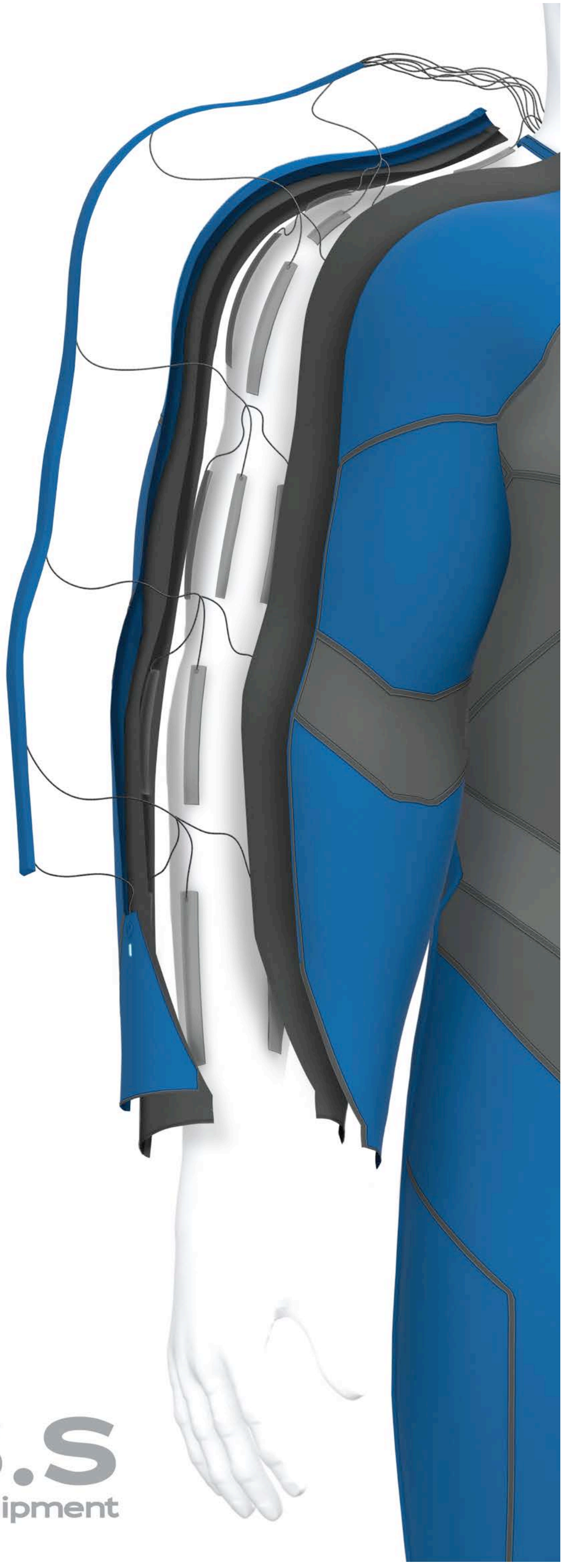

# E.M.-T.O.S.S

Professional Pitching Training Equipment

# Professional Pitching Training Efficiency

by

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Submitted in partial fulfillment of the requirements for the degree of

**Bachelor of Industrial Design**

School of Applied Technology
Humber College of Technology and Advanced Learning

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# Abstract

This thesis proposal will investigate how to increase a baseball pitcher's muscular strength while they perform pitching mechanics drills.  Since a pitcher's strength is related to ball velocity and therefore overall game-time performance, trainers have been attempting to increase fundamental strength in their athlete's through weighted/resisted movements in a fitness setting. Unfortunately, in order to affectively target the proper muscular groups, strength-training movements are separated and therefor mentally disconnected from throwing mechanic training drills. If strength training and mechanic training could be linked, overall pitcher training would be more effective, leading to better game-time performance while resulting in a more prosperous pitching career. This thesis proposes an in-depth study of the anatomy breakdown in a pitcher's throw, from foot placement on the mound up to hand action on the ball. Data will also be collected on how pitchers are currently trained as well as muscle resistance techniques through methods such as observation studies, interviews, and contextual inquiries. With use of gathered research, an on-body resistance training solution will be designed and prototyped, establishing a full-bodied human interaction design solution. Designing a product able to resist pitcher motion while they perform throwing drills will combine the multitude of training techniques, thereby increasing a pitcher's performance in a shorter duration of training.

# Acknowledgments

I would like to extend my gratitude to the teaching faculty at Humber, who have played a large role in my four years of study. The effort put forth by them throughout the years has not gone unnoticed and has played a large part in providing wonderful opportunities for the students. I would also like to extend a big thank you to the graduating class of 2020. Learning from one another has definitely made my time at Humber worthwhile and I am grateful to have worked along side each of you.

# Table of Contents

# 1| Problem Definition

## 1.1 Problem Definition

Since baseball was invented, athletes have been driven to improve their performance in game both for their benefit as well as the team. As the sport and industry has matured greatly since it was first introduced, the pressure on athletes to become more elite has increased exponentially. This pressure is due to increased competition from camp farmed players, technical advancements for measuring and comparing an individual's stats, scientific focus on strength and conditioning and a broken down, almost methodical understanding of the way the game is best played. Currently, players are trained on their fundamentals and gameplay mechanics in a field setting, utilizing replication drills and an extensive amount of repetition. As competition is getting stronger and more powerful, trainers seek for the best ways to introduce weighted equipment to their players in a way that improves the muscles they utilize most often, but does not interfere with their mind muscle connection in game. Injuries, especially to areas such as the shoulder or elbow, are a common problem while balancing on the line between training enough to better your opponent versus overtraining to where the player is out for the season. How can a baseball athlete train their body in the most efficient way possible, so that the strain placed on their joints and ligaments is minimalized, only being allowed in the most necessary forms of athletic activity?

## 1.2 Investigative Approach Taken

**Key information to be determined:**

- Target demographic
- User environment
- Current solutions
- Needs and goals of athletes
- Pain points
- Trainer to athlete interaction
- Ergonomics
- Anatomy breakdown of athletic movements

**Key questions to be answered:**

- In what ways are athletes currently training?
- What equipment is currently being used and what are the pros and cons associated with such equipment?
- What are players' preferences when it comes to their training and do they have any specific routines?
- How do trainers currently interact with their athletes and where is there a lack in communication?
- What are the ergonomic needs of the primary user?
- What is not currently being accomplished in the field of athletic training?
- What kind of technologies and scientific advancements have been recently made and can it aid in a potential solution?

