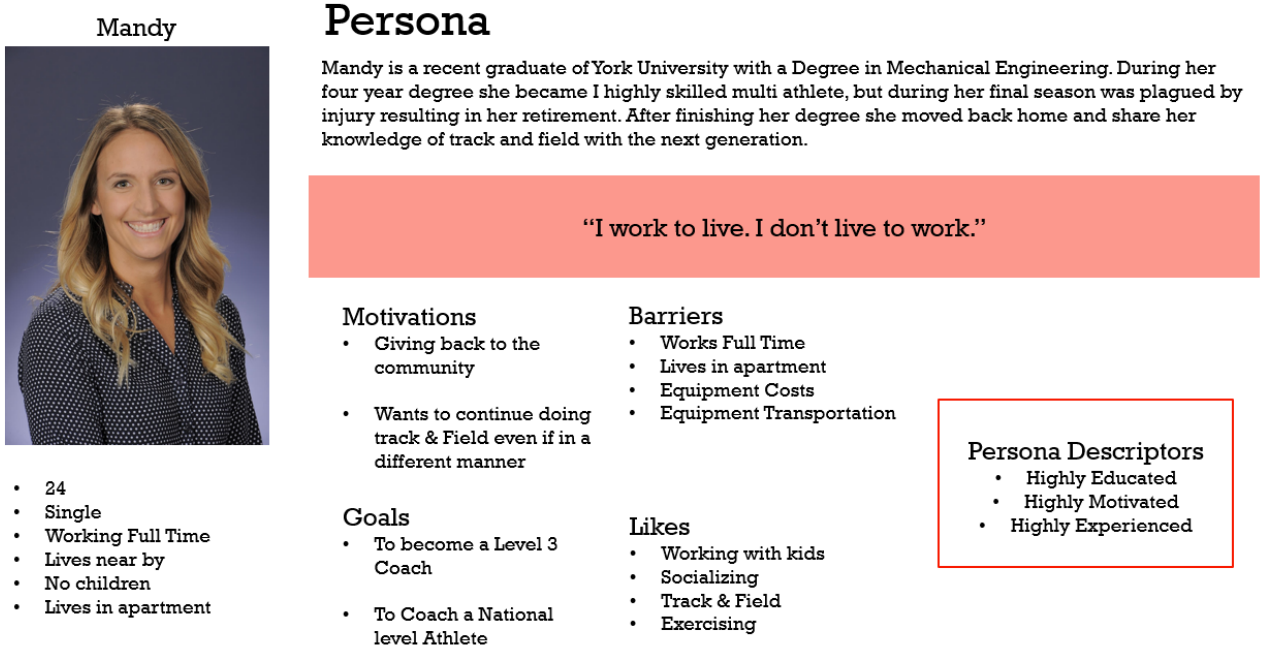


Figure 1 Persona

Primary User - Athlete

Demographic

- Age: 22-34
- Education: Post Secondary
- Income: $30,000 - $100,000+

Psychographic (Values)

- Organization
- Community
- Trust

Behavioral

- Frugal - Only spends money on what is needed so the rest can be invested in themselves (New equipment, new technology…)

Secondary User - Coach

Demographic

- Age: 22-65+
- Education: Post Secondary
- Income: $50,000+

Psychographic (Values)

- Free Time
- Community
- Social Interactions

Behavioral

- Frugal - Only spends money on what is needed so they have ‘‘Play Money’’

Tertiary User - Facility Manager/Owner

Demographic

- Age: 40-80+
- Education: Post Secondary
- Income: $80,000- $100,000+

Psychographic (Values)

- Organization
- Community
- Business

Behavioral

- Big Spender – Willing to spend money to improve their facility (New equipment, new technology…)
  - Buys fancy cars/Luxurious lifestyle

2.1.2. Current User Practice

Current user practices consist of regular and irregular tasks, patterns, and routines, as well as the environment in which the practice is taking place. The ability to understand why a user chooses to do these tasks over others will help to create a better product.

Regular Tasks, Attitude, & Environment

1. Good Attitude
   a. Weekly workout routine
   b. Recovery (after workout & off day)
   c. Health (Eating & Sleep)
   d. Monthly Fitness Testing & Evaluation
2. Poor Attitude
   a. Long Distance Training (Over 1000m)
3. Environments
   a. Track Facility (Technical Development)
   b. The Gym (Muscular Development)
   c. The Outdoors (Distance Running)

Expert Interview

Topic area currently being considered: Mitigation of Decathlete Injuries

Name of Interviewee: Laura Sivers

Background of interviewee (relevant to this topic): Level Four Track and field Multi-event Coach.

"I am currently in the discovery phase of selecting an area of interest.
This area is ……. Decathlete Injuries

1) Top 3 challenges

What do you believe are the **top 3 challenges** or major issues facing the area today?

1- Setting training plans for athletes, as every athlete is different.

2- Organizing practice sessions so that coaches can spend time with all their athletes.

3- Keeping young athletes interested in the sport and stopping athlete burnout.

- Burnout Is when an young athlete gets pushed too hard and causes a loss of interest in the sport.

2) Top 3 trends in the past 5 years

What are the **top 3 trends** in this area over the past 5 years facing the area today?

1- One of the positive trends that have been seen in track and field over the last five years has been the introduction of using multiple modalities in training. (Mobility, Active Recovery, Athletic Therapy, Physiotherapy, Massage Therapist)

2- A negative trend in the past decade has been a push towards sport specialization at too young an age. This has partially come from parents wanting their kids to be in an organized sport too early. No athlete development plan suggests sport specialization at a young age.

3- Virtual Coaching- "How do we effectively train athletes from a distance"

- Apps
  - Scheduling
  - Progress Tracking & Evaluation
  - Call, Video Chat (Demonstration Purposes)

3) Top 3 opportunities

What would you consider the **top three opportunities** in this area.

1- People- More people need to be involved. The sport has seen growth in the last few years with Damian Warner and Peirce Lepage, but this trend needs to continue if the sport is to become more well known.

2- Equipment- Have training facilities that can accommodate all ten events of the decathlon. This makes decathletes end up in large cities where the equipment is readily available.

- Having equipment that can easily be transported would be a great benefit for grassroot clubs.
- Pole vault is a struggle in Canada due to lack of equipment (hurdles, Pole Vault Equipment)

3- Technology- Development training tools (Progress tracking, Fitness Testing)

4) Impact of new technologies (be specific)

Can you identify **possible new technologies** that can be implemented in this area.

1- The leading camera technology currently helps coaches understand athletes better, but it is very expensive and cumbersome to set up. Because decathletes train a lot of events, they spend less time working on each event per day. This means corrections in technique need to be done faster by the coach otherwise the athlete will end up over training or run out of energy before corrections are made. Most of these “Cutting Edge” technologies aren’t available to grassroots clubs and are only available to the top athletes in the sport making it difficult for the sport to grow.

The newest technology available to Track and field are.

- Force Plates
- 3D Motion Capture
- Video Analysis
- Launch Monitoring
-

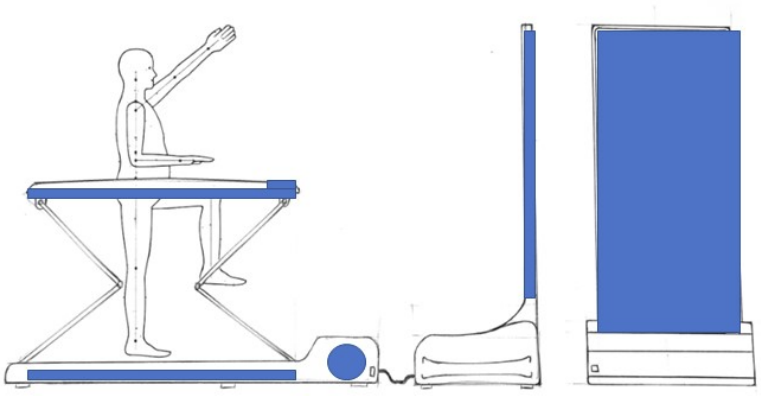
2.1.3. User Observation Activity Mapping

USER JOURNEY MAP

	Planning	Preparation	Task 1	Task 2	Task 3	Task 4	Goal	Finish Up
User Goals	To find the severity of injury	Create a plan with staff/coaches	To stimulate the hamstring	To Keep in touch with all events	To Maintain endurance	To Keep in touch with all events	To max out the hamstring	Be Fully healed and compete
User Actions	Gets hamstring scanned Do upper body exercises until scan comes back in order to not aggravate things	Has a meeting with coaches and medical staff. Discuses possible treatment options and timeline	A gym workout focused on activating the hamstring. Measure hamstring strength for testing	Goes to track Does Jav Does Shot Running 25%	Bikes in gym with high brake force. Talks to coaches realises they're not where they are supposed to be.	Goes to track Does familiarization of pole-vault Running 30%	Run reps that gradually get faster to find out when the hamstring says no, in order to plan next week.	Goes to track Does Hurdles Running 100%
User Thoughts	How bad is it? Will I be able to compete at the Olympics?	This is worse than I thought! Great now I have a plan!	Getting better?	I'm still able to do some things!	I'm still struggling Will I heal fast enough?	I'm still able to do some things!	Hami is better than I thought Progress is being made	Nothing hurts I'm not worried about reinjuring myself
User Feelings	Uncertain Stressed	Upset/Frustrated Reassured	Motivated Less Stressed	Motivated Happy	Frustration Highly Stressed	Motivated Happy	Excited Hopeful	Motivated Ecstatic
Storyboard / Photos								
User Experience								
Problems/Challenges	Getting a scan done quickly Getting results quickly	Organizing a time for everyone to meet in person.	Modified exercises don't have proper equipment	Track Rentals Equipment availability	Not where they were supposed to be originally in their training.	Track Rentals Equipment availability	Getting a scan done quickly Getting results quickly	none
Ideas / Take-aways	Mobile care unit	Video chat	Customizable equipment	Personal equipment	Frustration with low intensity!	Personal equipment	Mobile care unit	Happy athlete

Figure 2 Journey Map

2.1.4. Benchmarking



Components:

- Motor
- Arm Rests
- Controls
- Display
-

Location of these components affects:

- Interaction
- Ergonomics
- Functionality
- Aesthetics

Figure 3 Benchmarking

CHAPTER 3
Analysis

3.1. Analysis – Needs

This chapter analyses existing products. By doing this we can develop an understanding for mandatory features (Needs). We also compare products at different points on the price spectrum to see how each accomplishes these features. Looking at existing products is a quick way of finding out what users absolutely need in the product as well as what current product aren't giving users.

3.1.1. Needs / Benefits Not Met by Current Products

The strategy used in this example was to look at two products separated along the cost spectrum. Aside from common benefits, other differentiated benefits would also become clear.

The current products examined were Treadmills.

Needs Statement for a New Treadmill

Two Products: Treadmills - Cost Effective vs Expensive: Data Analysis

Figure 4 Benchmarking 2

SuperFit 2.25HP Electric Running Machine Treadmill
https://www.loblaws.ca/superfit-225hp-electric-running-machine-treadmill-/p/SP360276?marketplace-only

Sensor-Medica RunTime Treadmill
https://www.sensormedica.com/it/runtime-

Benefits and Features- from Promotional Literature

Table 1 Benefits & Features

Benefits	**Features**
Safe	Safety tether cord
Comfort	Shock absorbing belt, Under belt padding
Multi-functional	Bluetooth connection, App Connection, Heart Rate Sensors
Easy to use	Foldable, Wheels (Easy moving), 12 Workout presets

3.1.2. Latent Needs

LINKING BENEFITS WITH NEEDS – Treadmill

Table 2 Sensor-Medica Needs

Product- Sensor-Medica RunTime Treadmill				
Needs	**Benefits and Underlying Needs**	**Level of importance**		
Basic Needs *Physiological*				
Food, water, shelter	Product is used indoors	*Slight*		
Pleasure, gratification *(sensory, compulsive responses)*	Display Comfort Quality			*High*
Security *Safety, securing resources*				
Safety	Fall protection			High
State, Group, Individual	National to International Athlete, Club, Facility			
Securing resources *Optimization of limited resources (cost effectiveness)*	Price $1,000 - $3,000 Equipment bought personally or by organizations.		*Moderate*	
	Reliability and Accuracy of Data			High

• *Value* • *Accumulation of resources (wealth)*	Quick and Easy to Use (Without Technician)			High
Control over environment (tasks)	*Product (tool) that amplifies human abilities*			
Convenience *Ease of Use*	No Technician necessary Little to no set-up. Preloaded workouts Ability to customize Multiple profiles **MASTERY**		*Moderate*	High
Speed (fast, less time)	Coach can view stats anywhere			High
Control (precision, responsiveness, power)	Coach can design personalized workouts for individual athletes. **CONTROL and MASTERY**			High
Long Term Security/Stability of Group *Health/care/education of children*	Athlete Profiles with Security login			High

Environmental sustainability	Built from recyclable materials where possible	Slight		
Insurance (car, house), pension, investments	3 Year warranty on all parts		Moderate	
Social Belonging *Effort / resources to belong to a 'tribe'*				
Fear of Abandonment				High
Fear of the enemy	Another club has better equipment/coaches		Moderate	High
Tribal Identity	Similar aesthetic to other gym equipment			
Behavior cues for survival *(copying behaviors… safe to eat, learned skills)*	"Fitting in with the pack" (Following others' Movements/Actions)		Moderate	
Behavior cues for social interaction of group *(copying behaviors… Interaction cues, play, have fun)*	"Fitting in with the pack" (Following others' Movements/Actions)			
Peer Pressure	Pressure to join their club over another's	Slight		
Social Expectation	High level Athletes use High level equipment	Slight	Moderate	

Esteem ***Personal influence in 'tribe'***				
Social Status'The elite have it…I want to be like them'	High level athletes use equipment like this, I need it	Slight		
Social Recognition				
Sexual attractiveness				
Self-Actualization ***'Higher order' Functions/Needs*** ***Needs that are pre-dominantly 'outer cortex'***				
Intrinsic pleasure				
Creative endeavors				
Experiential (extrinsic)				
Experiential (intrinsic)				
Emotional	**Empathy:** Are all Users comfortable while using the Product?			High

Needs Statement for treadmill from FHN

Summarizing the results from the Table.

Benefits of both

- Both Treadmills have cushioning systems for reducing joint pain (**Comfort for User)**
- Both Treadmills are designed for a variety of user sizes (5^{th} - 95^{th} Percentile)

(**Comfort for User)**

- Both Treadmills are come equipped with a tether to stop the belt in case of a fall

(**Safety for User)**

- Both Treadmills Come equipped with quiet motors.

(**Comfort for Prime and Second Users)**

Benefits of Each

Product A: SuperFit Treadmill

- Cost Effective ($369.99) ***easily available*** *for users*
- 5 Layer Anti-Slip Belt ***ease of use*** *for user*
- 2.5hp Motor For walking 10km/h ***ease of use*** *for user*

Product B: Sensor-Medica RunTime Treadmill

- Prestige purchase **aspirational / status need**
- Smoother run **comfort** for user
- 2.5hp Motor for running speeds 22km/h **usability** for users
- 10,000 Sensors per m^2 **analysis** for user
- Better durability **value** for user
- Analysis software that detects **value** for user
    - Static Position Analysis **value** for user
    - Dynamic Analysis **value** for user
    - Stage analysis **value** for user
    - Live symmetry evaluations **value** for user

3.1.3. Categorization of Needs

Categorization of Needs

Treadmill

Marketing- Existing Need

Short term need.

The Product Immediately need to allow users to run great distances indoors at their preferred pace.

Psychology- Human Needs & Benefits

Focus:

-Ergonomics

- Display Angle
- Arm rest height
- Easy Start and Stop

Marketing- Latent Need

Some latent needs users may not be aware of are padded running area/belts.

Unanticipated Experience

The immersive ability that the treadmill display has and the feeling it creates.

Marketing- Incipient Needs

Type of need which people **want** but there is no product to satisfy that need.

Personalized Workout routines created specifically for themselves (Athlete) by their coach and have those workouts be able to be put into their treadmill

Wants

Bluetooth Music

App Connectivity

3.2. Usability Analysis

Analysis of the data related to usability was conducted and the results prioritized.

Usability is defined primarily by **4 quality components**:

1. **Ergonomics**

   How **safe** is it to do the task?

   -Treadmill belt won't move without user input

   -Treadmill has tether in case of falls

   How **comfortable** is it for the user to do the task?

   -**Ergonomic factors were considered for users reach**

   How **easy to use** is it for the user to do the task?

   -Users have the option of using a quick start option that removes some setup options that are necessary for metric evaluations

2. **Efficiency**

   How **quickly** can the user perform tasks?

   -Time and motion studies

   -User interface design

3. **Interaction**

   How **easy** is it for users to get **feedback** and **respond***?*

   -Indicators: light and sound, icons, and words

   -Human input: pushbuttons, knobs, touchscreen, etc.

4. **Satisfaction**

   How **pleasant** and **fulfilling** is it to use the design?

   -Feelings of control and mastery

   -Soft touch control surfaces

   -Feeling of quality

Method

Maps based on surveys, interviews and user observations were generated (see Ch. 2).

These maps filtered the data to emphasize pain points, points of delight, as well as the thoughts and feelings (user experience) of the user. The main points related to usability are summarized below.

Analysis

Empathy Map

An Empathy Map was generated from a user interview.

The main pain points related to usability are:

1. Can't get medical support fast enough
2. Emotional rollercoaster
3. Compares oneself to others

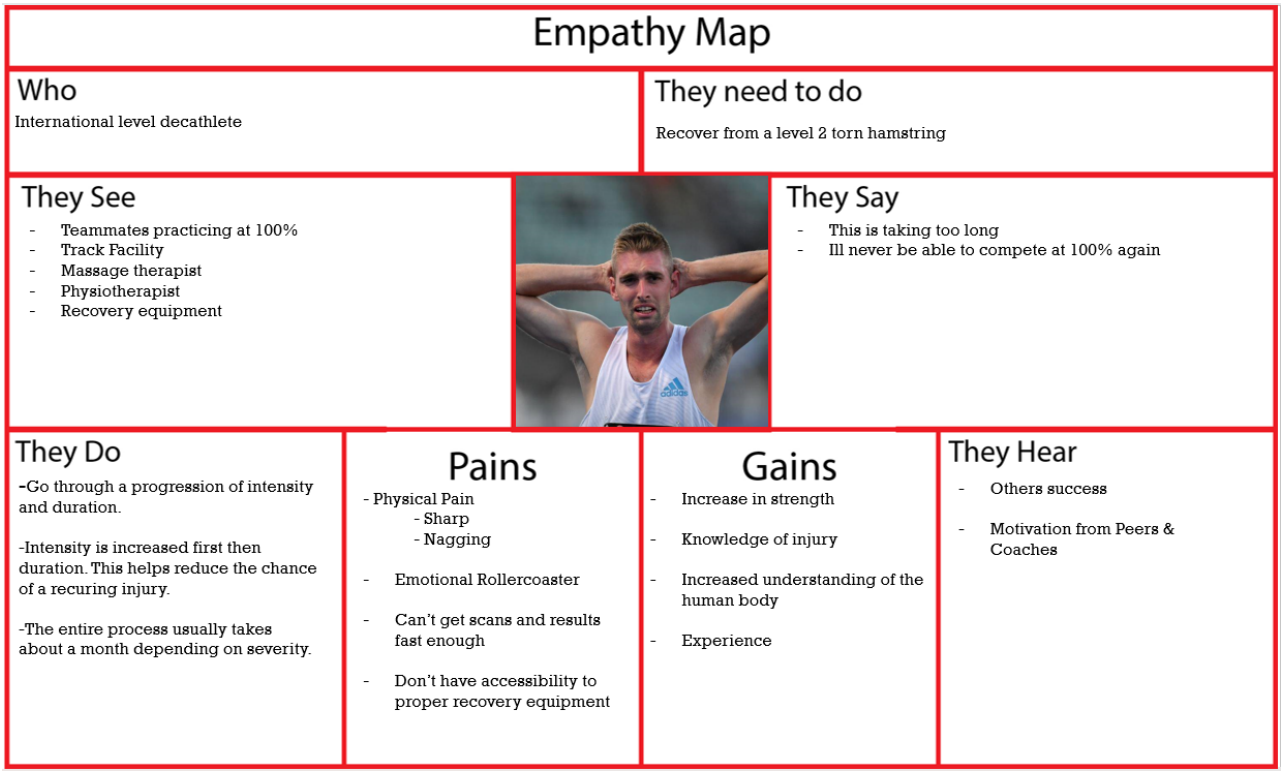


Figure 5 Empathy Map

3.2.1 User Journey Map & 3.2.2 User Experience Map

A User Journey Map / User Experience Map was generated from the first user observation (big picture)

The main pain points related to usability are:

1. *Time Management*
2. *Slow Progress*
3. *Availability of gym and facility equipment*

USER JOURNEY MAP

	Planning	Preparation	Task 1	Task 2	Task 3	Task 4	Goal	Finish Up
User Goals	To find the severity of injury	Create a plan with staff/coaches	To stimulate the hamstring	To Keep in touch with all events	To Maintain endurance	To Keep in touch with all events	To max out the hamstring	Be Fully healed and compete
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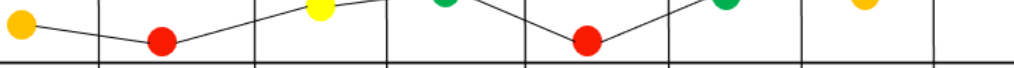
Storyboard / Photos								
User Experience								
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Ideas / Take-aways	Mobile care unit	Video chat	Customizable equipment	Personal equipment	Frustration with low intensity!	Personal equipment	Mobile care unit	Happy athlete

Figure 6 Journey Map

User Task Map *for Focused Observation*

A User Task Map for specific task (s) was generated, looking at design parameters of ergonomics, efficiency, interaction, and satisfaction. This is shown in the table below, with the keys used for these design parameters shown in the table underneath.

Table 3 User Task Map

		User Task Map		
Task: Running on Treadmill	Ergonomics	Efficiency	Interaction	Satisfaction
1: Getting on Treadmill	**Step Up** -Height -Access to railings	1 – 2 steps with utilization of supporting devices	Interaction with railing is likely but not 100% necessary	Little to no experience
2: Starting Treadmill	**Interactive Display** -Size of Touch Screen/ Tactile Buttons -Reach Distance -Height of Display **Safety Tether** -Height (waist) -Length of Rope -Type of clip	This has the possibility of being overly complicated if not done right, ruining the entire treadmill experience Must be clearly defined	Interaction with display Tether should be self-explanatory on how its used and have a proper mounting position when not in use.	Can be a difficult process on most treadmills
3: Running on Treadmill	**Running Area** **Legs** -Belt Width (Inaccuracy) -Belt Length (Stride) **Arms** -Space for arms to swing	Should start up quickly without any major delay and have a slow ramp for initial belt acceleration	Feet repetitively come into contact with the belt	Usually a good experience on most treadmill with the exception of when the tether gets pulled and you must restart your workout.
4: Stopping Treadmill	**Easy Access Emergency Stop Button** -Size of Tactile Buttons -Reach Distance	The button should be placed somewhere in the center of the treadmill so to be reached quickly	One hit with any part of your hand (For Safety the button shout be large and easy to press)	Normally a satisfying experience as it means you have finished your workout and achieved your goal for the day.
	Ergonomic Safety	Efficiency	Interaction	Satisfaction
	1: Awkward bends 2: Slips,Trips, and Falls	1:Minimizing distances between most commonly used buttons 2: Lack of Experience using the device	1: Light, sound, Icons & words (Buttons)	How well something is accomplished and the feeling that gives to the user

Main Usability Issues

- Gains: Social support network (continued contact with teammates, rehabbing with other injured athletes) is an important aid to recovery.
- Pains:
    - Frustration of not being able to train with teammates
    - Frustration at rehabbing alone
    - Frustration at not being able to compete
    - Hidden: body misses a good workout
    - Treadmill is confusing to use
        - Too many buttons
        - Interface is unclear
- Usability & Ergonomics
    - Chronic bending
    - Large distances between common use functions
        - Causing body & head rotation
- Efficiency
    - Preparation and organization
    - Easy treadmill start-up
- Interaction
    - With railing
    - With display
    - With running area (Belt)
    - With running area (General space for movement)
- Satisfaction

- Mastery and Control- First time users of a treadmill most commonly find them difficult to start with having to put in a ton of information.

Needs Statements

Needs Statement 1 (before research)

The Athlete **needs** assistance improving technique **because** it will reduce the chance of injury while increasing performance.

Needs Statement 2 (after benchmarking)

A running training device for athletes **needs** to allows coaches to increase their flexibility **because** when working with athletes their goal is to improve their running technique.

Further needs include ease of use, comfort, prestige, and the gathering of data.

Needs Statement 3 (after benchmarking **AND** linking with fundamental human needs)

Athlete training is an extremely important and should be taken and executed with purpose. The Athlete should be able to use the product on their own **(Control & Mastery)**, and be comfortable using it with the ability to make mistakes without major consequence (Breakage)**(Comfort & Security)**.

Athlete development is also a **social** activity, since most development happens when training with other athletes. Esteem can be afforded by good styling/quality cues of the device.

Control and **mastery** of the device is related to the performance of the machine (**effectiveness, ease** and **comfort)**.

3.3. Analysis – Human Factors

INTRODUCTION

This ergonomic study searches the ways in which ergonomics affect user convenience, interaction, and functionality. Modern treadmills are cheaply built with little in the way of adjustability and user convenience. Treadmill armrests are most commonly fixed, making users close to either end of the percentile range uncomfortable while using the device. The study should help identify problem areas and help to improve the treadmill user experience. An ergonomic one-to-one model was built to identify human factors in the treadmill use case. The study identified specific uncomfortable ergonomic situations for the higher and lower percentile ranges. This was helpful when working to define the placement of certain parts such as displays and control panels. Redesigning the treadmill from these outcomes should help improve user experience.

Keywords: ergonomic evaluation, full-bodied human interaction, 95th/5th percentile, human factors

LITERATURE REVIEW

Before undertaking this ergonomic study, a literature review was done to help understand human ergonomics, while in various positions. Henry Dreyfuss, “The Measurement of Man and Woman” a terrific resource giving clear explanations of the entire percentile range. The 95th percentile man and 5th percentile woman were used in this study to represent the range of possible users that may interact with a treadmill.

METHODOLOGY

The ergonomic evaluation and analysis of a one-to-one mockup was conducted with the following considerations:

Objective(s)

This report aims to evaluate the ergonomics and usability of the proposed design. The study will help identify full bodied human interaction design and full-bodied ergonomic challenges for the treadmill. In this case full bodied design refers to the touch points on the human body. In this case (The Treadmill) it refers to Feet, Hands, and field of vision.

Decision(s) to be made

Below are interactions relevant to the discovery and improvement of ergonomics, based around the major touchpoints in the treadmill design, in order to improve user experience:

1- Feet (Treadmill Belt)
2- Hands (Railings Support)
3- Hands (Railings Buttons)
4- Hands (Touch Display)
5- Visual (Display)

Description of Users Targeted by Product

The target demographic for the proposed treadmill design are users aged 20-34 male athletes, college educated making $20,000 and upwards per year.

Evaluation process

The evaluation process consisted of designing a full scale (1:1) ergonomic buck of a Treadmill which allowed for critical observation of the following:

1. Observing how the user enters and exits the machine. (Ingress/Egress)
2. Observing how high the users place the handrails. (Comfort)
3. Documenting the viewing angle of users for display comfort (Position & Angle)
4. Documenting stride length of users (Running Area)
5. Identifying critical human dimensions affecting product use

Description of User Observation Environment Used in this Study

This study was done in an open pace allowing for free range of movement. A one-to-one mock-up was used to test ingress and egress along with the height of armrests and display angle. Users were asked to use the mock-up as if was a real treadmill.

Location and Timeframe

Date of Observation(s): 22/12/03 (Observation 1)

Location of Observation(s): Humber College (Observation 1)

ANALYSIS

Observation One: Arms

The arms are very important in the design of the treadmill. Users use their arms while they are walking/running by swinging them back and forth to keep balance this motion is important to take into consideration as not all users swing their arms in the same way. Some users hold their arms bent, some more straight, while others further or closer to their sides. This means there must be adequate

space an both sides of the user between the handrails to accommodate this variation while staying close enough to grab both at the same time in case of emergencies to hold oneself upright. This space on either side is more important for the 95th percentile because they take up the most space, but must not be too large rendering the 5th percentile unable to reach both sides and support their self. The space in the front and back of the user is more important for the 95th percentile.

Observation Two: Arms/Hands

The natural hand position on the armrest is very important as this infers where the controls should be placed on the armrest. If the armrest controls are too close to the back, this will make the user stand uncentered on the belt increasing the chance of tripping or falling of the rear of the treadmill when starting to run. This is more important for the 95th percentile user as their arms are longest placing them further back on the treadmill. This means if a 95th percentile user can fit so can a 5th.

Observation Tree: Feet/Legs

Foot placement is, of course, very important to a treadmill's ergonomics. The 95th percentile user is much more important in this case as they take up more area on the belt. A 95th percentile user has not only a larger stride but also a wider stance and this needs to be taken into consideration when deciding the belt width of the treadmill.

Observation Three: Feet/Legs/Arms

Additionally, one of the main functionalities of the new treadmill will be vertical jump testing. This type of jump requires a deep bend in the knees and large swinging of the arm and finally an extension of the legs that drive you "straight" up into the air and down again. The ergonomic issue

here has to due with the error of this movement. As a vertical jump test is meant to test your absolute max output, this encourages error in technique making user often move side to side. This means the armrests/railings are no longer helpful and may increase the danger of the exercise. Having the armrest move entirely out of the way will increase safety as well as user comfort.

Observation Four: Field of Vision

Finally, since the height difference is so substantial between the 5th percentile woman and the 95th percentile man the field of vision only minorly overlaps. This mean that the 5th percentile woman will be straining her neck to look up at the display, not only causing discomfort, but also a potentially poor user experience.

LIMITATIONS AND CONCLUSION

The study brought forth many areas that could be improved. These areas are as follows:

1. The treadmill belt length as well as width.
2. The placement of hand controls on armrests.
3. Armrest Height (Adjustability)

Some Ergonomic Issues That Are Still Not Yet Resolved

Ergonomics of treadmills have had many years of development meaning that most treadmills have well thought out ergonomics. One thing that sticks out when it comes to treadmills, is that the vast majority have no adjustability. This leaves the 5th and 95th percentile with the least desirable experience.

Alternate possibilities for the future

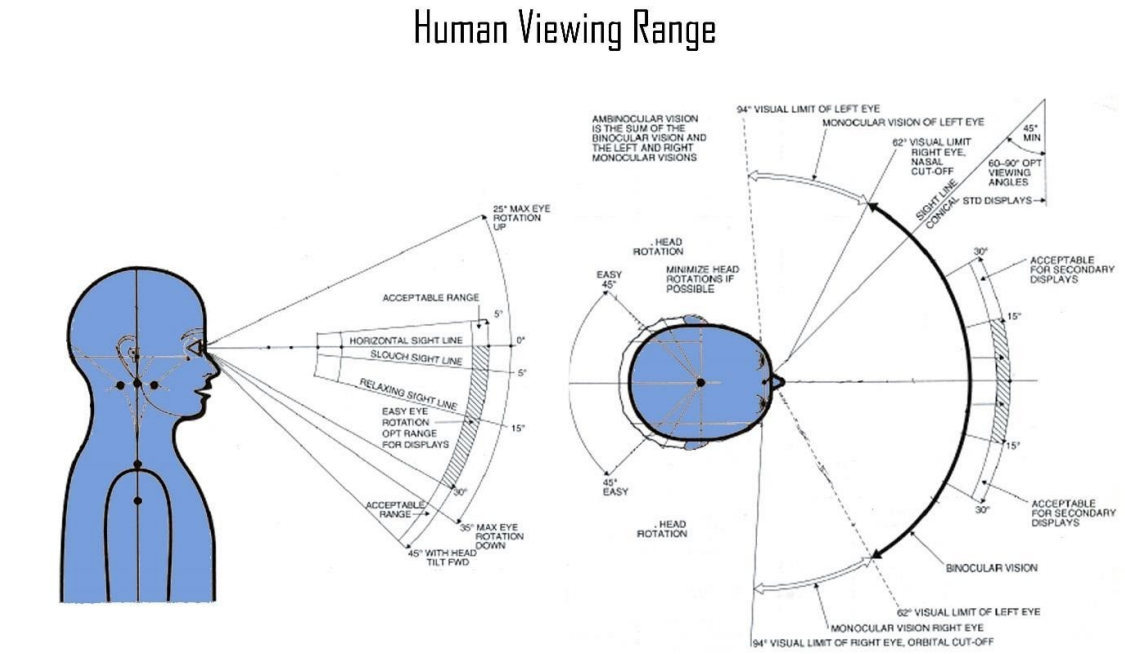
Based on the current study, the alternate options that could be explored in future are as follows:

1. Have a more users involved in the study for different perspectives.

2. Have a video camera run while executing the study for increased data retention.

This study helped bring to light critical ergonomic issues that would no doubt arise later in the design process if not discovered now. Location of controls, necessary space, and user position on the treadmill is invaluable data and will be used to further the design to better user experience. The study also brought about some possible dangers that needed to be assessed. This will fulfill the major thesis requirements as well as inform the three body-part areas.

3.3.1. Product Schematic – Configuration Diagram



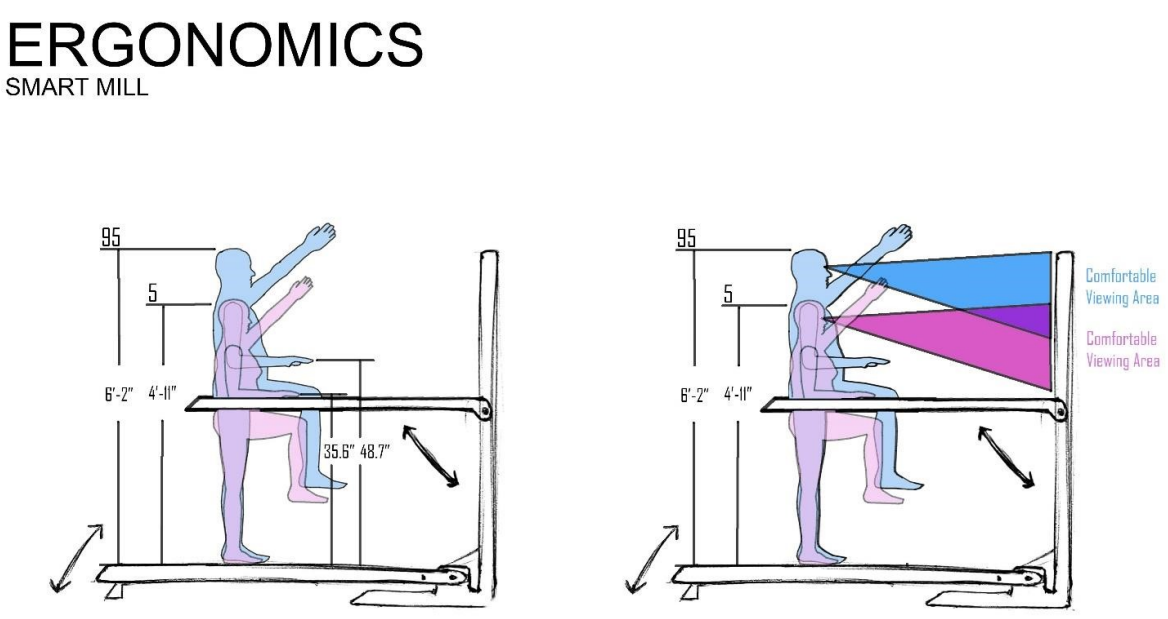


Figure 7 Product Schematic

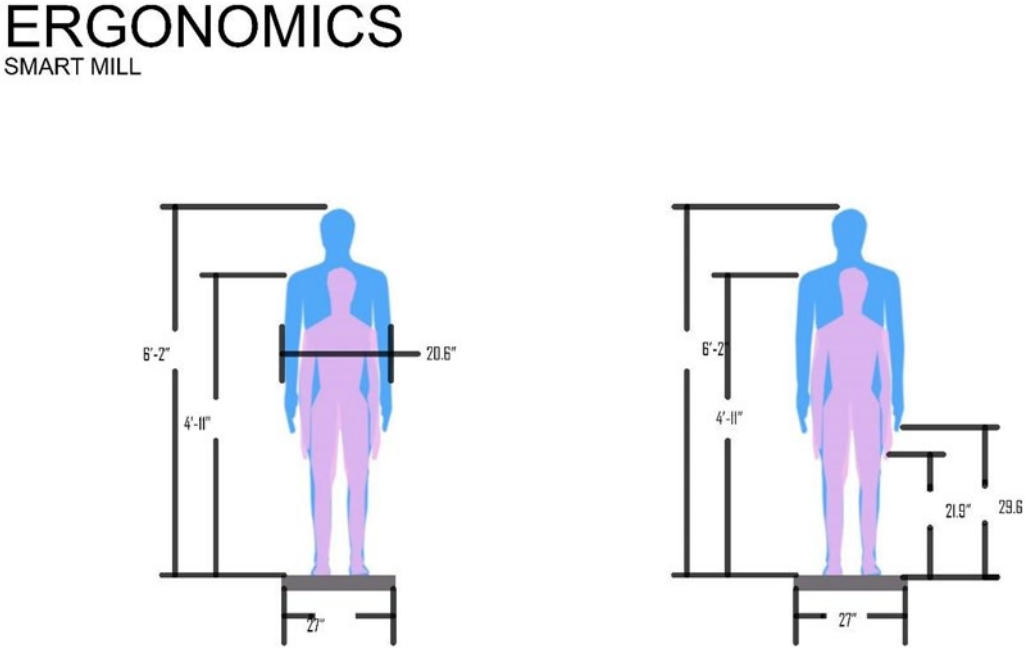
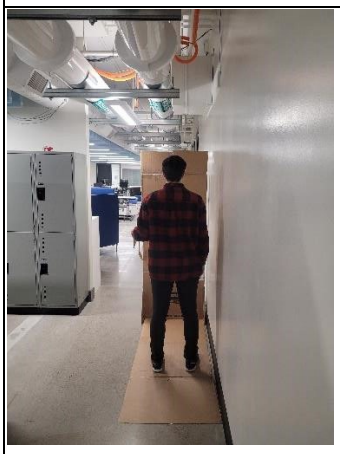


Figure 8 Product Schematic 2

3.3.2. Ergonomic – Human Scale Study

Table 4 1/1 Scale Mock Up

2: Mock-up with Models	Percentile
	95th Percentile Rear
	95th Percentile Side
	5th Percentile Side

	5th Percentile Rear

Chapter 4
Design Development

4.1. Initial Idea Generation

4.1.1. Aesthetic Approach & Semantic Profile

The approach for the Multi-Track's aesthetics was quite simple. The goal was to design a product that stood out compared to other products but that was calm enough to be placed both in a gym and a home. Gym equipment generally has a dark Aesthetic where the product disappears or a bright one that yells at you. In order to find a happy medium some products were benchmarked.

Figure 9 Bowflex Treadmill & GTLN Squat Rack

https://www.walmart.ca/en/ip/bowflex-treadmill-10/6000204204251

https://get-lean.com/products/gtln-c2-ae-v2-multi-gym-power-rack-yellow-and-black/

A colour palette and form influences were chosen to help inform the treadmills design language.