**Investigative approach planned:**

- User observation
- Interviews
- Video analysis
- Experience mapping
- Literature reviews
- Immersive research methods
- Product benchmarking
- Ergonomics studies

## 1.3 Background, History and Social Context

Invented in 1869, predominantly seen in North America, baseball is a sport rooted in deep tradition. So much so, that one might say its tactics for strength building are stuck in the past as well. Need to have a stronger swing? Here swing this heavier bat during practice. Need a harder throw? Here throw this heavier ball before you step on the mound. The idea behind these devices is though based in basic physics. If you can apply more force onto an object, it will travel faster and farther. Besides specific athletic movements, scientific study has moved players away from the field and into the weight room for ways to train their bodies to become stronger, more agile and even faster. Based on the degree of ability of current performers in 2020 to those in the early ages of the sport, one could definitely believe that these behind the scenes additions to the game have yielded strong results when it comes to putting numbers on the board. But are these tactics the best ways to accomplish their set out goals?

To truly focus in and solve a meaningful aspect of baseball's training there needs to be a narrowed target, which will be the position of the pitcher. The reason for selecting the pitcher is that the biometrics in the baseball pitch are very precise, somewhat unique to individual pitchers, and target a wide range of muscles while carrying out the motions of a throw. The difficulties these aspects poses make it very hard to train pitchers in areas such as strength. Proper strength training may consist of a full session's worth of varied weighted motions, exercising necessary muscles with a team of compartmentalized exercises.

Frequency of exertion, especially in a quick dynamic movement such as pitching a ball, can and will often result in injury. From the 2002 season through the 2008 season, an average of 438.9 players per year were placed on the disabled list, for a rate of 3.61 per 1000 athlete-exposures. There was a significant 37% increase in injuries between 2005 and 2008 (Posner, 2011, p. 1676). As pitchers are throwing at a high rate and the injury rate while overusing these motions is increasing, training pitchers in the most efficient way to reduce output volume will result in better pitcher longevity. As the use of a pitcher's arm in and off season is so finite, how may we build it's strength in a way the imposes the lowest amount of increased exertion?

# 2 | Research

## 2.1 User Research

### 2.1.1 User Profile/Persona

**User Types**

**Primary Users:** Major League Baseball Players

Primary users of this product would be baseball players of the professional level (MLB) although lower tiers such as minor leagues as well as college athletes may be included in the future as needs are very similar to those of professional players. These users will come in direct contact of the product and use it as a means of self-improvement.

**Secondary Users:** Trainers

Secondary users include trainers whether they are team trainers or trainers devoted to/hired by individual athletes. These users will play an indirect role, coming into contact with more of a feedback/course of action defining role. They will work with the user and the product to maintain a seamless and useful interaction between the two entities.

**Tertiary Users:** Team Crew

Tertiary users include individuals hired by the team for tasks such as maintenance, cleanup, house keeping tasks, etc. These users may come in contact with the product whether it is to prep it or move it to storage. They will not come in contact with the primary functions of the product, rather come in contact with handling it.

**Age and Gender:** Avg. 27 y/o, male

The average age of players currently in the MLB is 27.7 years old (Wakeman, 2010). As players in current MLB standing as well as rookie/entering players will be included as primary users, a safe range to include would be 20-35 years of age.

**Education:** High school diploma

As many players are drafted right out of high school and others move to America from foreign countries in pursuit of an MLB career, only 4.3 percent of baseball players have acquired a four-year college degree (Maller, 2012). That being said, these individuals have a vast amount of knowledge when it comes to their profession, educated in the field of the sport from first-hand experience.

**Income:** $480,000 - $23,000,000 - avg. $3,400,000

The average player income in 2012 was 3.4 million dollars with the range being from 480 thousand to 23 million dollar (Locsion). As the primary users themselves will not be the ones purchasing the final product but probably will instead be the player's teams, the income variation do not matter as much. The teams have a sufficient spending power for price-justified products.

**Ethnicity:**

Data from a study of major league baseball demographics over the years 1947-2016 indicates that the majority are Caucasian (Armour and Levitt). The latest year of 2016 indicated that 2.1% were Asian, 6.7% African American, 27.4% Latino, and 63.7% Caucasian (Armour and Levitt). A second study indicated the difference between Latino and African American, stating that Latinos surpassed African

American in 1993 and have been on a stead incline in relativeness ever since (Anzil).