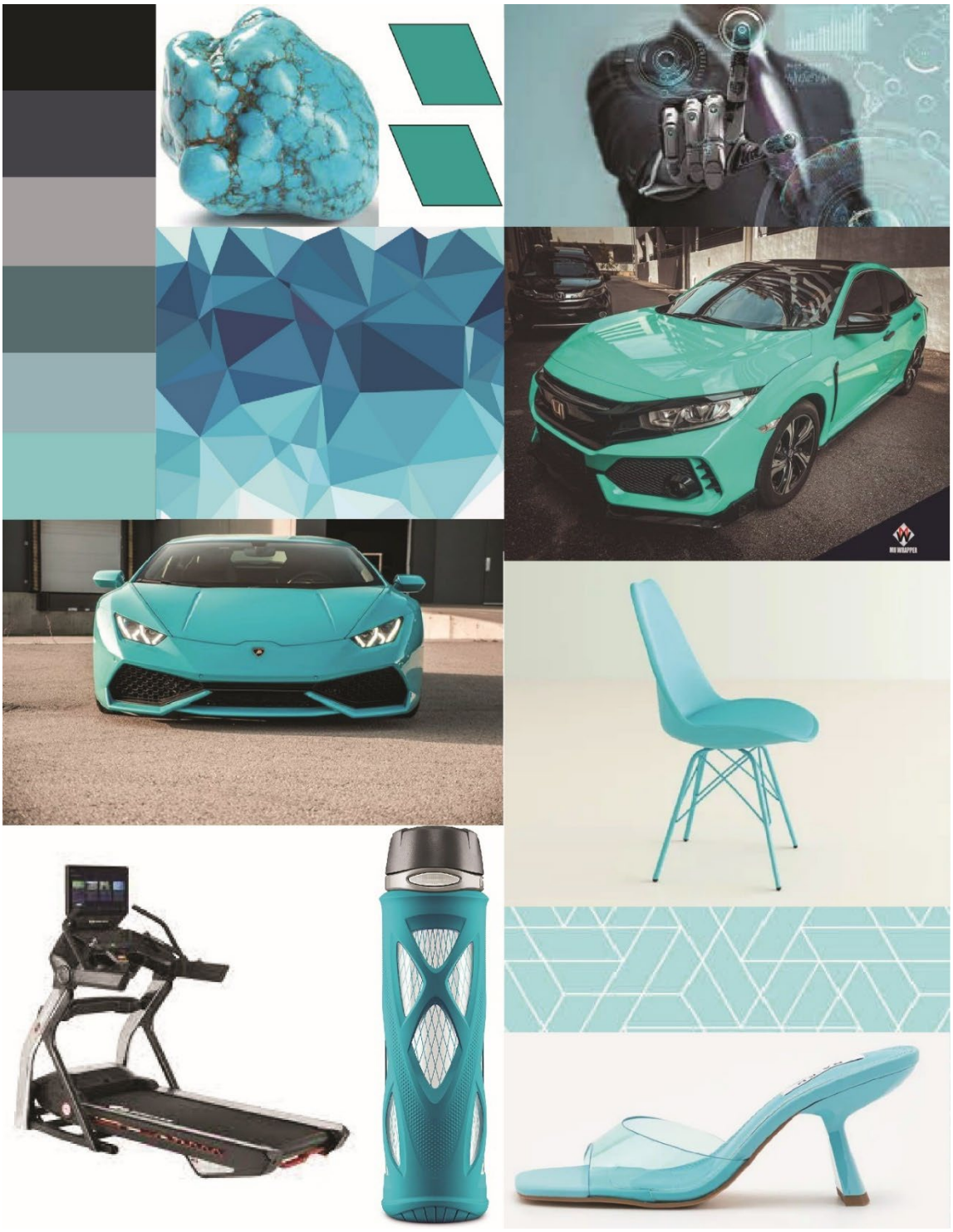


Figure 10 Aesthetic Inspiration

4.1.2. Mind Mapping

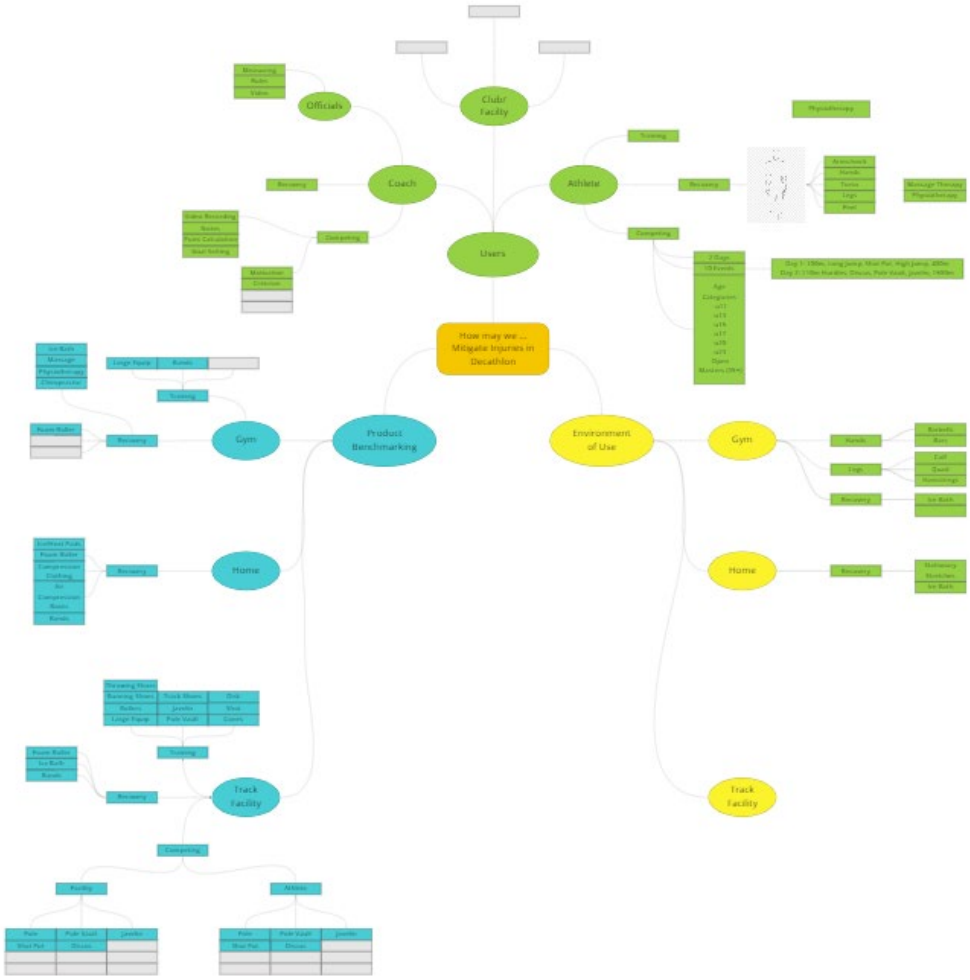


Figure 11 Mind Mapping

4.1.3 Ideation Sketches

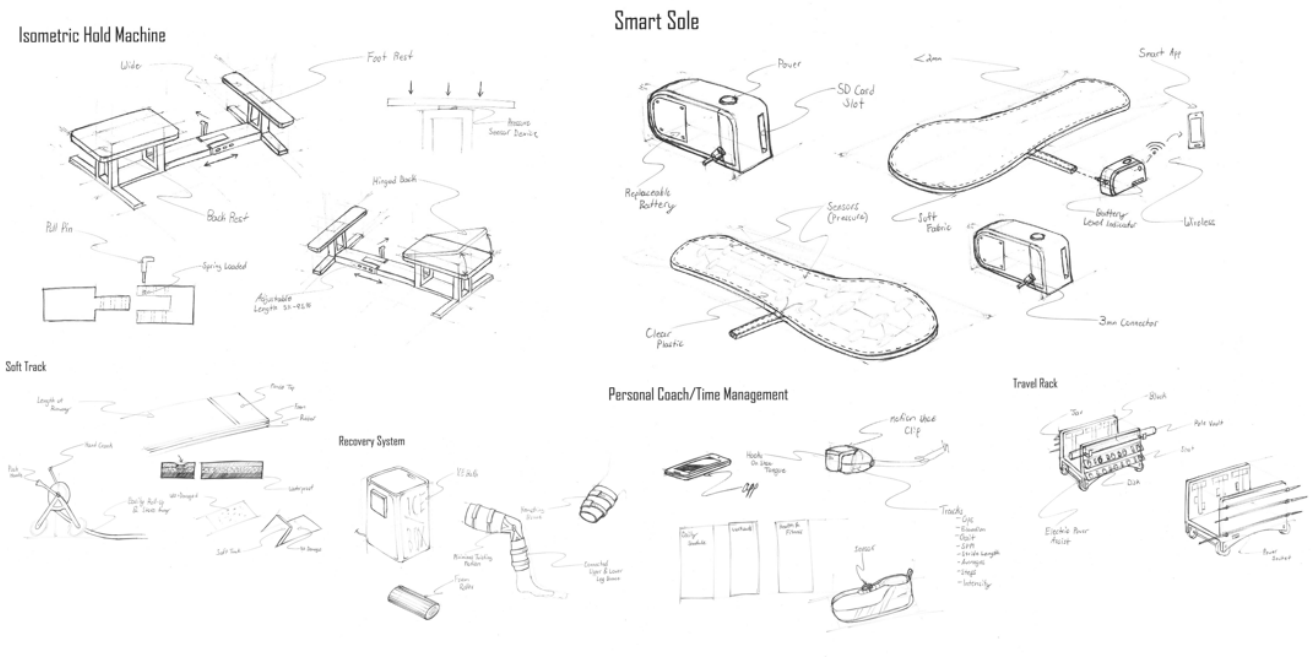


Figure 12 Ideation Sketches

4.2 Concept Exploration

After the Ideation phase comes concept exploration. This is where insufficient ideas are weeded out, and the good ideas from the ideation phase are chosen and further developed.

Objectives

1. Choose three ideas from the ideation phase
2. Further improve each concept with increased detail
3. To increase understanding of the Decathlon and Multi-Athlete struggles
4. To choose a final concept direction

4.2.1 Concept 1

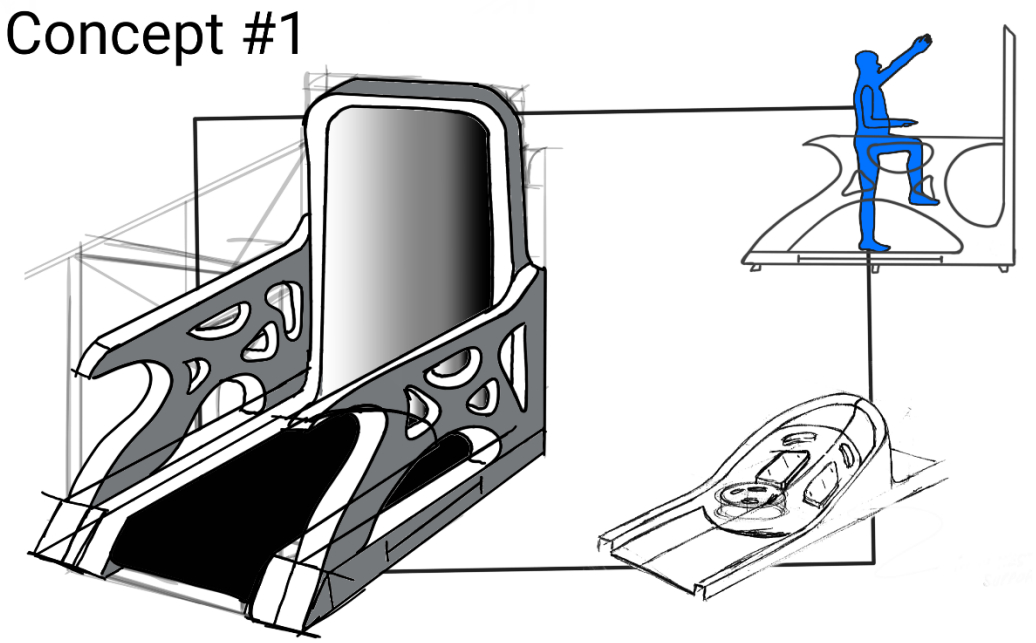


Figure 13 Concept 1

4.2.2 Concept 2

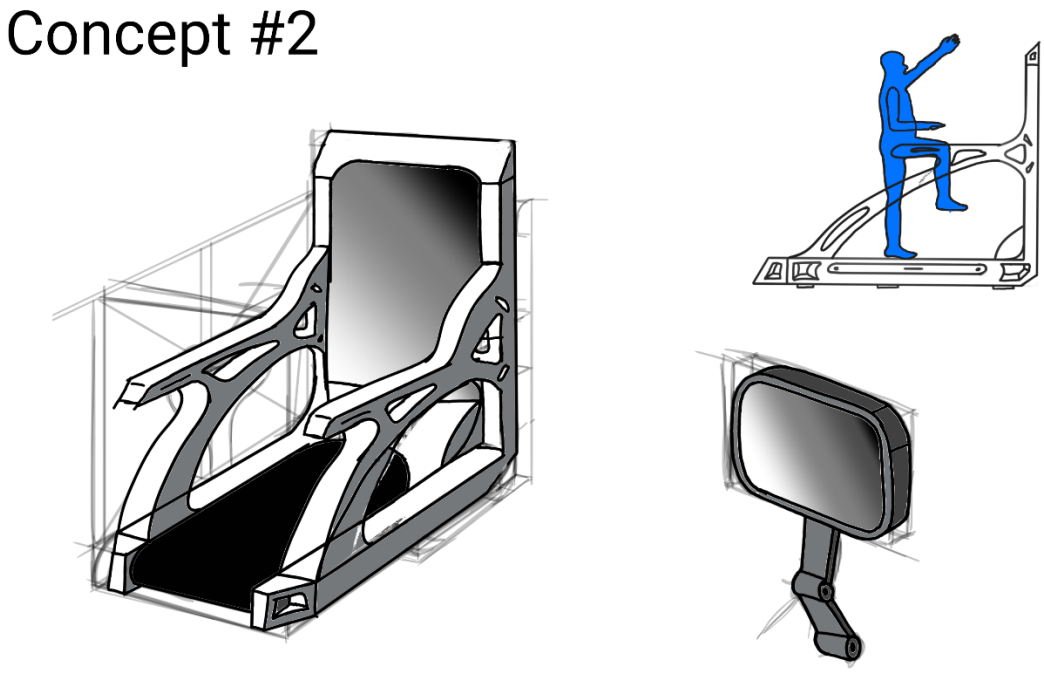


Figure 14 Concept 2

4.2.3 Concept 3

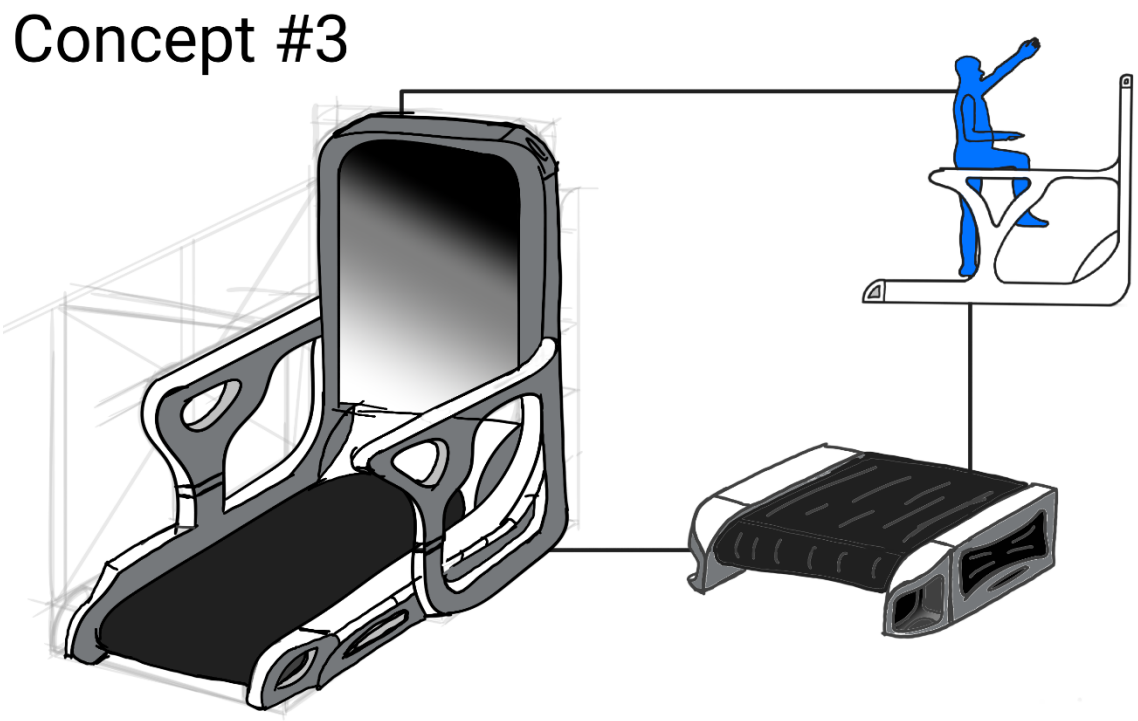


Figure 15 Concept 3

4.3 Concept Strategy

Moving forward, the final form and details are to be nailed down before the start of the CAD portion of the design process.

4.3.1 Concept Direction & Product Schematic One

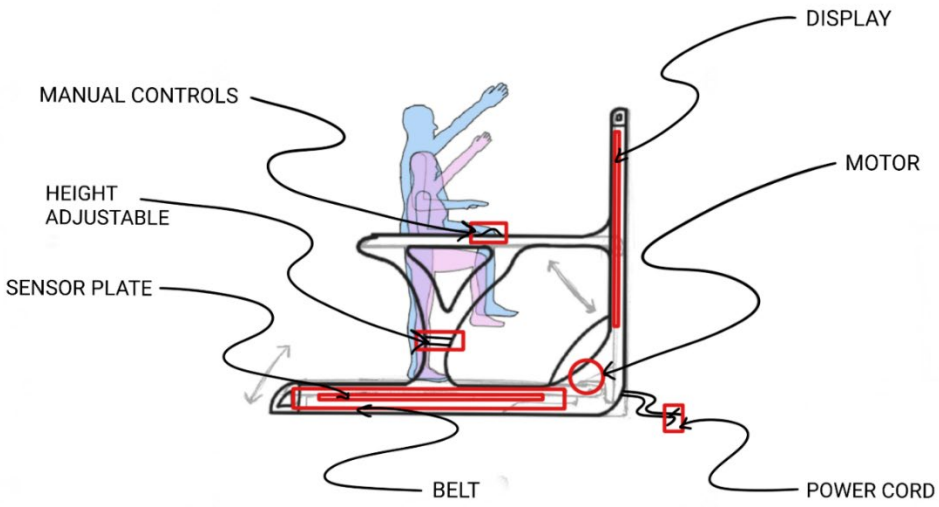


Figure 16 Product Schematic 1

4.3.2 Concept Direction & Product Schematic Two

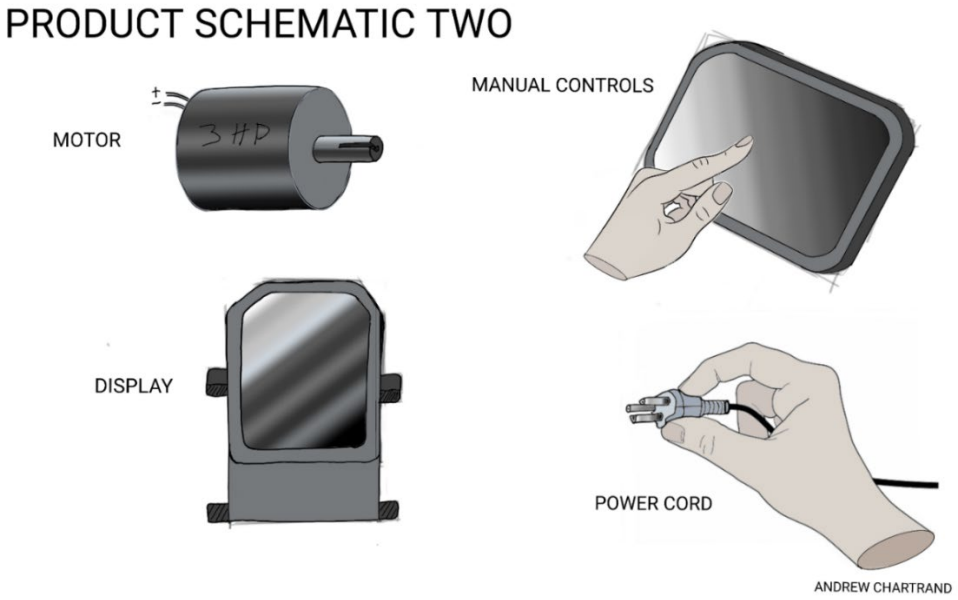


Figure 17 Product Schematic 2

4.4. Concept Refinement & Validation

Concept Refinement & Validation is when smaller details start to be realized and solidified. This means details are fully expressed and more importantly are fully expressed with reasoning. Throughout this chapter the previously stated research will inform design decisions, helping further the concept into its final form.