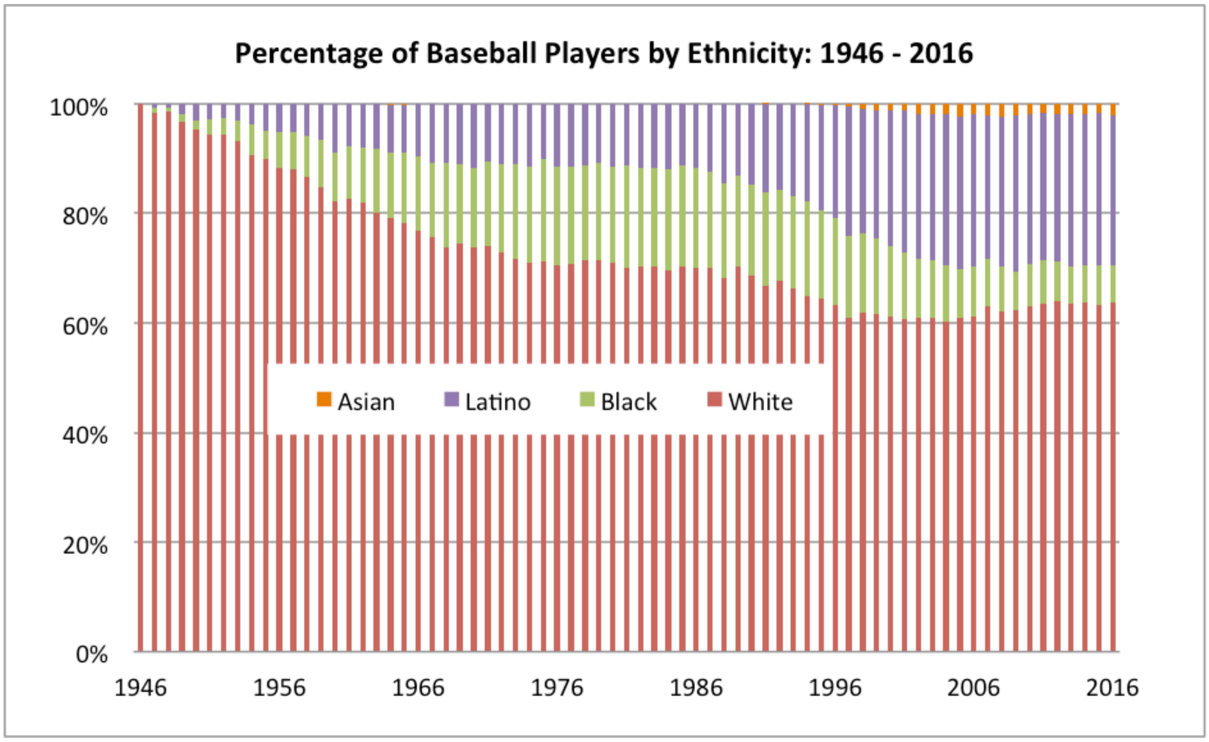



*Figure 1. Percentage of Baseball Players by Ethnicity. (Armour and Levitt)*

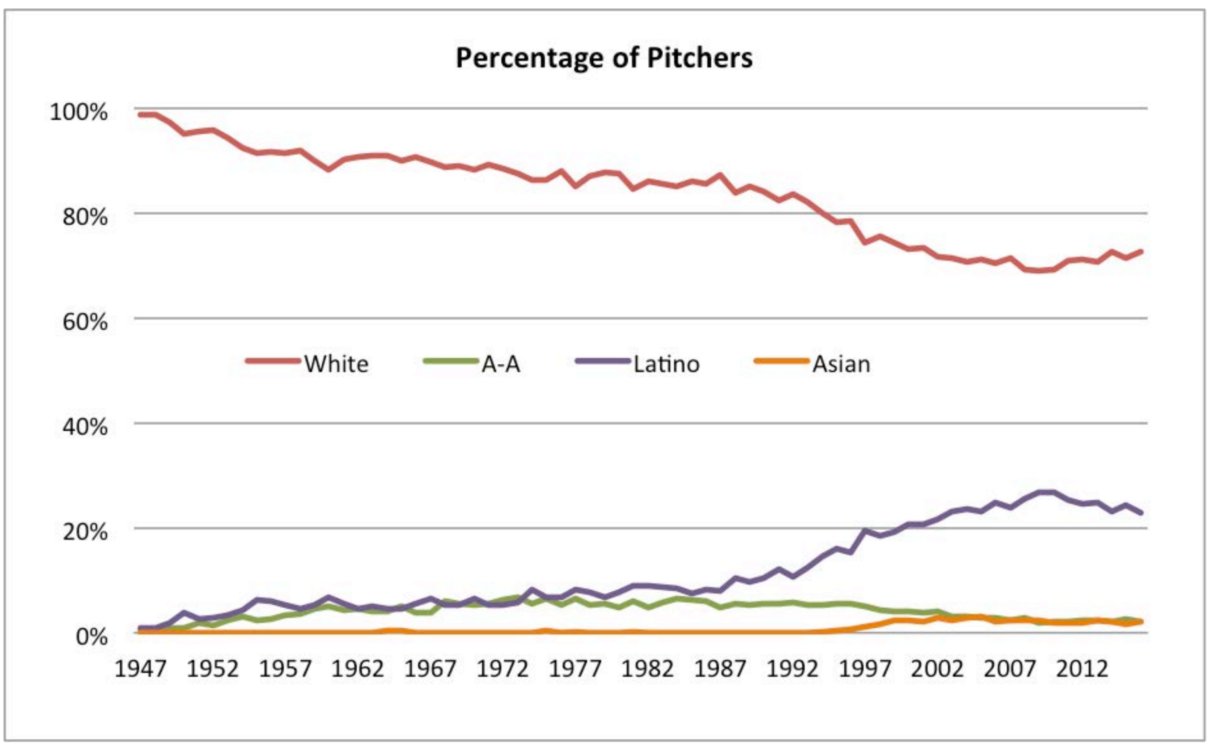



*Figure 2. Percentage of Pitchers. (Armour and Levitt)*

### User Persona

| | |
|---|---|
| **Name** | Chris Scherlander |
| **Age** | 27 |
| **Gender** | Male |
| **Income** | $3.4 million |
| **Job** | Professional MLB Pitcher |
| **Game Frequency** | 5-7 day schedule (6-7 days between game appearances) - (Driveline, 2016) |
| **Training Frequency** | 4-6 days train between outings (5-7 days total between outings in season) - (Driveline, 2016) |
| **Additional Notes** | Spends most of their harder strength training appearances during the off-season |

*Figure 3. User Persona*


*Figure 4. Jay's Pitcher. (Canadian Press, 2018)*

Chris Scherlander is a 27-year-old male pitcher in the MLB who is physically active at least five days a week. He has large muscular demands in areas like the arm and shoulder when it comes to repetitive movements. Chris person is frequently met by a trainer, coach and/or training partner for physical and performance improvements. Focus includes strength, pitching mechanics, and ball velocity. As Chris spends most of his time improving his performance, it is extremely important for him to work effectively while preserving the longevity of his arm as well as his career.

### 2.1.2 Current User Practice

For the purpose of this report, research was conducted of user behavior along related training routines and tactics. The goal was to determine how often pitchers train during and away from game time performance. Key information for product development can be derived from how, where and when the pitcher is in training. Research was also conducted from a different perspective looking into future pitchers. This researched looked to find if there are any obstacles young pitchers face that proven pitchers currently employed do not.

An article reported about the importance of spring training, explaining how pitchers are most benefited by such an extensive amount of training after coming out of off-season training (Kilgore, 2017). “ They need two months spent in a warm locale, in order to build stamina and strength in their throwing arms slowly enough to limit injury risk (Ellis, 2019).” The idea behind this statement is that pitchers are more benefited than position players when it comes to extensive season-entering routines. The amount of volume a pitcher sees training wise is a large factor for injuries, therefore to enter pitchers into such a rigorous in-season routine; they need extra care by their trainers. The following table breaks down a typical schedule of a pitcher in season.

| Days of rest | Pitcher's routine |
| --- | --- |
| Game day | Pitch 7-9 innings or throw 90-115 pitches on a pitch count |
| Day after | Full stretching and medi-ball program. Jog 10 polls; 10 sets of 60 yard sprints, run 2, walk 1; 25 pick ups. Light weight maintenance work. Toss easy on side lines. |
| 2 days after | Full stretching and medi-ball program. Jog 10 poles; 10 sets of 60 yard sprints. Light weight maintenance work. Play catch and drill work. |
| 3 days after | Jog - Stretch - Warm Up. Bullpen work at 3/4 speed or 8-10 minutes of BP. Run sprints. |
| 4 days after | Day previous to next start. Jog - stretch - shag B.P for pitcher. Short bullpen work for 5-6 minutes, 1/2 speed, at 52-55 feet. No running or sprint work. |

*Figure 5. Pitching on Four Days Rest. (Ellis, 2019)*

The user will be training multiple days a week, varying in frequency dependent on the time of year or games pitched. High volume in one area (throwing) opposed to other positions is not uncommon. Pitchers will often work with trainers or soft toss with a teammate. Much time is spent throwing after full body exercise is completed.