4.4.1. Design Refinement

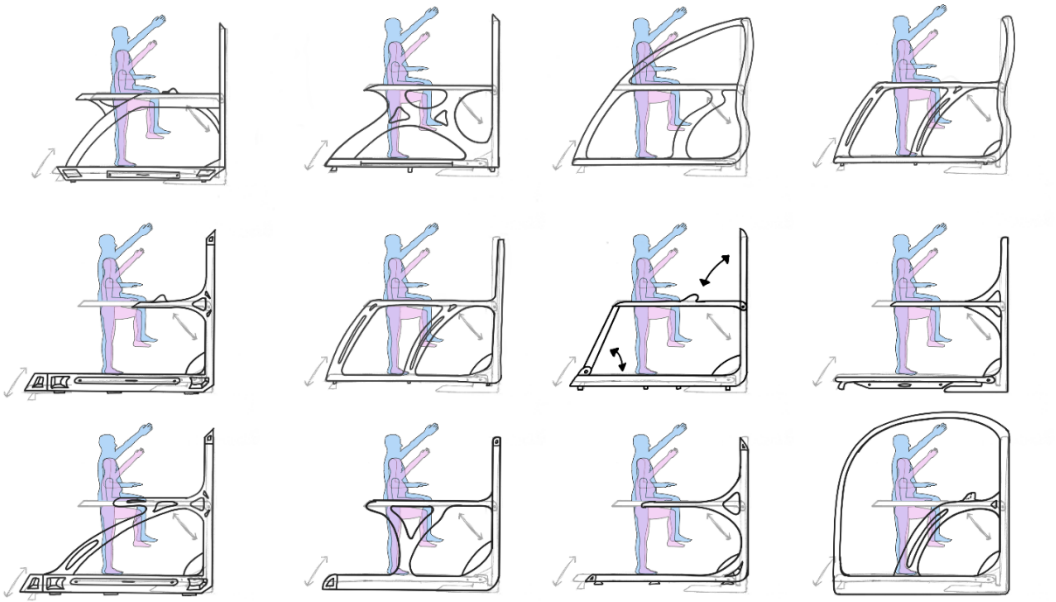


Figure 18 Side Profile Iteration Sketches

Figure 19 3/4 View Iteration Sketches

As the major form was decided Iterations focused the arms, the frame around the belt, and the front display. Keeping in mind ingress, safety, and comfort.

4.4.2. Detail Development

Multiple iterations of arms were drawn to define where the cup holders and soft touch areas would be.

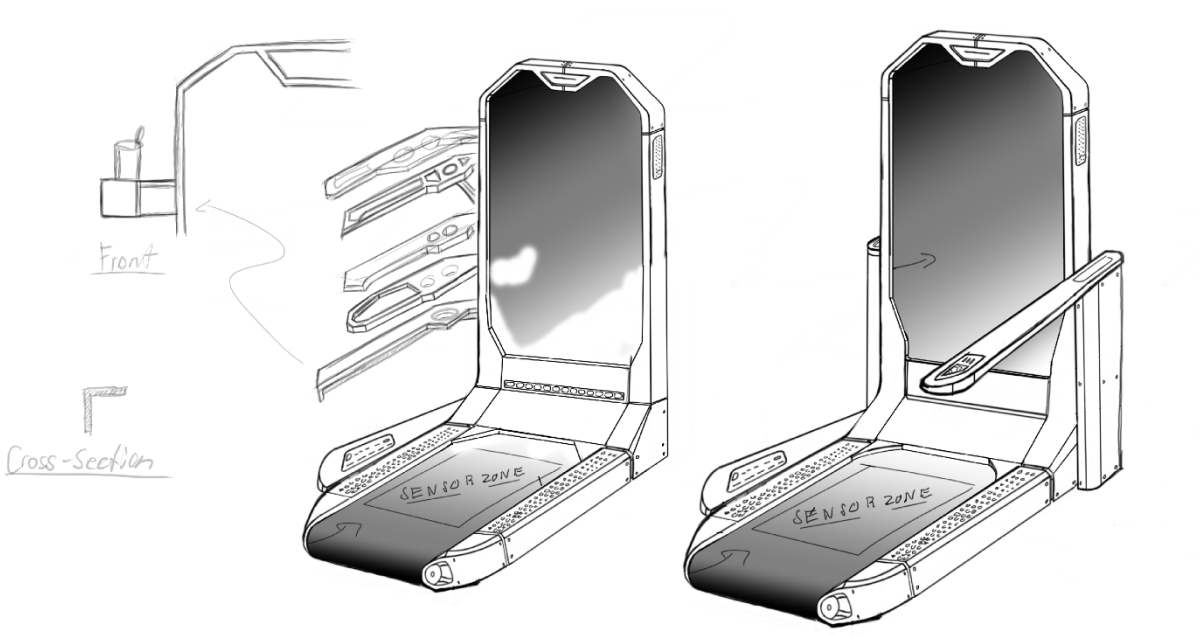


Figure 20 Detail Development

4.4.3. Refined Product Schematic & Key Ergonomics

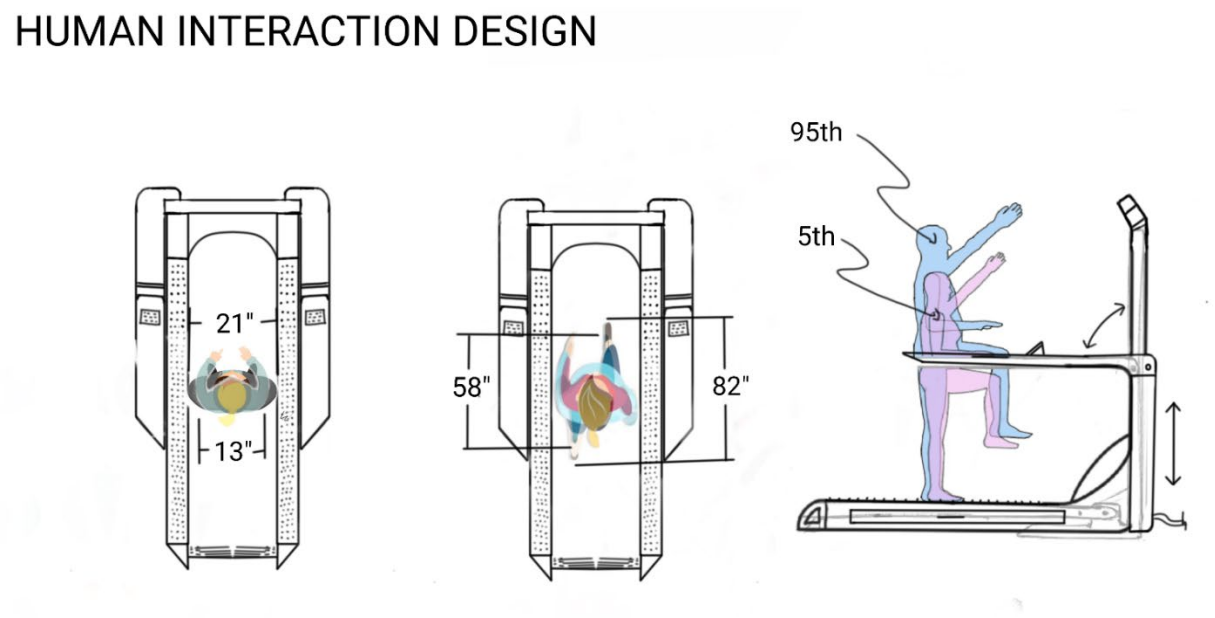


Figure 21 Refined Schematic

4.5 Concept Realization

4.5.1 Design Finalization

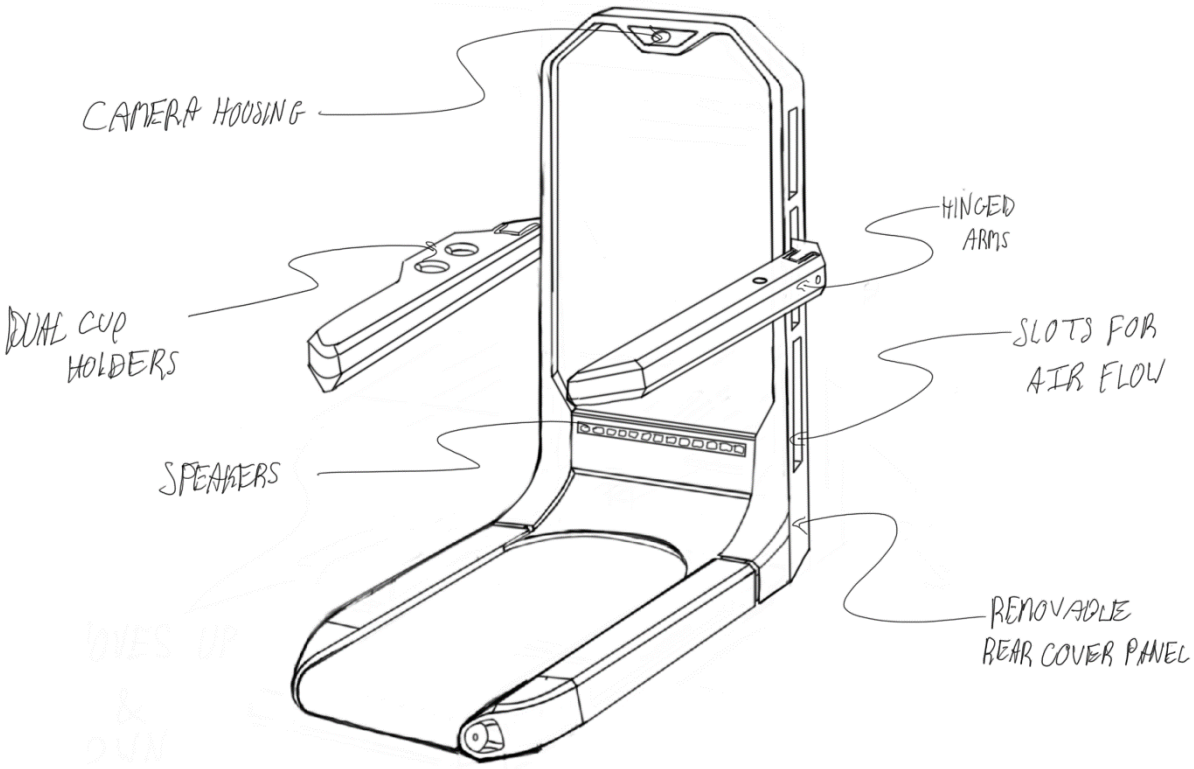


Figure 22 Final Design

4.5.2 Physical Study Models

The Physical model helped solidify scale and proportion.

Figure 23 Model 1

Figure 24 Model 2

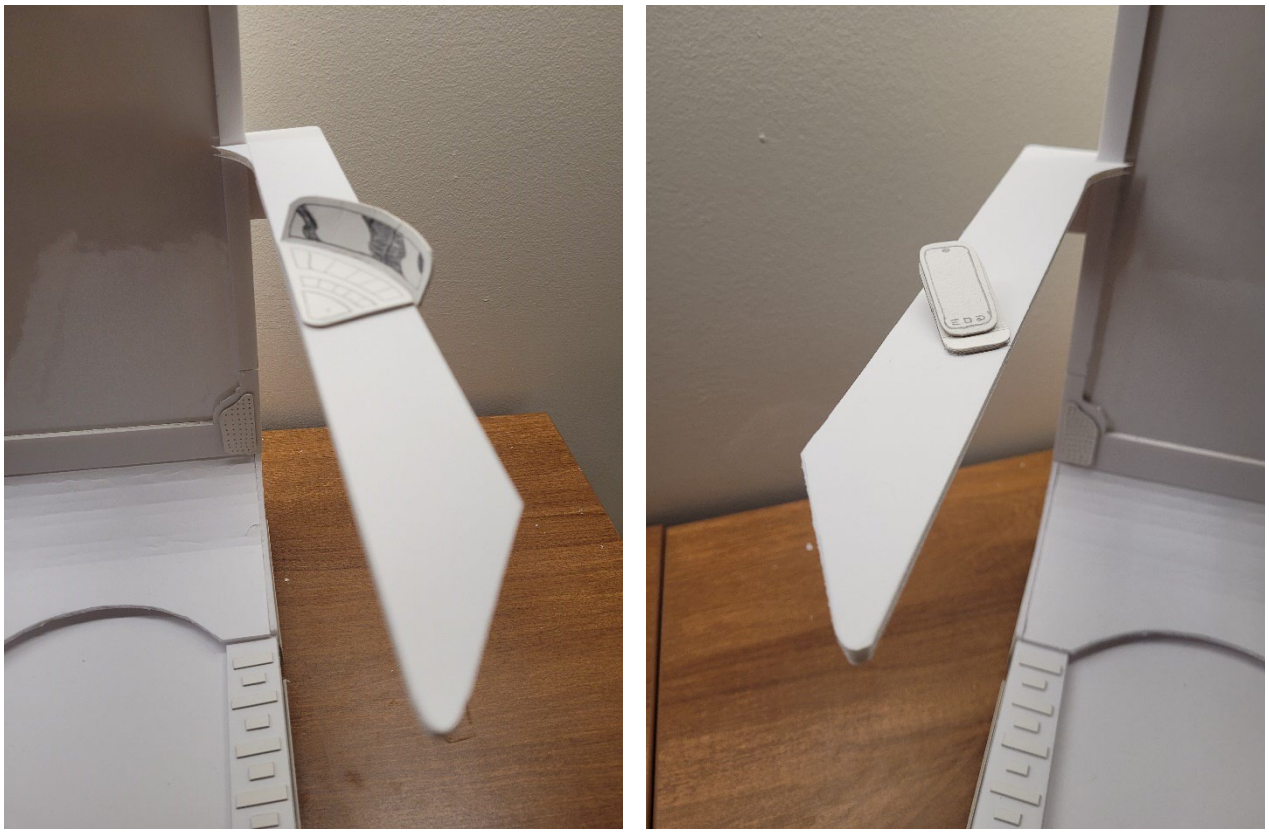


Figure 25 Model 3

Figure 26 Model 4

4.6. Design Resolution

4.7. CAD Development

CAD was one of the final steps before bringing the stated design into fruition. CAD is the process of bringing an idea to life truly making something 3-Dimensional. The following images show how the product evolved.

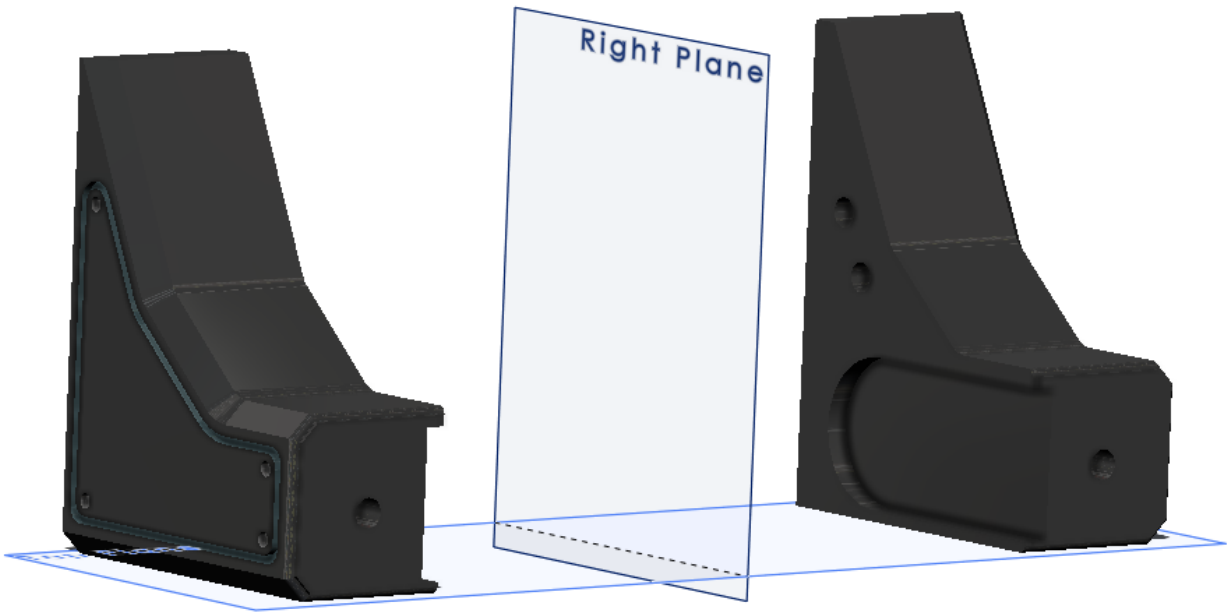
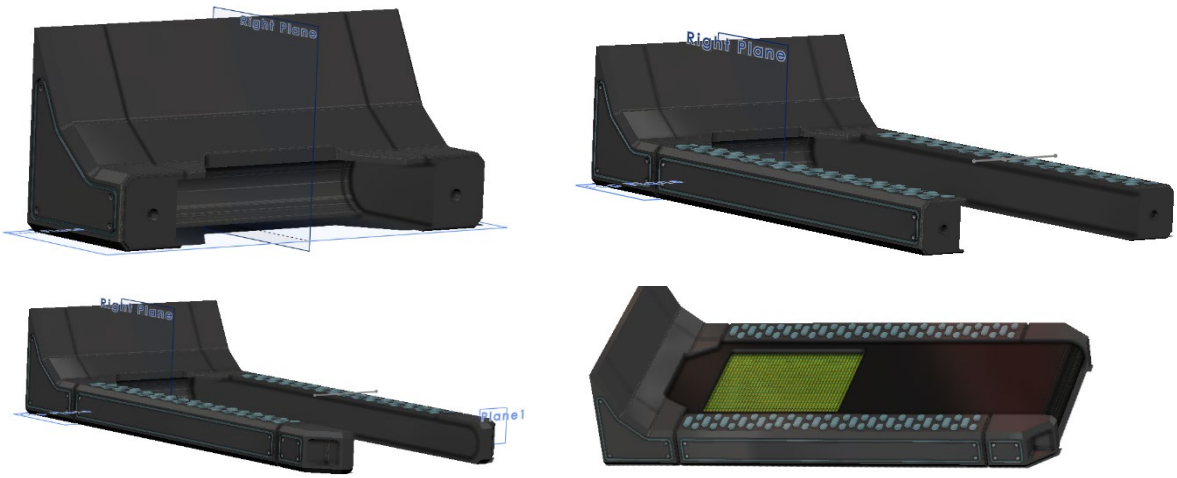


Figure 27 CAD

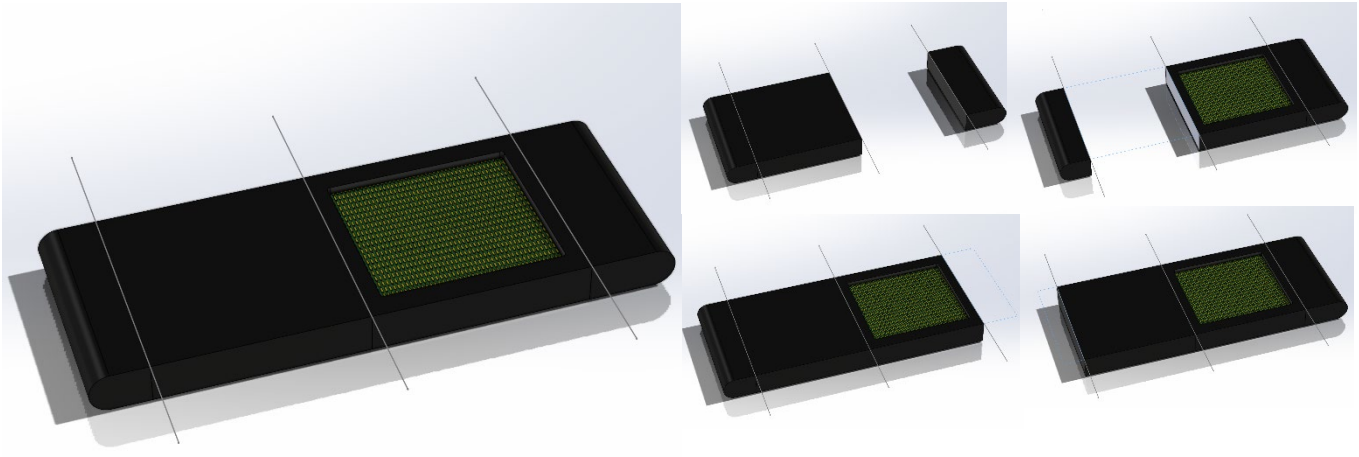
The first step was building the transition between the belt and the display. This was the basis of the treadmill, making this instrumental to get right. The mirror command was used to reduce the overall time of creating the model. This method was repeated for the entire model.



A lot of the geometry for these developments were based off the original transition part.

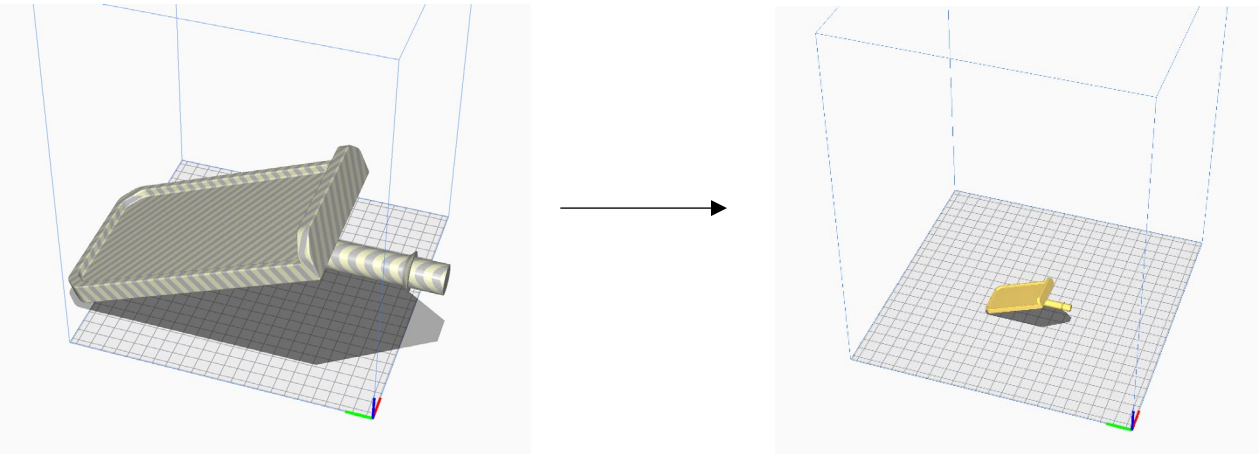
Next was construction of the display.

The last step before constructing the physical model was slicing the bodies up into manageable sizes that fit on a 3D printer.



4.8. Physical model Fabrication

The final model was 3D printed using a High-Performance Ender 5 Pro. The Model consisted of 43 parts. All of which needed to be scaled down from 1 to 1/4.



Once parts fit, they could be printed.

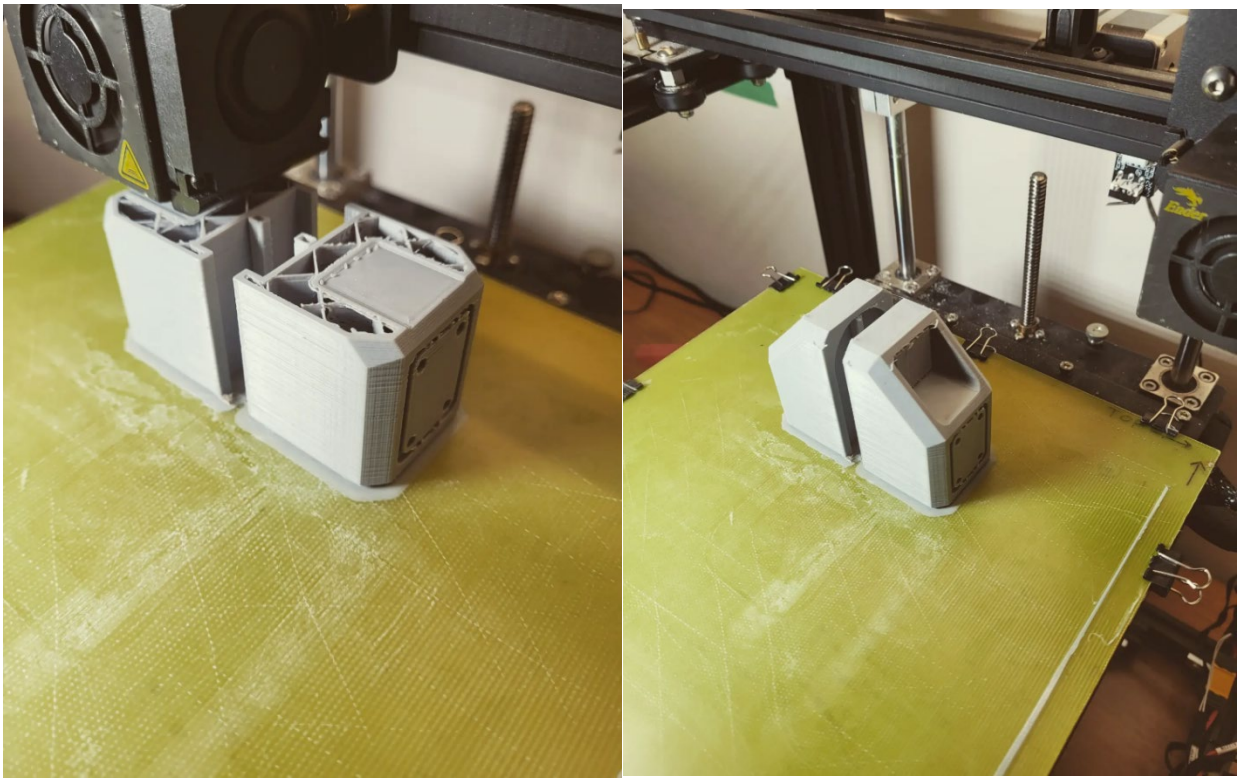
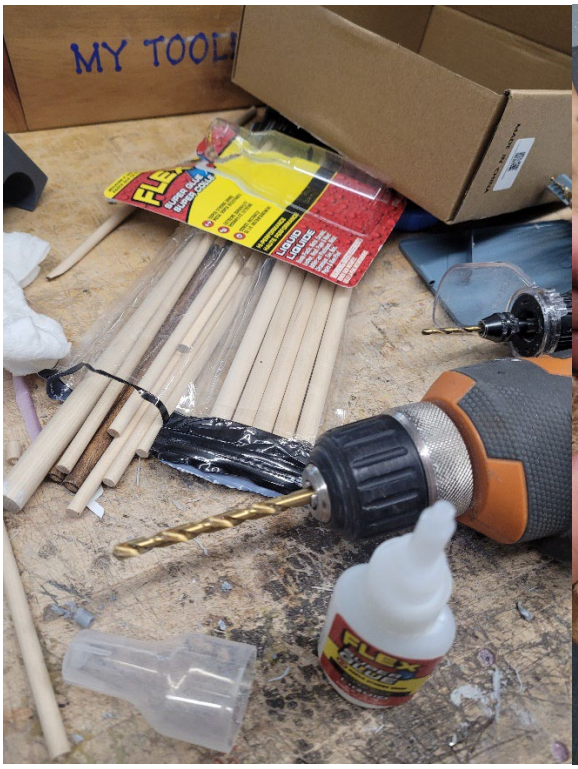


Figure 28 3D Printing

All parts were then sanded and either super glued or fixed with dowel connections.



The model was finally painted and assembled.

CHAPTER 5

5.1 Design Summary

The Problem

Multi Athletes are constantly pushing their bodies to the limit, both in competition and practice. This makes Multi Athletes especially susceptible to injuries.

The Multi-Track

The Multi-Track is a treadmill specifically designed for high caliber Multi Athletes looking for every advantage possible. The Multi-Track uses a combination pressure sensors and cameras to track user movement.

Sensors are placed under the belt of the treadmill. This allows for the tracking of gait, stride length, and the area where pressure is being transferred through the feet. Highly personal data such as how the feet are striking the ground while running and ground contact time (turn over rate).

Cameras focus on the body position, making sure the users form is correct. Notifications will arise on screen warning users their form is deteriorating and to correct or take a break.

Benefits

The Multi-Track has many benefits. Because the Multi-Track can track users body position, it helps users maintain better running form leading to less injuries and more effective training. The display makes the data easy to understand for the user using graphics and simple text. All data tracked from the workout is recorded and saved to your profile which can be looked over later for a more in depth understanding of how they are running and the changes they need to make to improve.

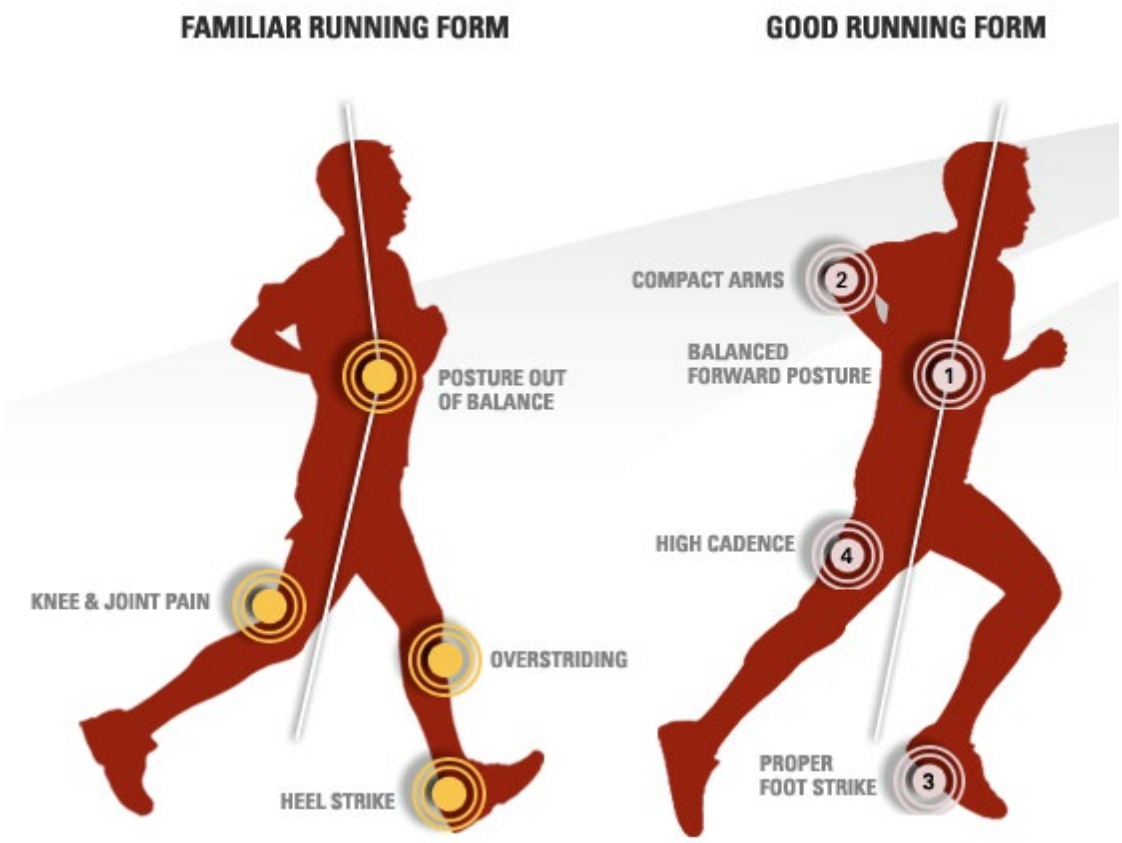


Figure 29 Running Form

5.2 Design Criteria Met

5.2.1 Full Bodied Interaction Design

The Multi-Track has six interaction points.

Arms & Handles

The arms of the treadmill have two touch points there are TPU pads where you would grab when raising yourself off the belt when running. There are also TPU wrapped handles to help users get on the treadmill and for when user step on the edge of the belt and it rolls on them. The handles are an added level of security.

Belt and Treads

The belt is cushioned with a thin layer of foam this reduces strain on the shins when over striding. The treads alongside the belt have a raised texture making for a non-slip surface.

Phone Mount

The phone mount swivels meaning it could be grabbed in multiple ways. The mount was chamfered and filleted leaving no sharp edges.

Display

The display was designed to fit 5th percentile females to 95th percentile males as their natural and most comfortable viewing angles are different.

5.2.2. Material, Processes & Technology

Long term durability and the feeling of quality is the most important. The body of the Multi-Track is injection molded ABS built on a frame of extruded and CNC aluminum. The internal aluminum chassis provides rigidity and support for the aesthetic injection molded paneling. TPU is used for the touch points on the handles and arms this is done using over molding. The sensor bed is mounted under the belt on a polycarbonate sheet, so the sensors can track with the flex of the treadmill.

5.2.3. Design Implementation

Table 5 BOM

Part	Material	Item Description	Colour	Manufacturing Method	Cost $
Frame	Aluminum	The metal inner skeleton of the product	Silver	Extrusion & CNC Machining	$3000
Body (Treads)	ABS & TPU	Panel covering internal structure	Blue & Gray	Injection Over Molded	$200
Body (Tread Caps)	ABS	Panel covering internal structure	Gray	Injection Molding	$50
Body (Motor Housing)	ABS & Aluminum	Panel covering internal structure	Gray	Injection Molding	$100
Body (Display Housing)	ABS	Panel covering internal structure	Gray	Injection Molding	$50
Computer	Silicon, Polycarbonate and Copper	Central processing unit	Green, silver, yellow	PCB Printing	$500
98” QLED UHD Display	copper, tin, zinc, gold, chromium, polymers	Display	Black, Transparent	PCB Printing	$10,000
Belt	Nylon & High-Density Polyethylene	Belt that is stood on	Black	Pressed	$250
Power Supply	Silicon, Polycarbonate and Copper	Product that powers the treadmill	Green	PCB Printing	$60
120v Motor 5hp	Aluminum & Copper	Rotates running surface	Silver, Black	Mechanical Assembly	$300
Drive Belt	Rubber	Rubber	Black	Extrusion & Machining	$70
Wires 18awg x50ft	Aluminum & PVC	Electrical cords that transfer electricity components	Red, Black, White, Yellow…	Draw through injection molding	$30
Bolts 3/16 x 1.5” (Access Panels) x22	Stainless Steel	Metal Fastener	Silver	Cold Forging	$10
Bolts 1/4 x 1.5”(Panel Mount) x110	Stainless Steel	Metal Fastener	Silver	Cold Forging	$30
Pressure Sensors (x176,000)	Polyimide Film	Flexible PCB	Silver, Transparent	PCB Printing	$5,300
				Total:	$19,950

5.3. Final Cad Rendering

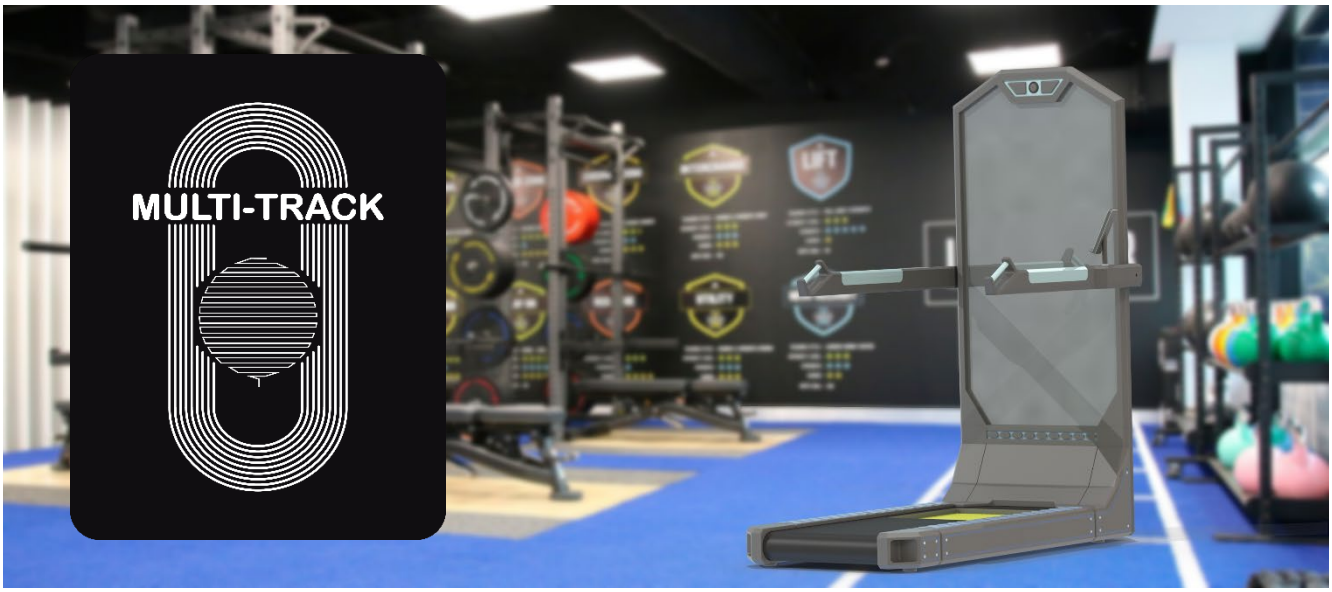
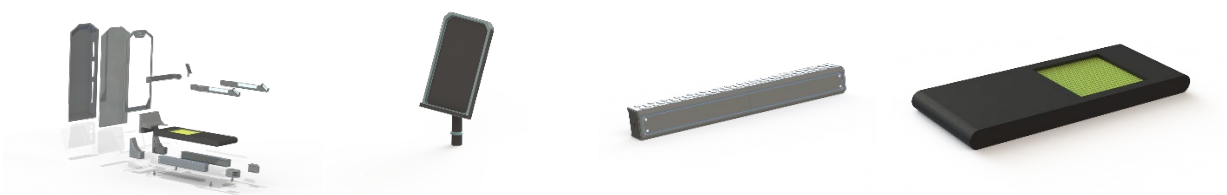
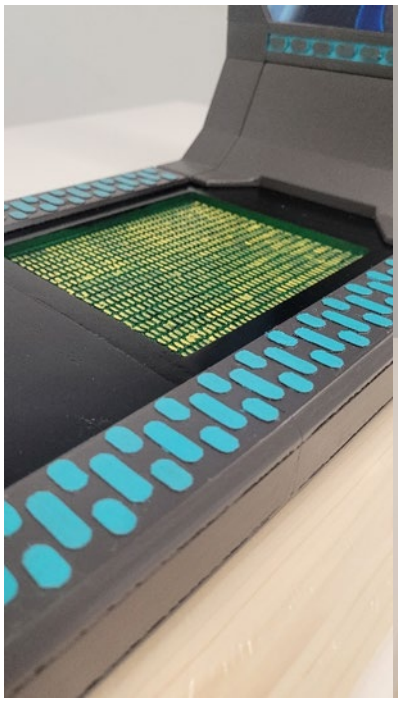


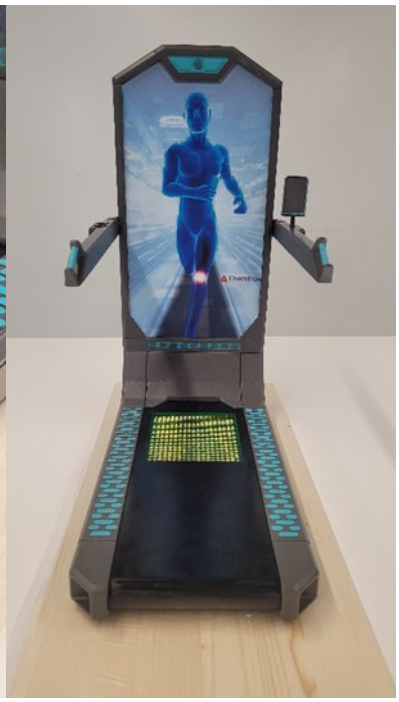
Figure 30 Final Render



5.4. Physical Model

Figure 31 Final Model





5.5. Technical Drawings

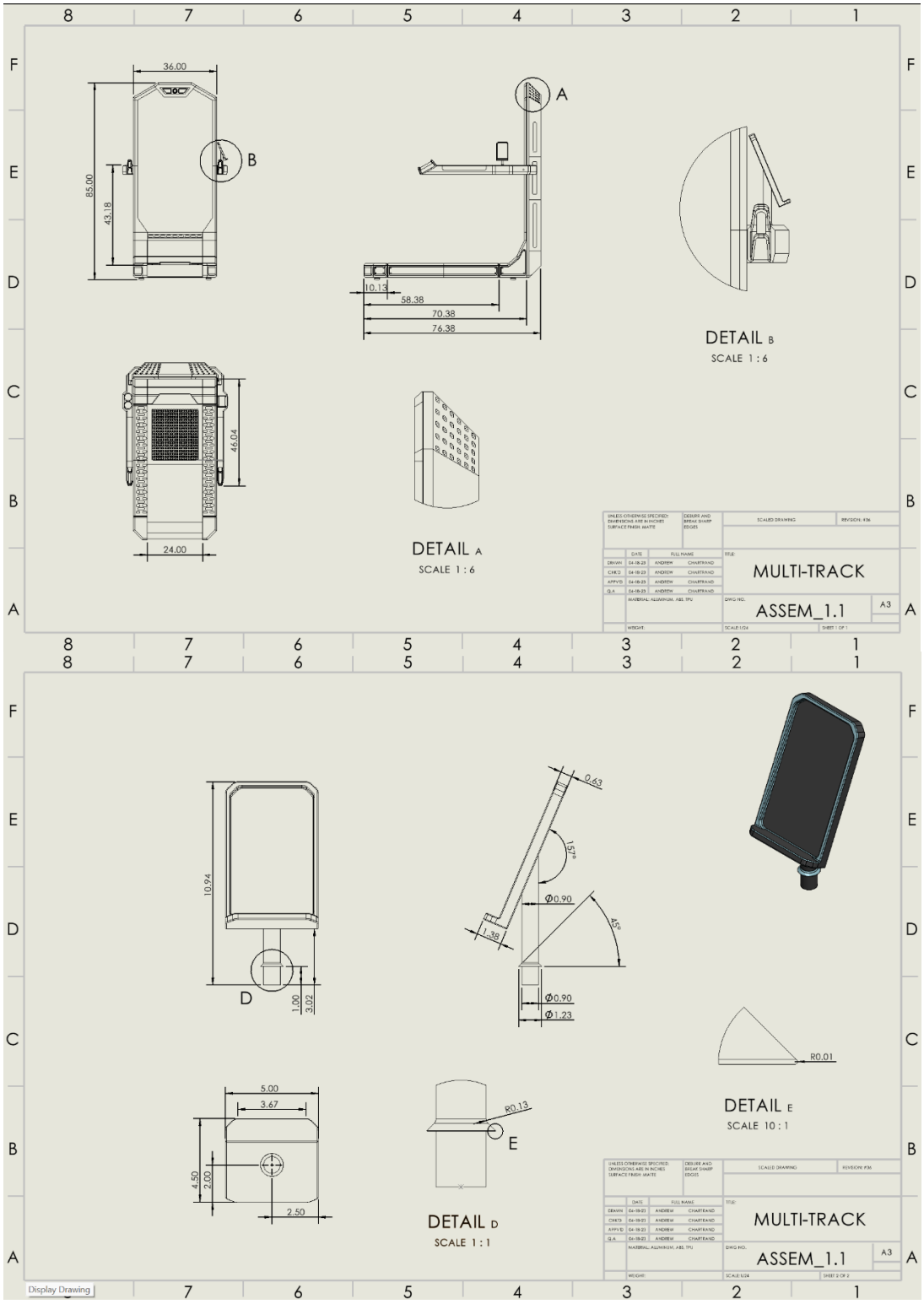


Figure 32 Tech Drawing

5.6. Sustainability

The sustainability of a product has become an integral part of design and cannot be overlooked. It was important both, short term during the manufacturing process, and long term during the products life span to be sustainable.