Another article based around the next generation of pitchers looks into how they are coming up opposed to current professionals. Explaining up and coming pitchers to MLB pitchers the article states, “When young pitchers are put on the Nationals’ throwing program, they are suddenly throwing every day, upping their workload from what it might have been in the collage when games are less frequent, even for starters, who are used to getting a week of rest instead of the big-league four (Janes, 2017)." Due to demand, this statement explains how pitchers are seeing more throwing opportunities with less rest as they try to prove themselves, putting in maximum effort while lowering concern for injury prevention. Although the risk for injury is so high given this method of performance, a pitcher is unlikely to verbalize a potential injury, explained in the article by the statement of, "-complicated for young pitchers, most of whom do not want to admit to a brand-new coaching staff – one that, in part, controls their professional future (Janes, 2017)." Furthering this idea of more volume requested from young pitchers, a Q and A regarding former pitcher Orel Hershiser speaking to changes from when he played. When asked about the banishment of pitch counts (a tool used to control and limit how many pitches a player threw) by his former team and how this might affect upcoming players he stated: "It's all about the abilities of the pitchers. So if they start to get unbelievable pitchers in Texas and they allow them to go past 110, 120, 130, 140 pitches, then you'll have something to evaluate. - But it doesn't do you any good to let somebody throw 130 pitches in five innings and say he's tougher, but he gave up 11 runs. (Hershiser, Helping out next generation, 2010)."

It seams as though the demand for a pitcher's ability to last long sessions of throwing is increasing as the market for new pitchers increases. Removal of aids to limit pitchers such as pitch counters means that the ability of the pitcher to last in an MLB setting is more gambled.

### 2.1.3 Activity Mapping

To determine how major league pitchers train for their sport, a video of current professional pitcher Justin Verlander was analyzed. The video titled "Real Workouts: Justin Verlander", goes through a full day of his normal workout routine, lead by a performance trainer of the Detroit Tigers baseball team. Key activities were broken down to see where focus is given as well as how the player is training for specific areas of his performance. The breakdown was of specific workouts divided into three areas in order from first to last: agility, explosive, and strength. The observation is as follows.

**Agility**

*Figure 6. Agility (Stack, 2013)*

1

- Dynamic warm-up
- Waling toe touches
- Walking foot grabs
- Walking knee ups
- Huggers
- Lung cross-overs
- Side steps

2

- Latter foot rotation Drill
- 90 degree rotations of the trunk for time
- 180 degree rotations of the lower body for time and speed

3

- Planked elbow to knee for mobility and balance

**Explosive**

Figure 7. Explosive (Stack, 2013)

4

- Half moon single leg steps in and out
- Each movement the trainer tosses a ball which the pitcher catches
- The ball is a football to make catching easier and removing focus of the catching aspect and placing it more towards the movements

- Half moon ground ball pickup
- Pitcher moves around semi circle stepping in with one leg as the trainer rolls a baseball to the pitcher
- The drill incorporates movement speed and agility to a more refined motor skill training
- Focus on explosiveness of the drive leg

6

- Overhead med ball throws
- Ball placed on ground, pitcher grabs with both hands and swings ball into air over head
- Working on shoulders back, core and legs for explosive power through the hips
- Using lighter weight that can be moved very quickly
- Full body movement

7

- Split squat switch jump with medicine ball catch and toss
- Working on core especially with legs while using the med ball to work on coordination
- The lower the ball was thrown the deeper the athlete had to lung, increasing leg requirement
- Plyometric intensity, trying to stimulate multiple areas by incorporating the ball

*Session moves indoors to weight room*

**Strength**

8

- Balanced dumbbell lunge toe touches
- While balanced on a 2 by 4 in a lunge position, the athlete touches a single dumbbell to his front foot
- Working on controlled strength as well as balance
- Somewhat replicating the motion of reaching for a ground ball
- Front foot and hands are alternated between sets of 6

*Figure 8.* Explosive (Stack, 2013)

9

- Scrap six-pack routine
- Stomach on a physioball on top of an incline bench, the athlete is bent over holding resistance cables in each hand
- Hands are stretched over head, out to the side, and then out to the back
- Each held for time and then repeated the group of three motions six times
- Focus on shoulder strength as well as balance providing a static load on the shoulder while load increases as muscle tightens

10

- Squat
- High rep warm up moving to higher weight strength training for leg dominant strength
- Large compound movement for strength building
- Pyramid sets up to high weight and then dropped back down to initial starting weight
- Improving leg power for pitch drive

11

- Weighted alternating lunge
- Weighted vest and dumbbell in each hand
- Lunging alternating down the length of the gym
- Improving one leg power and strength

12

- Box split squat
- Balanced single leg balance and strength exercise
- On box, squat down to just over ground level without touching the ground

13

- Same thing with slight weight bar placed horizontally in both hands out front

14

- Physioball leg curl
- Multi joint stability in hips focusing on gluteus and hamstring strength
- Superset with glue ham raise focusing on same but with more lower back and gluteus activation

15

- Flamingos superset with ball catching RDL
- Flamingos are stability, catching and resisting the impact of catching the weighted ball
- Mixed with rear deadlift of same ball that is caught and thrown between trainer

16

- End of video, which is probably followed by a small cool down

**Key Activity 1: Agility Training**

- Mostly working on footwork and full body movements, this training is seen to increase overall athleticism and is a lesser focus of the thesis topic.

**Key Activity 2: Explosive Movements**

- Mostly focusing on core and leg drive, this training can be a target of the thesis topic.

**Key Activity 3: Strength Training**

- Building strength in muscles, which influence ball velocity greatly. This section will be the most relevant for the problem at hand.

From the data a user experience map was developed. Because this thesis will yield a new solution to athletic training of pitchers, the tasks were given a 1-10 ranking judging on difficulty and relativity in the form of if it relates to the goal of this thesis. If the task was sufficient and not relative to the thesis then it received a higher mark. If the task was relative to the thesis objective and had areas where it could be improved, then that tasked received a lower mark.

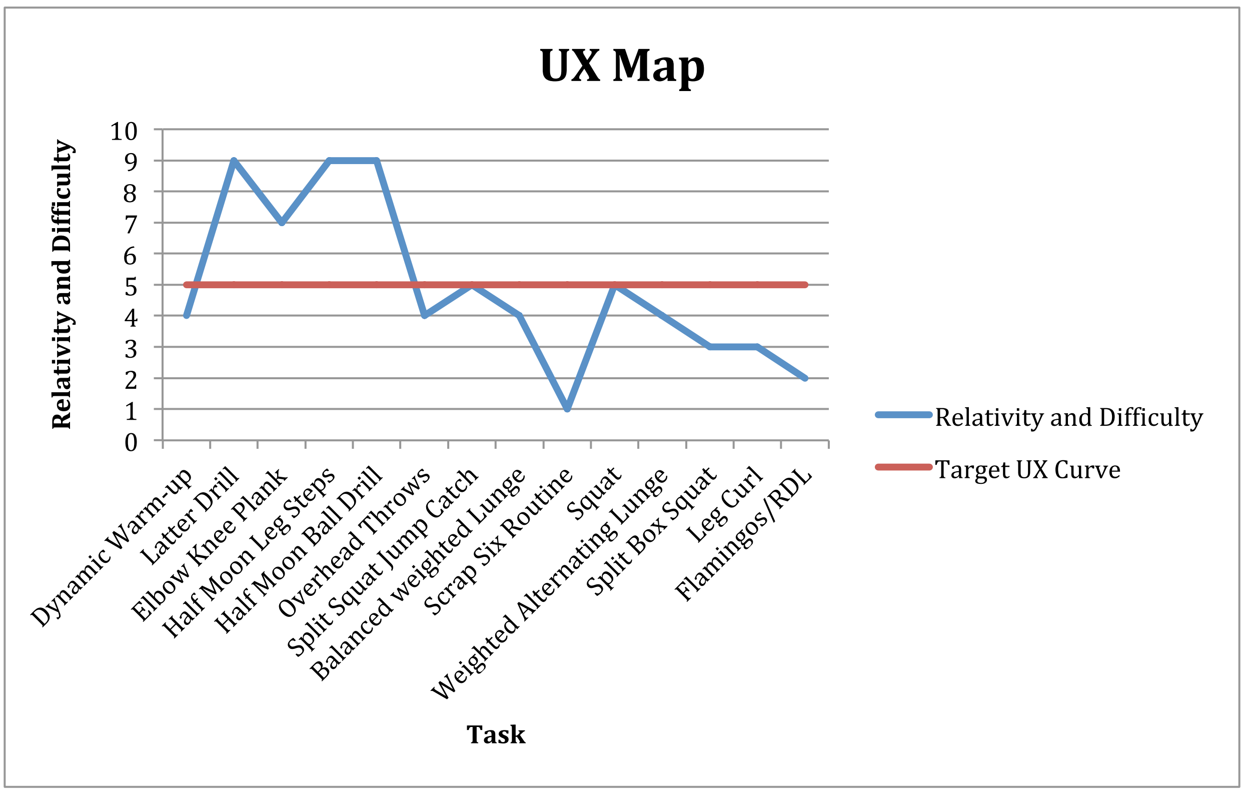



*Figure 9.* UX Map

**Potential User Experience Improvement Chart:**

| Task | Current UX | Potential Improvement |
|---|---|---|
| Dynamic Warm-up | 4 | 1 |
| Overhead Throws | 4 | 1 |
| Balanced Lunge | 4 | 1 |
| Scrap Six Routine | 1 | 4 |
| Weighted Alt. Lunge | 4 | 1 |
| Split Box Squat | 3 | 2 |
| Leg Curl | 3 | 2 |
| Flamingos/RDL | 2 | 3 |

*Figure 10.* Potential User Experience Improvement Chart

**Overall Analysis**

The major observations, which inform design, are how the pitcher trains his strength. In the video, the pitcher used multi joint movements on order to incorporate most of the body. These movements somewhat replicated the motion of throwing through direction, but did not copy it to a point because, it was mentioned, motions that we too close to throwing but still off from throwing might mess up the muscle memory within throwing mechanics. Learning this was a good sign for a potential solution. The main multi-joint movements (that were mentally disconnected from throwing) were the Scrap Six Routine, Flamingos mixed with RDLs, and the balanced Split Squat. These observations need to be combined with the EMS training research and participation that was done earlier, while further look into muscle mechanics of throwing will be researched.

### 2.1.4 Ergonomic Research

As the resulting product of this thesis will likely be a wearable for pitchers, ergonomic research for the product will be heavily reliant on the measurement of man from the $50^{th}$ to the $95^{th}$ percentile height. This narrow window is due to research of baseball player sizing and finding out that they fit into this height region and that pitchers are usually found to be more towards the tall end of the spectrum (Baseball Players All Shapes, 2018). These sizing measurements will also benefit areas such as overall range of motion and maximum arm/leg range of motion/extension to ensure proper proportions and maneuverability. Since the concept will likely be wireless and free from any static structures or volumes, these measurements will be what are needed for ergonomic research. The breakdown of this full ergonomic study can be found in section 3.3.

## 2.2 Product Research

After exploring the possible implementation of electronic muscle stimulation as a way to activate proper muscles in players, product benchmarking of current EMS suits was conducted. As these suits are very capable of contracting muscles for benefits such as strength, conditioning and recovery, they unfortunately do not pose a suitable means of training when it comes to the biometrics of a pitch. Well known tools found in user interviews that pitchers do find suitable for throwing strength, recovery, warm-up and speed are overweight and underweight balls. Because of this finding, underweight/overweight training baseballs have also been added to this benchmarking research.

**The products being discussed are as follows:**

- AQ8 by BODYTEC
- TRAN NIN3 by Visionbody
- XBODY Training Suit by XBODY
- Model-907/906 by BODYTECH
- I-body by Miha
- Easy Motion Skin by Easy Motion Skin
- EMS Pro Full by Innine
- Weighted Baseballs (12 oz. and 10 oz.) by Skilz

### 2.2.1 Benchmarking Benefits and Features

Each product was researched to determine the features and benefits that their promotional materials provided. Taking note of what aspects are displayed by the companies in promotional material will provide insight to the most important aspects of these products. The data was collected and organized in the chart below.