Manufacturing Methods & Materials

The main manufacturing method for the Multi-Track is injection molding. ABS was used for the body panels of the treadmill as it has great durability characteristics and can be recycled. TPU was also injection molded for areas that would come in contact with the user. TPU could have been over molded onto the ABS but this would make recycling difficult. Instead, the TPU panels would be fastened into place making for easy disassembly and repairs.

The internal frame of the Multi-Track was designed out of reclaimed aluminum tubing. This done so the treadmill could be light if it needed to be moved and reclaimed aluminum uses 95% less energy to produce than to produce primary aluminum.

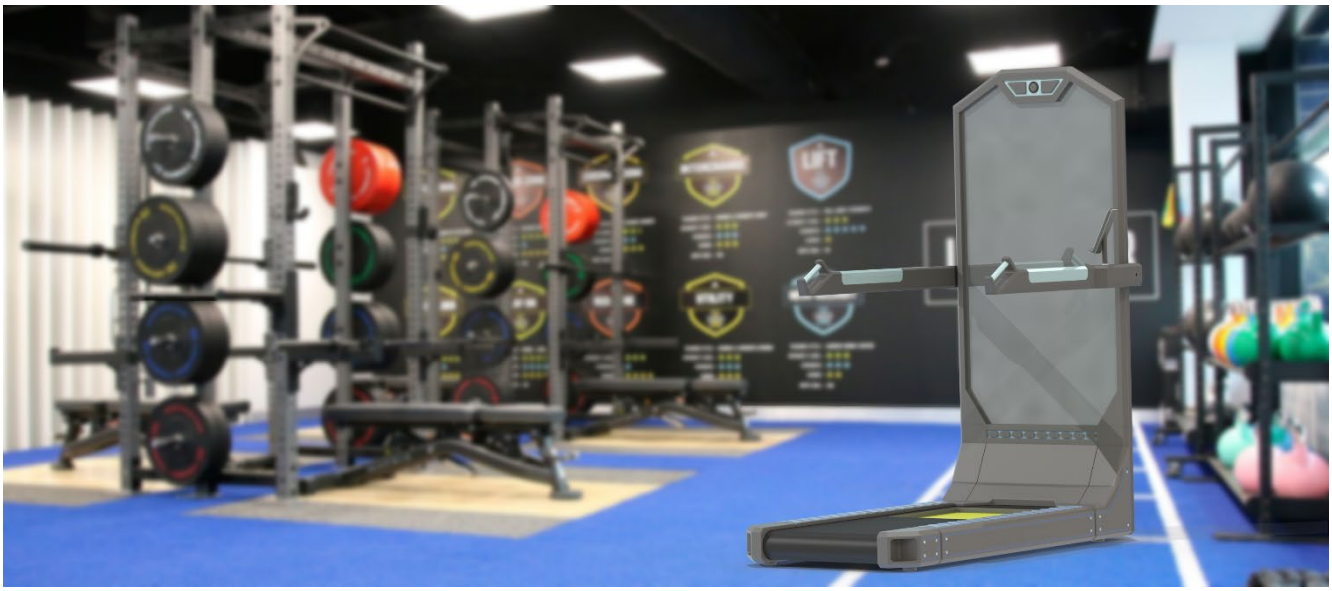
Business Model

The Multi-Track is designed to last forever. All the parts on the Multi-Track are easy to replace if anything breaks via access panels all around the treadmill base. Because of this all Multi-Tracks sold would have a life time part replacement warranty.

Green Energy

The Multi-Track also reduces the energy it uses by charging large capacitors in the power supply when stopping the treadmill. It does this in a manner similar to electric car regenerative breaking. When users slow their speed or stop the treadmill at the end of a run the motor polarity is reversed charging the capacitors, so next time it starts the motor draws from the capacitors first, relieving the initial heavy load.

CHAPTER 6
Conclusion



The drop out rate in multi events has been becoming increasingly alarming as it now seemingly acceptable for a third of the field not to finish the competition. The preposed solution, the Multi-track, breaks away from old school coaching, braving a new path for athletes to train more effectively while also mitigating the risk of injury.

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Appendix A – Discovery

Search- Major Challenges / Issues Andrew Chartrand

Objective: To quickly determine major challenges or issues in a topic area

Deliverable: 2 Searches *(Step 2 searches- any combination of peer-reviewed or non-peer reviewed)*
Table of possible thesis topics (based on Step 2 searches). *Very preliminary possible topics.*
Table of possible 'experts' for the Information Interview.

Resource: Example of this type of search is given (pages 3-11)
You have the option of using it as a template to follow, or not.
Note: *Skip pages 4 and 5…. This was submitted last week.*

Due Date: *Week 3 Monday Sept 19*

Step 2: Major Issues / Challenges- *search*	*Track and Field (Humber Libraries)*

Epidemiology of Injuries in National Collegiate Athletic Association Men's Track and Field: 2014–2015 Through 2018–2019

Journal Link
https://www.proquest.com/docview/2553151188?parentSessionId=ubNzLF4zMwJos85QEKJHb6u5uL6qn2FZnLdgtWoh8uM%3D&accountid=11530

Highlights

- Time loss due to injury is important as you are "falling behind". Injuries usually resulted in one day or more of time off.
- Majority of injuries were in the lower leg or thigh.
- Most injuries were sustained while sprinting or doing long distance exercises.
- Higher percentage of injuries are acquired during competition than practice.
- Jumpers are at a significantly higher risk of injury during competition than in practice.

Abstract

Background
Monitoring injuries of men's track and field athletes using surveillance systems is critical in identifying emerging injury-related patterns.

Objective
To identify injury related patterns.

Methods
Exposure and injury data collected in the National Collegiate Athletic Association Injury Surveillance Program during the 2014–2015 through 2018–2019 academic years were analyzed. Injury counts, rates, and proportions were used to describe injury characteristics; injury rate ratios were used to examine differential injury rates.

Results
Overall, men's track and field athletes were injured at a rate of 2.37 per 1000 athlete-exposures; injuries occurred at a higher rate during competition compared with practice. Most injuries were to the thigh (26.2%), lower leg (17.3%), or knee (10.7%) and were caused by noncontact (37.2%) or overuse (31.5%) mechanisms. The most reported injury was hamstring tear (14.9%).

Injuries by Track and Field–Specific Activities and Positions
Most reported injuries in men's track and field between 2014–2015 and 2018–2019 occurred during sprinting activities (29.9%) and distance running (21.3%). A higher prevalence of sprinting injuries was observed in competition (36.3%) than in practice (27.6%). Distance-running injuries were more prevalent in practice (24.0%) compared with competition injuries (13.5%). Overall, most injuries were reported among runners (60.9%), jumpers

(14.7%), and throwers (11.1%). Comparable proportions of competition and practice injuries were reported among runners (Table 4). Injuries to jumpers accounted for a higher proportion of competition (18.5%) than practice injuries (13.4%).

Time Loss
More than one-third (36.3%) of all reported injuries resulted in TL of 1 day or more (approximately 26% of all injuries were missing TL information). The prevalence of TL injuries was higher among competition (41.3%) than practice-related (34.5%) injuries. Rates of practice-related TL injuries were lower than rates of competition-related TL, and practice-related TL injury rates were markedly more stable across the study period (Figure C).

Injury Characteristics
Overall, the most commonly injured body parts were the thigh (26.2%), lower leg (17.3%), and knee (10.7%). During competition, the most prevalently injured body parts were the thigh (36.3%), ankle (12.5%), and knee (10.3%). In practice, the most prevalently injured body parts were the thigh (22.6%), lower leg (20.4%), and knee/trunk (10.9%). Lower leg injuries accounted for a greater proportion of practice (20.4%) than competition (8.5%) injuries (Table 3). Noncontact (37.2%) and overuse (31.5%) injuries were the most frequently reported mechanisms of injury overall. Notably, the prevalence of overuse injuries was higher in practice (35.8%) than in competition (19.2%), whereas a greater proportion of competition (17.4%) as compared with practice injuries (8.1%) was attributed to surface contact. Between 2014–2015 and 2018–2019, the most frequently reported injuries were strains (33.6%), inflammatory conditions (musculoskeletal pathologies with degenerative characteristics in the tissue involved, such as bursitis, capsulitis, etc; 18.6%), and sprains (9.4%). The prevalence of strains was higher in competition (42.4%) than in practice (30.5%), whereas the prevalence of inflammatory conditions was higher in practice (22.3%) than in competition (8.2%). The prevalence of spasms was similar in competition (8.9%) and in practice (8.3%). The most commonly reported injuries during the study period were partial or complete hamstring tears (14.9%), partial or complete lateral ligament complex tears (ankle sprains) (5.0%), hamstring spasms (4.1%), and medial tibial stress syndrome (4.1%). The rate of hamstring tears fluctuated across the study period (Figure D). Temporal patterns in rates of lateral ligament complex tears, hamstring spasms, and medial tibial stress syndrome are not reported because of low injury frequencies (n , 5) observed in certain years across the study period.

Future research should focus on longitudinal prospective studies

1- The difference in indoor vs Outdoor season injuries.

Summary Statements

- Overall, and across five years, the competition injury rate was higher than the practice injury rate.
- The overall preseason injury rate was not different than the regular season injury rate.
- Nearly half of all competition-related injuries were diagnosed as strains and were ankle-related.

Though not considered a contact or collision sport, track and field combines running, throwing, and jumping field events, making athletes susceptible to both acute and chronic injuries. Running events include long-distance, sprinting, and hurdle events, and field events include throwing as well as horizontal and vertical jumping. Each of these requires rigorous and event-specific training, leading to a wide spectrum of possible injuries. Importantly, the popularity of men's track and field events has steadily grown at the collegiate level. Over the past 3 decades in particular, participation in men's track and field within the National Collegiate Athletic Association (NCAA) has increased from 422 to 734 teams in indoor track and field and from 577 to 834 teams in outdoor track and field.[1] Given the observed popularity of and participation in men's track and field, it is important to continue surveying injury incidence in this complex and growing sport.

Sports injury surveillance allows for the continuous monitoring of injury-related patterns[2,3] and has been integrated into the NCAA since 1982[4] via the NCAA Injury Surveillance Program (ISP).[5] Using the ISP, previous researchers have been able to describe injury incidence and outcomes in men's track and field, yet there exists a paucity of epidemiologic evidence in this population. In the extant literature, it has been previously noted that overuse injuries impose a particular burden among NCAA men's track and field athletes.[6] It has also been noted that the lower extremity is most affected in this population,[6,7] with hamstring strains accounting for the majority of both injury and outdoor injuries.[7] As men's track and field continues to grow, it is important to update these findings in order to identify injury incidence patterns and better inform injury prevention practices. Accordingly, the purpose of this study is to describe the epidemiology of track and field–related injuries captured among NCAA men's track and field athletes between 2014–2015 and 2018–2019.

Table 3. Distribution of Injuries by Body Part, Mechanism, and Injury Diagnosis, Stratified by Event Type[a]

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Estimates (%)	Injuries Reported (%)	National Estimates (%)	Injuries Reported (%)	National Estimates (%)
Injury site						
Head/face	21 (1.94)	1001 (1.74)	8 (2.85)	347 (2.20)	13 (1.63)	654 (1.57)
Neck	3 (0.28)	77 (0.13)	1 (0.36)	36 (0.23)	2 (0.25)	41 (0.10)
Shoulder	20 (1.85)	1058 (1.84)	2 (0.71)	127 (0.80)	18 (2.25)	931 (2.24)
Arm/elbow	17 (1.57)	958 (1.67)	5 (1.78)	238 (1.51)	12 (1.50)	721 (1.73)
Hand/wrist	17 (1.57)	731 (1.27)	5 (1.78)	152 (0.96)	12 (1.50)	579 (1.39)
Trunk	106 (9.81)	6343 (11.05)	19 (6.76)	1496 (9.47)	87 (10.88)	4847 (11.64)
Hip/groin	92 (8.51)	4144 (7.22)	22 (7.83)	1023 (6.48)	70 (8.75)	3121 (7.50)
Thigh	283 (26.18)	16 331 (28.44)	102 (36.30)	5581 (35.33)	181 (22.63)	10 750 (25.82)
Knee	116 (10.73)	6880 (11.98)	29 (10.32)	2169 (13.73)	87 (10.88)	4711 (11.32)
Lower leg	187 (17.30)	9706 (16.90)	24 (8.54)	1255 (7.94)	163 (20.38)	8451 (20.30)
Ankle	95 (8.79)	4417 (7.69)	35 (12.46)	1746 (11.05)	60 (7.50)	2671 (6.42)
Foot	111 (10.27)	4872 (8.48)	26 (9.25)	1490 (9.43)	85 (10.63)	3381 (8.12)
Other	13 (1.20)	910 (1.58)	3 (1.07)	139 (0.88)	10 (1.25)	771 (1.85)
Mechanism						
Noncontact	402 (37.19)	27 147 (47.27)	108 (38.43)	7417 (46.95)	294 (36.75)	19 730 (47.39)
Contact with player	10 (0.93)	621 (1.08)	8 (2.85)	555 (3.51)	2 (0.25)	67 (0.16)
Contact with surface	114 (10.55)	4770 (8.31)	49 (17.44)	2051 (12.98)	65 (8.13)	2719 (6.53)
Contact with apparatus	45 (4.16)	1952 (3.40)	14 (4.98)	521 (3.30)	31 (3.88)	1430 (3.44)
Contact with out-of-bounds object	7 (0.65)	324 (0.56)	1 (0.36)	20 (0.13)	6 (0.75)	303 (0.73)
Overuse	340 (31.45)	15 446 (26.90)	54 (19.22)	2550 (16.14)	286 (35.75)	12 896 (30.98)
Illness/infection	11 (1.02)	737 (1.28)	1 (0.36)	79 (0.50)	10 (1.25)	658 (1.58)
Other/unknown	152 (14.06)	6431 (11.20)	46 (16.37)	2605 (16.49)	106 (13.25)	3825 (9.19)
Diagnosis						
Abrasion/laceration	10 (0.93)	702 (1.22)	4 (1.42)	162 (1.03)	6 (0.75)	540 (1.30)
Concussion	15 (1.39)	550 (0.96)	8 (2.85)	347 (2.20)	7 (0.88)	204 (0.49)
Contusion	48 (4.44)	2394 (4.17)	20 (7.12)	1185 (7.50)	28 (3.50)	1209 (2.90)
Dislocation/subluxation	5 (0.46)	317 (0.55)	0 (0)	0 (0)	5 (0.63)	317 (0.76)
Entrapment/impingement	8 (0.74)	270 (0.47)	2 (0.71)	93 (0.59)	6 (0.75)	177 (0.43)
Fracture	28 (2.59)	1575 (2.74)	6 (2.14)	333 (2.11)	22 (2.75)	1242 (2.98)
Illness/infection	2 (0.19)	345 (0.60)	0 (0)	0 (0)	2 (0.25)	345 (0.83)
Inflammatory condition	201 (18.59)	9401 (16.37)	23 (8.19)	1418 (8.98)	178 (22.25)	7982 (19.17)
Spasm	91 (8.42)	4787 (8.34)	25 (8.90)	1040 (6.58)	66 (8.25)	3746 (9.00)
Sprain	102 (9.44)	5027 (8.75)	34 (12.10)	1868 (11.82)	68 (8.50)	3159 (7.59)
Strain	363 (33.58)	21 349 (37.18)	119 (42.35)	6845 (43.33)	244 (30.50)	14 503 (34.84)
Other	208 (19.24)	10 712 (18.65)	40 (14.23)	2507 (15.87)	168 (21.00)	8205 (19.71)

[a] Data presented in the order of reported number, followed by the proportion of all injuries attributable to a given category. Data pooled across event types are presented overall, and separately for practices and competitions. National estimates were produced using sampling weights estimated on the basis of sport, division, and year. A reportable injury was one that occurred due to participation in an organized intercollegiate practice or competition, and required medical attention by a team Certified Athletic Trainer or physician (regardless of time loss). Only scheduled team practices and competitions were retained in this analysis.

Step 2: Major Issues / Challenges- *search*	*Track and Field Hamstring Strains (Humber Libraries)*

Acute hamstring strain injury in track-and-field athletes: A 3-year observational study at the Penn Relay Carnival

Journal Link

https://onlinelibrary-wiley-com.ezproxy.humber.ca/doi/full/10.1111/sms.12159

Abstract

This study aimed to observe the incidence rates of hamstring strain injuries (HSIs) across different competition levels and ages during the Penn Relays Carnival. Over a 3-year period, all injuries treated by the medical staff were recorded. The type of injury, anatomic location, event in which the injury occurred, competition level, and demographic data were documented. Absolute and relative HSI (per 1000 participants) were determined, and odds ratios (ORs) were calculated between sexes, competition levels, and events. Throughout the study period 48 473 athletes registered to participate in the Penn Relays Carnival, with 118 HSIs treated by the medical team. High school girls displayed lesser risk of HSI than high school boys (OR = 0.55, $P = 0.021$), and masters athletes were more likely than high school- (OR = 4.26, $P < 0.001$) and college-level (OR = 3.55, $P = 0.001$) athletes to suffer HSI. The 4 × 400-m relay displayed a greater likelihood of HSI compared with the 4 × 100-m relay (OR = 1.77, $P = 0.008$). High school boys and masters-level athletes are most likely to suffer HSI, and there is higher risk in 400-m events compared with 100-m events.