**Feature Comparison Table**

| | **AQ8 by BODYTEC** | **TRAN NIN3 by Visionbody** | **XBODY Training Suit by XBODY** | **Model-907/906 by BODYTECH** | **I-body by Miha** | **Easy Motion Skin by Easy Motion Skin** | **EMS Pro Full by Innine** | **Weighted Baseballs (12 oz. and 10 oz.) by Skilz** |
|---|---|---|---|---|---|---|---|---|
| Users | 8 | | | | | | 6 | 1 |
| Warranty | 5 year | | 5 year | 3 month | | | | |
| Power | 6800 mA - 6 Cells | | | 2650mAh – 3.8V | | | | |
| Connection | Wireless | Wireless | Wireless | Wired | Wired | Wireless | Wireless | |
| Indoor or out | Both | Indoor | Indoor | Both | Indoor | Both | Both | |
| Battery life | 72 hour | | | | N/A | | 6 hour | |
| Range | 5 km | | | 300 m | N/A | | | |
| Wet/Dry | Wet | Dry | Wet | Wet | Wet | Dry | Wet | |
| Wire attachments | Hidden | Hidden | Hidden at back | Magnetic | Magnetic | Visible | Magnetic | |
| Nodes | 300 muscles individually | 20 pulse patches | 12 channels Miniaturized EMS device | Removable | Visible | 22 Muscle stimulation points | 22 Muscle stimulation points | |

*Figure10.* Feature Comparison Table

As promotional material was mainly to sell a buyer the whole service as a package (suit, control interface, product support, and various service features) suit specs were limited. The main specs that seemed to be apparent and would benefit the thesis would be to have the solution wireless and dry nodes instead of wet nodes as the suit prep time and ease of use would be positively affected. Some battery specs will help with sizing the battery in the design, while making the wire connections magnetic will be a good idea.

A frequency analysis of the features and benefits seen in the promotional material will be conducted. We will first see the top five most commonly used words/phrases of each and then record the amount of time these phrases are seen. This data will be used to see what the most important elements that marketing thinks will sell their equipment and in turn provide a focus for the thesis solution.

**Key Features**

| Benefit | Times Seen |
|---|---|
| Muscle Development | 13 |
| Comfort | 12 |
| Clean/Hygiene | 8 |
| Short training time | 7 |
| Mobility | 5 |

**Key Benefits**

| Feature | Times Seen |
|---|---|
| Wireless | 15 |
| Battery Life | 8 |
| Magnetic | 6 |
| Dry Nodes | 6 |
| Indoor/Outdoor | 6 |

*Figure 11.* Key Features and Benefits

## 2.2.2 Benchmarking - Functionality

Two main features will evaluate functionality of the suits, freedom of movement and muscle coverage in order to determine functionality. Suits towards the top left of the graph will be the more successful.

**Functionality Chart**


*Figure 12.* Functionality Chart

For functionality, most suits preformed similar. Suits with wired attachments (i-body) greatly suffered in freedom of movement while suits with strong muscle coverage (XBODY) often needed a bump in freedom of movement.

### 2.2.3 Benchmarking – Aesthetics & Semantic Profile

To assess the aesthetics and semantics of the benchmark products, two graphs were constructed. The first looking at the visual usability of the products under the two categories of visual complexity versus visually sound and low colour indicator use versus high colour indicator use; the former in both categories being perceived as weaker than the latter.

**Interface Chart**

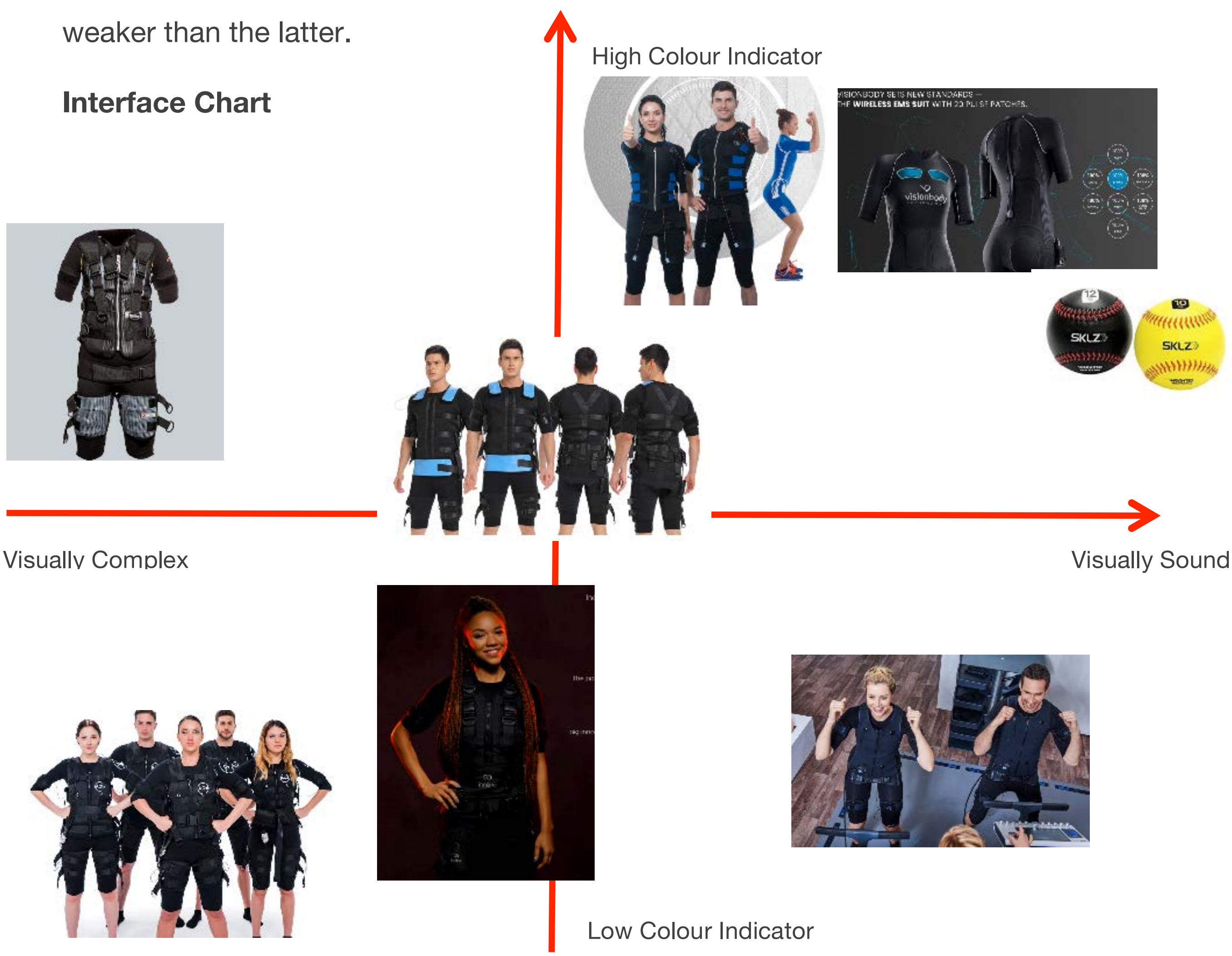



*Figure 13.* Interface Chart

The second will discuss the semantics of the aesthetics. The two criteria in discussion are utilitarian versus sleek and low contrast versus high contrast. As well with this graph, the former of the pair will be considered more favorable than the latter.

**Form**

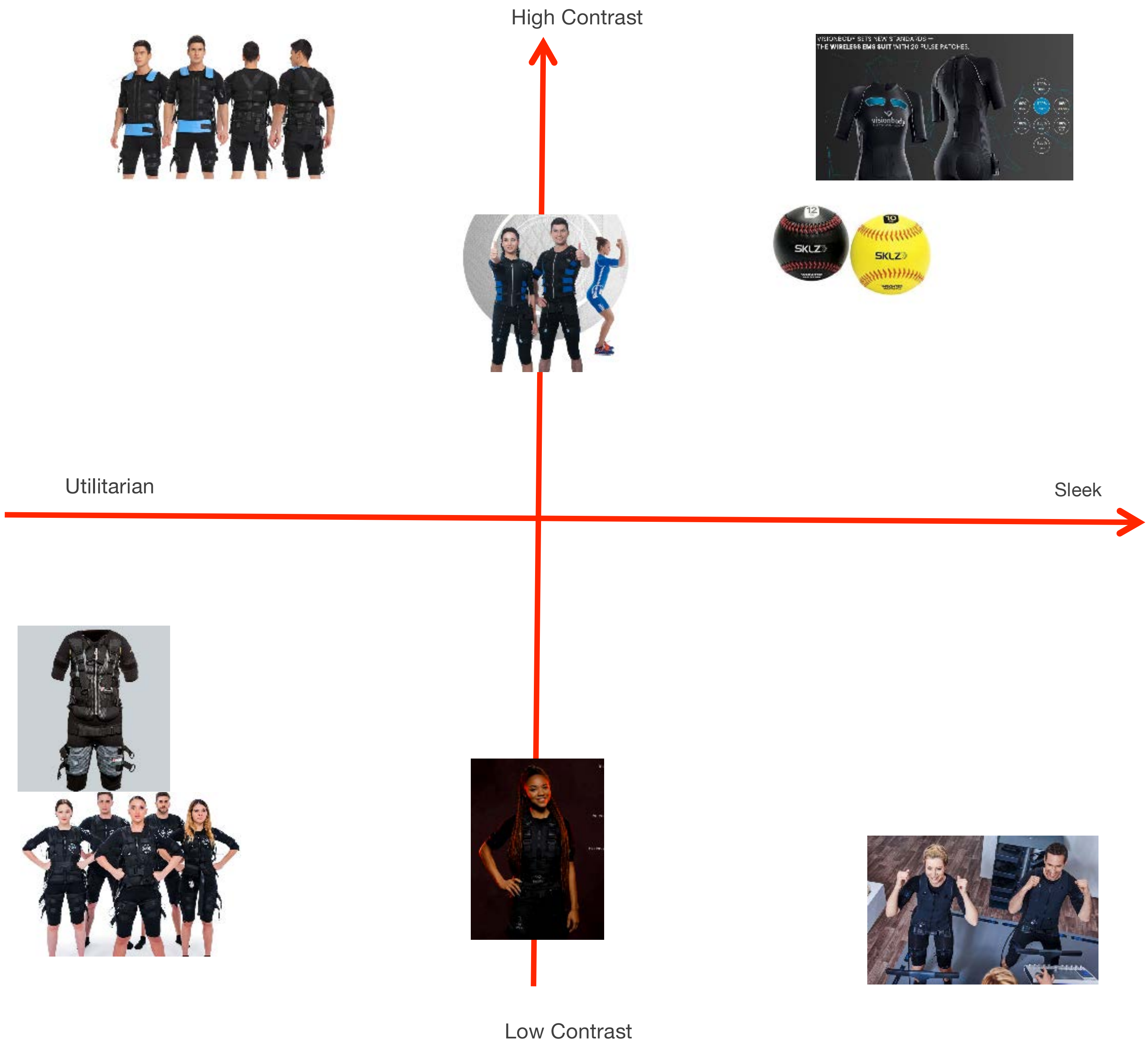



*Figure 14. Form*

For functionality, most suits preformed similar. Suits with wired attachments (i-body) greatly suffered in freedom of movement while suits with strong muscle coverage (XBODY) often needed a bump in freedom of movement. The winter of the form category being the TRAN NIN3 had a well-rounded and attractive look but accomplished this by sacrificing the “one size fits all” claim.

### 2.2.4 Benchmarking – Materials & Manufacturing

Current EMS suits tailored for basic fitness member training utilize standard materials devoted to low manufacturing costs and high durability or longevity of use. The separate parts of the suit include:

**Suit Materials Used**

- Polyamide spandex mix
  - Delivers flexibility allowing movement

**Electrode material make-up**

- Silver electrodes
  - Delivers pulse to the body allowing low impedance

**Power Unit**

- Direct pulse generator
  - Ensures a steady pulse of electricity to the muscles
- Lithium-ion battery
  - 2650 mA – 6800 mA

### 2.2.5 Benchmarking – Sustainability

Due to the fact that these suits are marketed to companies and/or personal trainers, their agenda is linked to selling a long-lasting product. With this in mind, materials and processes are made in cost efficient ways, utilizing materials that won't break down over multiple user wear and tear. Because of this, sustainability is not a well-achieved goal in these current benchmarked products. Instead sustainability through material and manufacturing means, sustainability is instead touched upon by product longevity.