Results

Athlete participation information

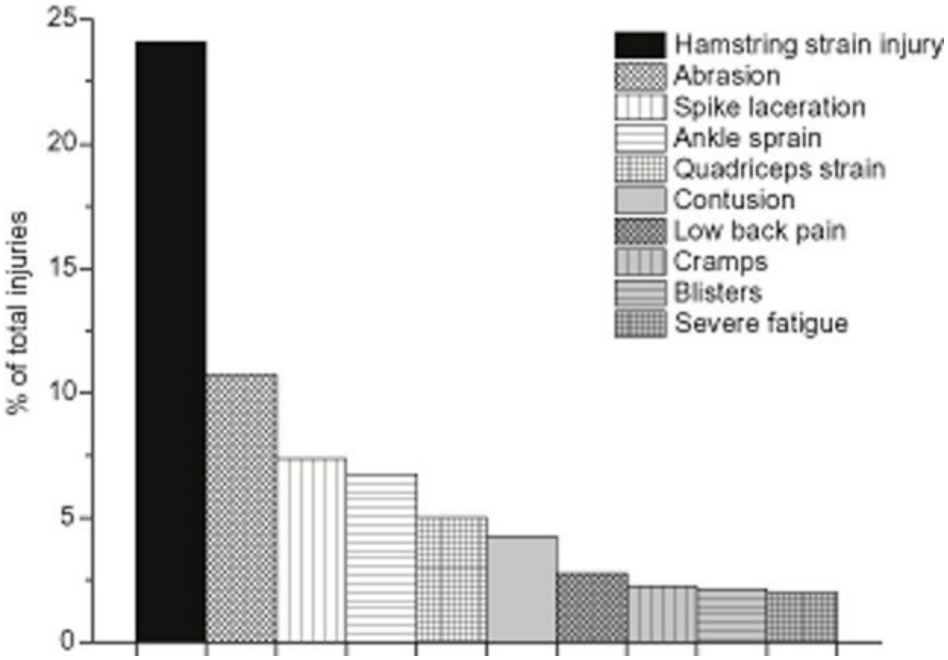
Across the 3-year observational period, 48 473 athletes registered to participate in the Penn Relays Carnival, with slightly more men (*n* = 25 232) than women (*n* = 23 241) competing (Table 1).

Weather conditions

Across the 3-year period, there was a gradual increase in 3-day average maximum temperature (year 1 = 17.0°C; year 2 = 20.7°C; year 3 = 25.2°C). There was no rainfall recorded on any of the days of the carnival across the observational period.

Injury data collection

During the observational period of the study, there were 489 injuries treated by the medical staff. Figure 1 displays the 10 most common injuries treated by the medical team during the study. HSI was the most common injury evaluated, accounting for 24.1% (*n* = 118) of all injuries. HSIs accounted for over 75% of all lower limb strains treated.



Event

Event participation data can be found in Table 2. Of the three most heavily participated events, the 4 × 400-m relay displayed a higher risk to sustain HSI compared with the 4 × 100-m relay (OR = 1.77, 95% CI = 1.15–2.70; $\chi 2 = 7.05$, P = 0.008) but not compared with the 4 × 200-m relay (OR = 1.59, 95% CI = 0.83–3.04; $\chi 2 = 1.96$, P = 0.162; Fig. 5). There was no difference in the risk of HSIs between the 4 × 100 and the 4 × 200-m relay (OR = 0.89, 95% CI = 0.46–1.76; $\chi 2 = 0.10$, P = 0.754). Although participation rates in a number of other events were too low to run valid statistical analysis, the 100 m, 110-m hurdles, and triple jump all showed high relative rates of HSIs (Table 3).

Summary Statements

1. 3 major injuries Track & Field
    1. Hamstring Strain (75% of total injuries)
    2. Abrasion
    3. Spike laceration

2. Hamstring strains are generally acquired during sprinting or long-distance events.

3. The causes of hamstring strains
    1. Improper warmup
    2. Improper muscle recover (Leading to tight tense muscles)
    3. Poor Technique
    4. Return to sport too soon after injury (Repetitive injury)

Step 2: Major Issues / Challenges- *search*	*Google: 'Major Injuries for competitive swimmers'* *Possible follow up articles*

Possible Follow Articles

Hamstring Injuries in the Athlete: Diagnosis, Treatment, and Return to Play
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5003616/#:~:text=Hamstring%20injuries%20are%20very%20common,the%20pathology%20from%20chronic%20overuse.

Hamstring Strain Injury in Athletes
https://www.jospt.org/doi/10.2519/jospt.2022.0301

Usain Bolt and Andre De Grasse: Hamstring injuries explained
https://theconversation.com/usain-bolt-and-andre-de-grasse-hamstring-injuries-explained-82431

Step 2: Major Issues / Challenges- *search*	*Possible Thesis' focus*

Possible Thesis' Focus

Approaches to injury topic

1. Injury prevention
2. Training recovery
3. Injury recovery
4. Training products

Athletics Hamstring Strain

1- Hamstring strengthening product
2- Hamstring stretching product
3- Repetition monitoring Device
4- Form monitoring Device
5- Hamstring stress transferring device (Brace)

Athlete Issues

1. Funding
2. Equipment Accessibility (Fitness Testing)
3. Training Progress Tracking
4. Traveling (Pole vault Poles, Javelins)

Step 3: Connections to 'experts'		*Information interview*
Personal Contacts		
Laura Sivers (Combined events Coach)	*Brockville Legion Head Coach*	*https://www.brockvillelegiontrackandfield.com/*
Liz House (Combined events Coach)	*London Western Multi Coach*	*https://www.londonwesterntfc.com/coaches*
Peter Bartha (Pole Vault Coach)	*York University Junior Coach*	*Phone number*
Coaches		
Bradley Matheson **yorkutrackclub@gmail.com**	York University NCCP# 1183332	https://www.yorkutrackclub.com/coaches#:~:text=Raymond%20Rudder%20is%20the%20Head,with%20the%20multi%2Devent%20athletes.
Raymond Rudder **drudder@yorku.ca**	York University NCCP# 5849629	https://www.yorkutrackclub.com/coaches#:~:text=Raymond%20Rudder%20is%20the%20Head,with%20the%20multi%2Devent%20athletes.
ARYE Rosenoer	York University NCCP#1005115	*https://www.yorkutrackclub.com/coaches#:~:text=Raymond%20Rudder%20is%20the%20Head,with%20the%20multi%2Devent%20athletes*.
Athletes Care Sports Medicine Centre	**Many locations:** - Universities (York / Waterloo) - Health Clubs	https://www.athletescare.com/
Education- Sports		
Humber College Exercise Science and Lifestyle Management		https://healthsciences.humber.ca/programs/exercise-science-lifestyle-management.html
Physiology Programs- Ontario Universities		http://www.canadian-universities.net/Universities/Programs/Exercise_Physiology-Ontario.html

Appendix B – Contextual Research (User)

VIDEO USER OBSERVATION

This User Observation was focused on specific key activities.
These specific key activities were ….. running on a treadmill and vertical jump tests.

These specific key activities were determined by …. The main uses of the potentially designed product as well as benchmarking described these (Running) as the most important use cases.

Objective

To determine the usability (ergonomic and ease of use issues) as well as effectiveness (time and optimization of steps) of key activities.

Method

The type of User Observation selected was

1- **User** simulates doing key activities **on mock-up**

The user observation occurred on (December 3rd at the Humber) with a decathlete with over 5 years of training experience.

Consent forms were obtained.

This actual observation was recorded with ….. photos, and note-taking, video etc,

Conversations were recorded by … note-taking

Results

An excerpt of the transcription is below, along with preliminary coding.

The full transcription is available in the Appendix.

Cedric Dubler Vlog-

https://www.youtube.com/watch?v=UNGFbCmKPWA&t=103s&ab_channel=CedricDubler

I was trying to do like sharp contacts but the left foot was just kind of dragging through and by the end it was sharp contacts like it sounded a lot better and I was actually cycling through a little bit more as well so I'm really happy with today's session and uh I will see you guys tomorrow welcome to Thursday today is our hurdles Sprints and discus day I plan to do all of the events just modified for the hurdles I am just going to set up probably three hurdles and set up my blocks and do some visualization and then probably even get into my blocks kind of feel the position close my eyes and go through a race or a couple races then for the Sprints it's really just going to be a progression from the runs from yesterday and then discus it all depends on how the hammy feels with doing some standing throws I'd love to work into like a split stance to actually do some some normal stand throws but it depends if the hammy is up for that today otherwise we'll just modify it and um bring in like into a smaller stance all right we have finished training for this morning well actually no we're not we are actually heading to the gym to do some uh bike work but what we did at the track was really good that's a rough session we've done one set we're gonna do one more set three two one here we go all right we are done for the morning now we're gonna go back to some recovery stuff have lunch and then I'll see you guys at the gym soon welcome to Saturday today Mark's one week post hamstring tear and now that a lot of the bleeding and stuff should have settled and the muscle repair is underway we are able to start pushing the hamstring a little bit so what I've been told is yesterday was a consolidation day so that today we could push the hamstring faster apparently a lot faster than we've been going and that honestly makes me really nervous because I don't know currently where the limit lies exactly so I think the plan for this morning is to just warm up do my activation kind of build it up slowly and over eight reps try and find where that that speed currently lies think from the last couple days we were running around 13 to 15 seconds for 30 meters today apparently we're trying to drop to around six seconds so we are going to go a lot faster this is frustratingly slow but we're doing okay I definitely feel like that was my Max and even maybe a little bit past where I should have pushed just the last like 10 meters of the runs I was just getting super fatigued in the hamstring it was pretty much just like not activating properly but for the other the other part of the run it actually felt quite nice so we're going to shut down the session now uh go I'm gonna go home and ice and then we're gonna go out to the gym later to do some solid strength work for it that is the end of the Vlog we did go to the World Gym and do a session the session actually went really well I felt very strong through my hamstrings it gave me a lot of confidence.

Coding

More in-depth coding was then conducted.

Time	Location	Do	Say	Social Interactions	Positives	Negatives
9pm Thursday	Track Facility	Modified Exercises	plan to do all of the events	With coaches and fellow athletes	Touching all events (Feeling Connected)	Realizes how large a setback the injury was
10am Friday	Track facility	Modified Exercises	I'd love to work into like a split stance to actually do some some normal stand throws	With coaches and fellow athletes	Improved comfort, can be more aggressive	Still not where they want to be
2pm Friday	Gym	Recovery Exercises	go back to some recovery stuff	Motivation from coaches	Improved hamstring strength & performance	There is still a range of weekness
2pm Saturday	Track Facility	Testing	we are able to start pushing the hamstring a little bit	With coaches and fellow athletes	Can push the hamstring harder and can see results	There is still pain during top speed

Codes:

- Dates/Time
- Progress
- Injury Type
- Exercise Type
- Emotion/Feeling
- Modified Exercises
- Recovery/Health/Medical Treatment

User Task Map for Focused Observation

A User Task Map for specific task (s) was generated, looking at design parameters of ergonomics, efficiency, interaction, and satisfaction. This is shown in the table below, with the keys used for these design parameters shown in the table underneath.

		User Task Map		
Task: Running on Treadmill	Ergonomics	Efficiency	Interaction	Satisfaction
1: Getting on Treadmill	**Step Up** -Height -Access to railings	1 – 2 steps with utilization of supporting devices	Interaction with railing is likely but not 100% necessary	Little to no experience
2: Starting Treadmill	**Interactive Display** -Size of Touch Screen/ Tactile Buttons -Reach Distance -Height of Display **Safety Tether** -Height (waist) -Length of Rope -Type of clip	This has the possibility of being overly complicated if not done right, ruining the entire treadmill experience Must be clearly defined	Interaction with display Tether should be self-explanatory on how its used and have a proper mounting position when not in use.	Can be a difficult process on most treadmills
3: Running on Treadmill	**Running Area** **Legs**	Should start up quickly without any major delay and have	Feet repetitively come into contact with the belt	Usually a good experience on most treadmill with the

	-Belt Width (Inaccuracy) -Belt Length (Stride) **Arms** -Space for arms to swing	a slow ramp for initial belt acceleration		exception of when the tether gets pulled and you must restart your workout.
4: Stopping Treadmill	**Easy Access Emergency Stop Button** -Size of Tactile Buttons -Reach Distance	The button should be placed somewhere in the center of the treadmill so to be reached quickly	One hit with any part of your hand (For Safety the button shout be large and easy to press)	Normally a satisfying experience as it means you have finished your workout and achieved your goal for the day.
	Ergonomic Safety	Efficiency	Interaction	Satisfaction
	1: Awkward bends 2: Slips,Trips, and Falls	1:Minimizing distances between most commonly used buttons 2: Lack of Experience using the device	1: Light, sound, Icons & words (Buttons)	How well something is accomplished and the feeling that gives to the user

Summary: How this may inform design

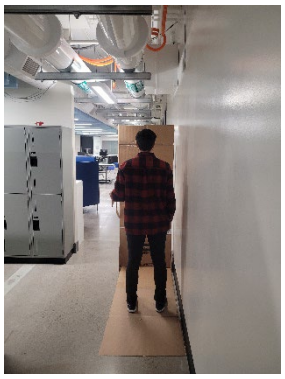
- Gains: Social support network (continued contact with teammates, rehabbing with other injured athletes) is an important aid to recovery.
- Pains:
  - Frustration of not being able to train with teammates
  - Frustration at rehabbing alone
  - Frustration at not being able to compete
  - Hidden: body misses a good workout
  - Treadmill is confusing to use
    - Too many buttons
    - Interface is unclear
- Usability & Ergonomics
  - Chronic bending
  - Large distances between common use functions
    - Causing body & head rotation
- Efficiency
  - Preparation and organization
  - Easy treadmill start-up
- Interaction

    - With railing
    - With display
    - With running area (Belt)
    - With running area (General space for movement)
- Satisfaction
    - Mastery and Control-
        - First time users of a treadmill most commonly find them difficult to start with having to put in a ton of information.

Using Cedric Dubler's vlog as an observational study, it can be concluded that the healing process from a hamstring tear is a slow and incremental one that can take as little as 2 weeks with an elite medical and training staff.

A hamstring tear can also be an emotional rollercoaster as not everything heals evenly at once. This can make you feel as though you ready to progress because some motions will have no pain while others will continue to have pain for much longer a duration.

Modified exercises are very important for a decathlete. When a decathlete completely stops doing an event for a time, they will lose confidence and trust in themselves that they are capable of successfully completing the event. Staying "In



Touch" with all events can't be overlooked while injured.

Appendix C – Field Research (Product)

Benchmarking Product
Using Promotional Literature of Competing Products Topic: Bicycle

Name:

Objective: To identify customer benefits of using a product comparable to your thesis topic
To identify the features which help meet customer benefits
To determine how competitor products meet customer needs
To examine the relationship between customer benefits and how they are being met (features)

Method: Four products which were similar to the thesis topic were selected.
Promotional material from each was gathered and shown on the following pages.
Benefits and **Features** were identified by colour (**red** and **blue** respectively) and gathered into an Excel spreadsheet.
In the Excel spreadsheet they were sorted, and a word frequency table generated for each.

Due Date: Mon Nov 14, 2022

Product #1

Nordic C Series

https://www.nordictrack.ca/c-series

Promotional Piece *(Highlight the Benefit/Feature)*

1. Dive into our full-color Smart HD Touchscreen that transports you to the studio, Grecian streets, or beautiful Thai beaches.
2. Your machine works as hard as you with up to an incredible 4.25 CHP DurX™ Plus motor, powering your calorie-torching iFIT workouts.
3. Our tread cushioning allows you to soften impact on your joints with one turn or simulate a real road-running experience with another.

Features *(Highlight the Benefit/Feature)*

1. Increased Support
2. Incredible Comfort
3. Self Cooling

Product #2

Peloton Bike

https://www.onepeloton.ca/shop/bike/bike-basics-package-ca

Promotional Piece *(Highlight the Benefit/Feature)*

The Peloton bike brings you the most convenient and immersive indoor cycling experience, streaming daily live classes from our NYC studio directly into your home. You'll have 24-hour access to studio cycling classes available to your entire household.

Features *(Highlight the Benefit/Feature)*

1. Rotating Touch Screen
2. Automatic Resistance Adjustments
3. Compact 4’ x 2’ Footprint

Product #3

Bowflex Stationary Bike C6

Chapter 1 Promotional Piece *(Highlight the Benefit/Feature)*

1. Own your health with C6, the indoor fitness bike that connects with world-class app experiences for your smart phone or tablet. You'll approach each day with fresh workouts that keep you energized, motivated, and consistent on and off the bike.
2. Personalize your C6 experience with adaptive workouts, real-time coaching, virtual destinations, and on-demand classes.
3. Stream live and on-demand classes directly into your home.
4. Interact, train, and compete against others in a virtual world that motivates you at every mile.

Features *(Highlight the Benefit/Feature)*

1. Smooth 2. Quiet 3. Backlit LCD 4. 100 Resistance Levels	5. Dual Sided Pedals 6. Set of 3# Dumbbells 7. Device Holder 8. Metric Tracker

Product #4

Nordic RW900 Rower

https://www.nordictrack.ca/rowing-machines/rw900-rower

Promotional Piece *(Highlight the Benefit/Feature)*

1. An improved sliding rail system combined with an upgraded flywheel & SMR™ Silent Magnetic Resistance technology, ensures your rowing experience will be buttery smooth and quiet.
2. With a 22" HD Touchscreen that tilts and pivots along with a 30W Premium Sound system, your worldwide workout will be highly immersive–on or off the rower
3. Your Rower will automatically adjust resistance as you enjoy world-class on-demand training sessions with elite iFIT Trainers

Features *(Highlight the Benefit/Feature)*

1) 22” Tilt & Pivot Touch Screen 2) Inertia-Enhanced Flywheel 3) Innovative Slide System & Design 4) Premium Sound System	5) Smooth 6) Quiet 7) Comfortable 8) Fully Immersive

Using Excel to Sort Your Data

*Gather up **Benefits** and place in a column in Excel (left-hand column below)*

Benefits		Sort 1		Sort 2	
From Promotional Material		A-Z		Catagorized	
transports you		Comfort		**Comfort**	**9**
works as hard as you		Comfortable		Comfortable	
soften impact on your joints		consistent		Quiet	
simulate a real road-running experience		convenient		Quiet	
Comfort		energized		quiet.	
convenient		enjoy		Smooth	
immersive		immersive		smooth	
Own your health		Immersive		Smooth	
energized		immersive		soften impact on your joints	
motivated		motivated			
consistent		motivates		energized	
motivates		Own your health		enjoy	
Smooth		Quiet		**motivated**	**8**
Quiet		Quiet		motivates	
smooth		quiet.		works as hard as you	
quiet.		simulate a real road-running experience		Own your health	
immersive		Smooth		consistent	
enjoy		smooth		convenient	
Smooth		Smooth			
Quiet		soften impact on your joints		**immersive**	**5**
Comfortable		transports you		Immersive	
Immersive		works as hard as you		immersive	
				simulate a real road-running experience	
				transports you	

*Gather up **Features** and place in a column in Excel (left-hand column below)*

Features	Sort 0	Sort 1	Sort 2	
From Promotional Material	**Noun first**	**A-Z**	**Catagorized**	
Sliding Rail System	Row: Sliding Rail System	Comfort: Device Holder	**Comfort**: Device Holder	5
Upgraded Flywheel	Resistance: Upgraded Flywheel	Comfort: Dual Sided Pedals	Comfort: Dual Sided Pedals	
Silent Magnetic Resistance	Comfort: Silent Magnetic Resistance	Comfort: Increased Support	Comfort: Increased Support	
22" Touch Screen	Display: 22" Touch Screen	Comfort: Silent Magnetic Resistance	Comfort: Silent Magnetic Resistance	
Automated Reistance Adjustments	Resistance: Automated Reistance Adjustments	Comfort: Tread Cushioning	Comfort: Tread Cushioning	
22" Pivot Touch Screen	Display: 22" Pivot Touch Screen	Display: 22" Pivot Touch Screen		
Inertia-Enhanced Flywheel	Resistance: Inertia-Enhanced Flywheel	Display: 22" Touch Screen	**Display**: 22" Pivot Touch Screen	5
Adaptive Workouts	Motivation: Adaptive Workouts	Display: Backlit LCD	Display: 22" Touch Screen	
Real-Time Coaching	Motivation: Real-Time Coaching	Display: Metric Tracker	Display: Backlit LCD	
Backlit LCD	Display: Backlit LCD	Display: Rotating Touch Screen	Display: Metric Tracker	
100 Resistance Levels	Resistance: 100 Resistance Levels	Durability: 4.25 CHP DurX Plus Motor	Display: Rotating Touch Screen	
Dual Sided Pedals	Comfort: Dual Sided Pedals	Durability: Self Cooling		
Device Holder	Comfort: Device Holder	Motivation: Adaptive Workouts	**Durability**: 4.25 CHP DurX Plus Motor	2
Metric Tracker	Display: Metric Tracker	Motivation: Live Classes	Durability: Self Cooling	
Rotating Touch Screen	Display: Rotating Touch Screen	Motivation: Real-Time Coaching		
Live Classes	Motivation: Live Classes	Resistance: 100 Resistance Levels	**Motivation**: Adaptive Workouts	3
Autmating Resistance Adjusting	Resistance: Autmating Resistance Adjusting	Resistance: Autmating Resistance Adjusting	Motivation: Live Classes	
Compact Footprint 2'x4'	Storage: Compact Footprint 2'x4'	Resistance: Automated Reistance Adjustments	Motivation: Real-Time Coaching	
Self Cooling	Durability: Self Cooling	Resistance: Inertia-Enhanced Flywheel		
Increased Support	Comfort: Increased Support	Resistance: Upgraded Flywheel	**Resistance**: 100 Resistance Levels	6
Tread Cushioning	Comfort: Tread Cushioning	Row: Sliding Rail System	Resistance: Autmating Resistance Adjusting	
4.25 CHP DurX Plus Motor	Durability: 4.25 CHP DurX Plus Motor	Storage: Compact Footprint 2'x4'	Resistance: Automated Reistance Adjustments	
			Resistance: Inertia-Enhanced Flywheel	
			Resistance: Upgraded Flywheel	
			Resistance: Sliding Rail System	
			Storage: Compact Footprint 2'x4'	1

Benefits Table

Key Benefits of Comparable Products	
Keyword	***Frequency***
Comfort	9
Motivation	8
Immersive	5

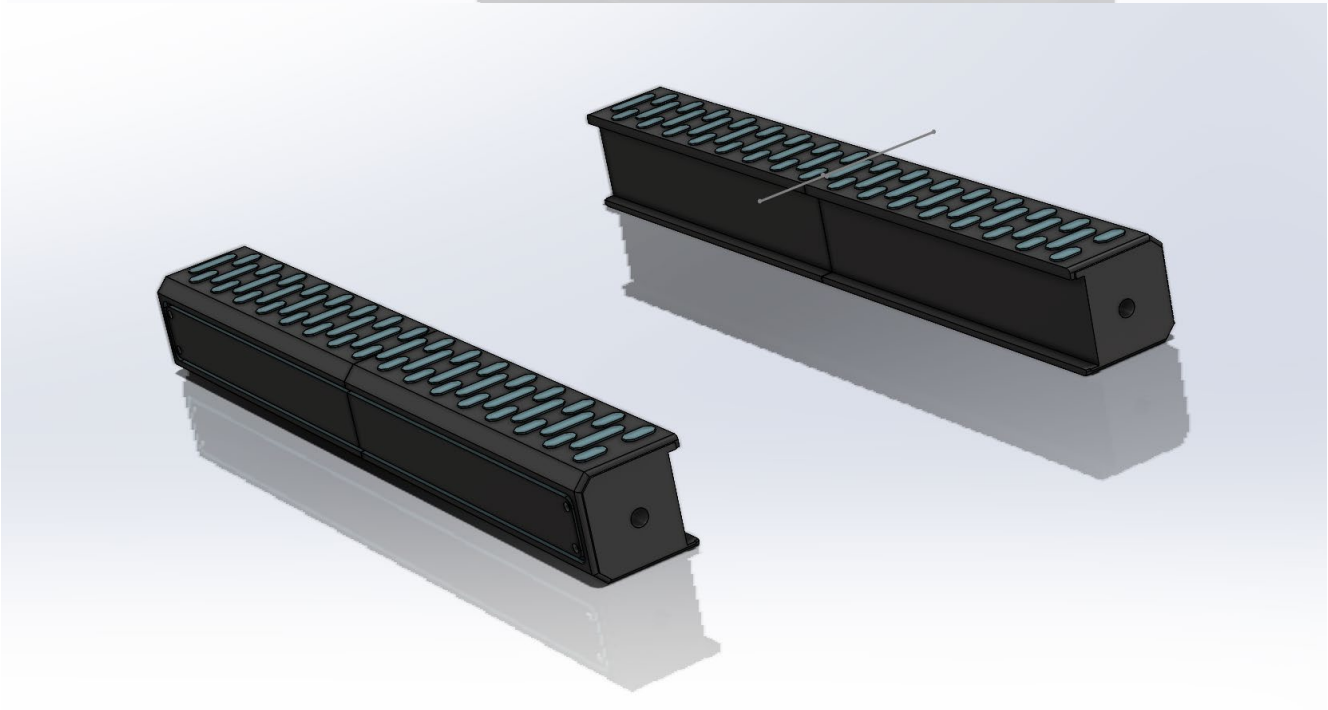
Features Table

Key Features of Comparable Products	
Keyword	***Frequency***
Comfort	5
Display	5
Durability	2
Motivation	3
Resistance	6
Storage	1

Appendix D – Needs Analysis

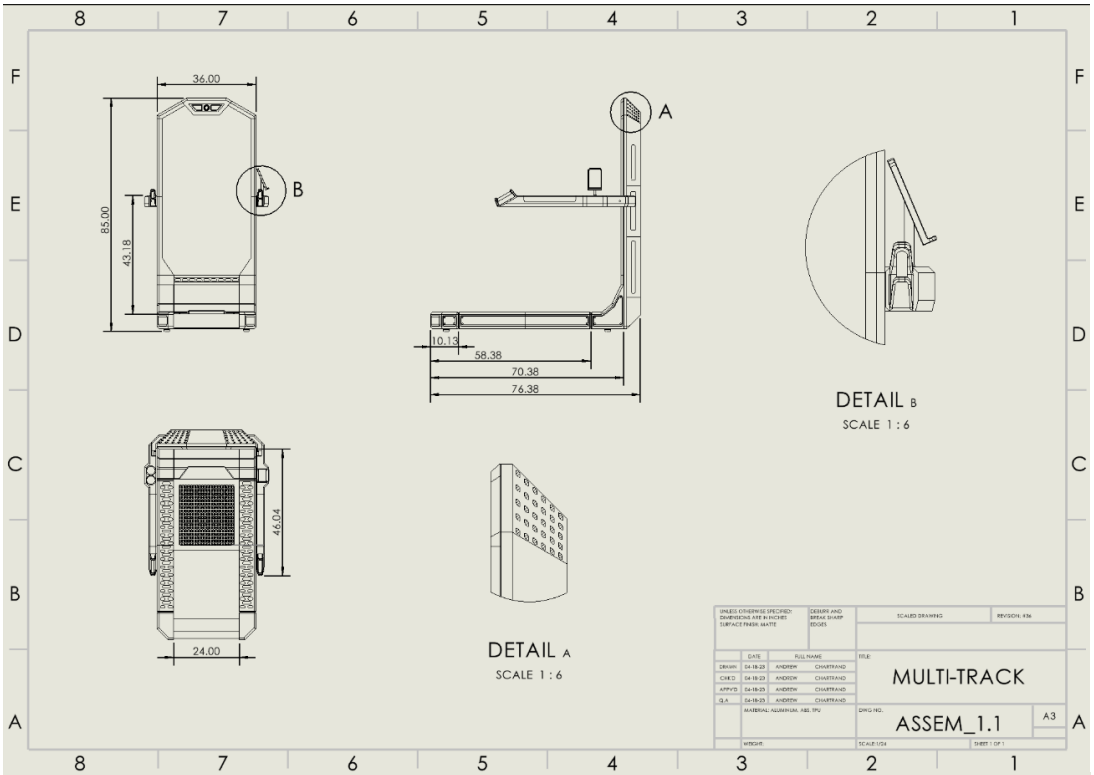
« Continue with the rest of Appendix where applicable. Refer to the Thesis Report Reference Content document for detail »

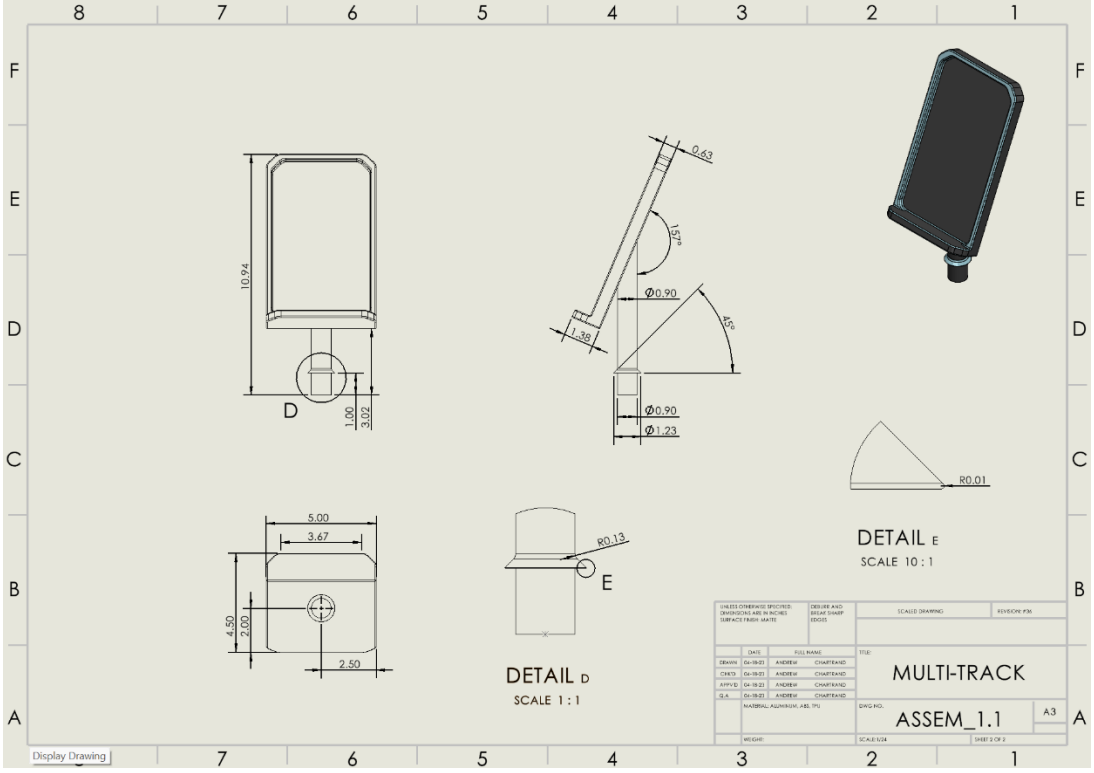
Appendix E – CAD Development



Appendix F – Physical Model Photos

Appendix G – Technical Drawings





Appendix H – Bill of Materials

Part	Material	Item Description	Colour	Manufacturing Method	Cost $
Frame	Aluminum	The metal inner skeleton of the product	Silver	Extrusion & CNC Machining	$3000
Body (Treads)	ABS & TPU	Panel covering internal structure	Blue & Gray	Injection Over Molded	$200
Body (Tread Caps)	ABS	Panel covering internal structure	Gray	Injection Molding	$50
Body (Motor Housing)	ABS & Aluminum	Panel covering internal structure	Gray	Injection Molding	$100
Body (Display Housing)	ABS	Panel covering internal structure	Gray	Injection Molding	$50
Computer	Silicon, Polycarbonate and Copper	Central processing unit	Green, silver, yellow	PCB Printing	$500
98” QLED UHD Display	copper, tin, zinc, gold, chromium, polymers	Display	Black, Transparent	PCB Printing	$10,000
Belt	Nylon & High-Density Polyethylene	Belt that is stood on	Black	Pressed	$250
Power Supply	Silicon, Polycarbonate and Copper	Product that powers the treadmill	Green	PCB Printing	$60
120v Motor 5hp	Aluminum & Copper	Rotates running surface	Silver, Black	Mechanical Assembly	$300
Drive Belt	Rubber	Rubber	Black	Extrusion & Machining	$70
Wires 18awg x50ft	Aluminum & PVC	Electrical cords that transfer electricity components	Red, Black, White, Yellow…	Draw through injection molding	$30
Bolts 3/16 x 1.5” (Access Panels) x22	Stainless Steel	Metal Fastener	Silver	Cold Forging	$10
Bolts 1/4 x 1.5”(Panel Mount) x110	Stainless Steel	Metal Fastener	Silver	Cold Forging	$30
Pressure Sensors (x176,000)	Polyimide Film	Flexible PCB	Silver, Transparent	PCB Printing	$5,300
				Total:	$19,950

Appendix I – Sustainability Info

Appendix J – Approval Forms

IDSN 4002
SENIOR LEVEL THESIS ONE

Humber ITAL / Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022
Catherine Chong / Frederic Matovu

THESIS TOPIC APPROVAL:

Student Name:	Andrew Chartrand
Topic Title:	How May We Mitigate Injuries in the Decathlon?

TOPIC DESCRIPTIVE SUMMARY (PRELIMINARY ABSTRACT)

The sport of track and field is a large one with many disciplines. The decathlon brings all these disciplines together in one event happening over two days. The decathlon is the ultimate challenge and causes many injuries both in training and competition. Currently there are several injury preventative techniques used by national/International level athletes. Some include Warm-up and Cooldowns, Injury Prevention, Mobility, Strength training, and Physio and Massage Therapies. Athletes also track their progression using technology such as Pressure Plates, Video, and Radar. Many of these technologies aren't available to up-and-coming athletes, often resulting in injury. The thesis research will be done using a combination of user interviews (specific details), surveys (broad picture), and user observation (product interactions). These research methods will provide a clear area of focus as well as define the target users. User testing along with ergonomics studies will validate the functions of the product and whether it fulfills the needs of the user. A solution will be developed that can resolve the issues faced by decathletes and their coaches. The solution will mitigate decathlete injuries in training and competition as well as be available to early developing athletes.

Student Signature(s):	**Instructor Signature(s):**
Andrew Chartrand	Catherine Chong
Date: 26 / 09 / 2022	**Date:** 06 October 2022

6

Chong, Kappen, Thomson, Zaccolo

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE 2022

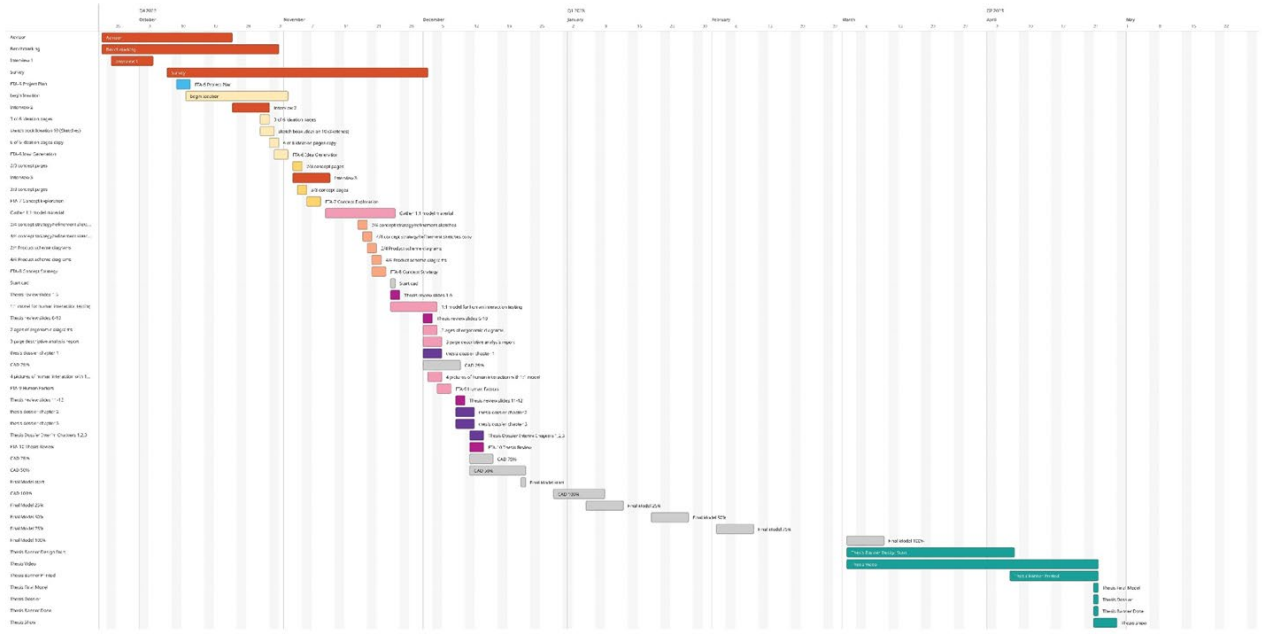
Certificate of Completion

This document certifies that

Andrew Chartrand

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

Certificate # 0000836216 **14 August, 2022**



Appendix K – Advisor Meetings and Agreement Forms

HUMBER
Research Ethics Board

Consent Form Guidelines

For consent to be considered valid, it must be ***informed*** consent. Respect for Persons implies the participant must be given an adequate explanation about the nature of the proposed investigation, its anticipated outcome, as well as the significant risks involved. For informed consent to be valid the person concerned must be competent to make a decision, and the consent must be voluntary. For those who lack the capacity to decide for themselves, an authorized third party acting on behalf of the individual's behalf may decide whether participation is appropriate.

Informed consent is an on-going process that starts with the researcher's first contact with a participant and continues until the study is complete or the participant withdraws. Any discussion of informed consent with the participant, the written informed consent form, and any other written information given to participants should provide adequate information for the participant to make an informed decision about his/her participation.

The obligation to obtain informed consent always rests with the primary investigator conducting the research. This duty may be delegated as needed (to research assistants, students, etc.), assuming those individuals have the knowledge to be able to provide adequate explanations to potential participants on behalf of the Principal Investigator. The Principal Investigator must ensure that consent is not obtained in a manner where undue influence, coercion, of incentives for participation undermine the voluntariness of a participants' consent to participate.

Consent forms should be written on official letterhead in a direct style, using terms and language that potential participants can easily understand. Consent forms should be dated and signed, and the participant should receive a copy of the consent form for his or her own reference.

Consent can be withdrawn at any time, and the participant can request withdrawal of their data. Participants should be made aware if there is a specific point in the study at which their data cannot be withdrawn, and why (ex. Data has been anonymized).

A comprehensive Consent Form should include:

- Title of research project
- The name of the researcher(s)
- A statement regarding the participant's right to refuse to participate/withdraw from the study at any time without penalty
- Verification that the participant has received and read the provided information letter
- Contact information for the researcher(s) conducting the research
- Contact information for the Research Ethics Board (Dr. Lydia Boyko, Lydia.boyko@humber.ca, 416-675-6622 ext. 79322)

For more information about informed consent, including obtaining consent from minors, see Chapter 3: The Consent Process of the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans, 2nd edition (TCPS 2).*

A consent form template is included below and must accompany a detailed Information Letter. The below makes the assumption that at the necessary details of the study and participation are included in the Information Letter.

HUMBER
Research Ethics Board

Andrew Chartrand
Email: ajchartrand12@gmail.com
Phone: 1 613 640 2000

[Project Title] Industrial Design Thesis

[Document Title] Consent Form

I, (please print) _____, have carefully read and understood the Information Letter for the project [Industrial Design Thesis], led by [Andrew Chartrand]. A member of the research team has explained the project to me and has answered all of my questions. I understand that if I have additional questions about the project, I can contact [Andrew Chartrand] at any time during the project.

I understand that my participation is voluntary and give my consent freely. I also understand that I may decline or withdraw from participation at any time, without any penalty or any explanation.

In 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 Andrew Chartrand (1 613 640 2000, ajchartrand12@gmail.com).

My signature below verifies that I have received a copy of the Information Letter, and that I consent to participate in this study:

_____	_____	_____
Participant's Name (printed)	Participant's Signature	Date

Andrew Chartrand <ajchartrand12@gmail.com> Fri, Nov 25, 5:21 PM
to Laura.Sivers

Hi Laura,

Attached are some forms to fill out. There is no rush. Just fill them out when you get a chance. Don't be afraid to ask if you have any questions,

Thanks,
Andrew Chartrand

One attachment • Scanned by Gmail

Im free all day tomorrow. Does 11:00am work for you?

As of right now, yes. Unless I hear back from this guy I'm buying a Polevault set from and I end up having to pick it up from Rochester tomorrow

Are you in Toronto for your last year? If you're local, did you want to do video or meet somewhere for coffee and you're questions?

Yes im in toronto. A video isn't necessary, but I would like to have an audio recording. Is this alright? I'll plan on a video chat on messenger tomorrow at 11:00. If anything changes let me know and we can reschedule.

Sure, sounds good

Sep 22, 2022, 12:08 PM

Video chat
1 hr 7 mins

Sep 22, 2022, 12:33 PM

Thanks you so much for the interview. It was great catching up with you!