### 2.2.6 Benchmarking – Interview Results

In order to truly find out if these products could be suitable for a proposed solution, further testing needed to be conducted. It was determined that the best way to perform further testing would be a direct interview with an EMS manager/personal trainer while interacting with the EMS suits themselves. A product study was conducted at a local EMS training fitness center.


*Figure 15. Researcher Product Testing With EMS Trainer*

The session commenced by following through with a full muscle strength building routine followed by a shorter tutorial of the other functions of the suit including the suit's cardiovascular and recovery modes. It was determined that the electronic muscle stimulation preformed well beyond what was expected in the muscle building routine through muscle activation. This conclusion came from a tough and extensive workout, followed by noticeable improvements with more than usual delayed onset muscle soreness. The suit works by sending electronic signals to the brain, much like how the brain triggers movement, resulting in the muscles contracting. With this method, opposing muscles work against each other, so that the body is basically strengthening itself through resistance of opposing muscles. An example of this would be to train the triceps (which perform arm extension) the user would be extending their arm against the biceps' contraction (which preform arm adduction). The user would be focusing on the extension while the EMS suit is sending the muscle pulses to preform adduction.

Although this suit was great at typical body training movements that would be seen in a gym setting, while performing a mock throwing motion, the movements were not as well resisted. This was due to the fact that the layout of the suit was targeted to hit larger muscle groups as well as affect the body equally. As the node concentration was equally sporadic across the body and not focused onto the shoulder, the process of throwing was not well resisted.

# 3 | Analysis

## 3.1 Needs Analysis

This thesis proposal will investigate how to increase a baseball pitcher's muscular strength while they perform pitching mechanics drills.  Since a pitcher's strength is related to ball velocity and therefore overall game-time performance, trainers have been attempting to increase fundamental strength in their athlete's through weighted/resisted movements in a fitness setting. Unfortunately, in order to affectively target the proper muscular groups, strength training movements are separated and there for mentally disconnected from throwing mechanic training drills. If strength training and mechanic training could be linked, overall pitcher training would be more effective, leading to better game-time performance while resulting in a more prosperous pitching career. This thesis proposes an in-depth study of the anatomy breakdown in a pitcher's throw, from foot placement on the mound up to hand action on the ball. Data will also be collected on how pitchers are currently trained as well as muscle resistance techniques through methods such as observation studies, interviews, and contextual inquiries. With use of gathered research, an on-body resistance training solution will be designed and prototyped, establishing a full-bodied human interaction design solution. Designing a product able to resist pitcher motion while they perform throwing drills will combine the multitude of training techniques, thereby increasing a pitcher's performance in a shorter duration of training.

### 3.1.1 Needs/Benefits Not Met by Current Products

**Introduction**

Currently pitchers do not train utilizing the technology of electronic muscle stimulation during throwing drills. Because of this, products related to the technology category currently do not reflect the needs and biometrics of the pitching activity. This section will reflect on the current needs of users, tested against both EMS products and the most used throw training equipment, weighted baseballs.

**Method**

This section will reflect on the information gathered and represented in sections 2.1 and 2.2 regarding User Profile, User Behaviors, Features and Benefits, and Expert Interviews. Information in these sections as well as a product research report produced the following results.

**Results**

Based on user research the primary training tools for developing better pitching, whether it be fast twitch muscle fiber speed or overall arm velocity, are the off-weight baseballs (under and over weight). These tools are compact and easy to use anywhere. The over-weight ball for example will give the player a sensation of ease when they transfer back to throwing with regulation weight balls. They get the arm used to a heavier weight so that the pitcher will ideally develop an increased velocity with moving back to regulation size balls. As these tools are used both for training and warming up, where they lack is how the load is placed on the arm. Because the tools rely on the increased gravitational force from the heavier weight, the load on the arm is directed downward as well as applied to the hand. Although once the ball is moving, centripetal force and inertia will adjust the angles of the force, they currently do not act perfectly on the throw and its biometrics. With this, the balls also only act on the muscles in the arm and shoulder due to the fact that there is no extra load added to the legs or core. The biggest needs not being met be these tools are full body interaction and proper biometric activation.

The larger category of products researched are the electronic muscle stimulation suits. In order to properly determine if these suits were one, effective and two, applicable to pitching, an EMS suit was tested by the researcher. Where these suits lack in pitcher needs is that there are not designed for that type of activity. Currently the suits are designed to equally activate major muscle groups of the body for a “full body” feeling workout. The suits did well to resist motion in exercises such as a replicated bench press or lat pull down because of the node placement and programed resistance. When preforming a throwing motion as the suit is acting on the body, the resistance did not apply well to the body. The most important user need not met here is that these suits do not properly act on the biometrics of a pitch, not strengthening or resisting the body in that area.

### 3.1.2 Latent Needs

**Introduction**

Relating to the fundamental human needs, the needs discussed in this section are those present or dormant while operating existing or potential solution products. By determining these needs it can be assured that, when designing a potential solution, current and potential future needs are met without creating unseen problems to the user. In order to accomplish this task, objectives will be as follows:

- Identify user latent needs
- Understand order of importance between needs
- Understand how the product responds to the user on a fundamental level
- Understand how these needs must be met by the final product

**Results**

The priority needs determined in section two are determined and referenced to Maslow's Hierarchy of Needs. Results are collated in the chart below. Discrete, comfort, style, efficiency, durability, flexibility, portability

| | Product Need | Possible Corresponding Fundamental Human Needs (FHN) | Relationship between Benefits and FHN |
|---|---|---|---|
| 1 | Comfort | Control, security | High |
| 2 | Efficiency | Accomplishment, autonomy, self-esteem | High |
| 3 | Durability | Security, control, safety | High |
| 4 | Flexibility | Security, control | High |
| 5 | Portability | Control | High |
| 6 | Discrete | Control, esteem | High |
| 7 | Style | Esteem, belonging, aesthetically pleasing | Moderate |

*Figure 16.* FHN Chart

**Comfort**

The user must be able to comfortably move while utilizing the product. It must not interfere with their traditional feel and experience with throwing. It must not interfere with how they go through current practice.

**Efficiency**

The product must excel in what it was created for which is training the body while preforming a pitch. Areas it needs to be proficient in are strength, recovery, warm-up, primary to secondary user interaction, ease of use and overall outcome.

**Durability**

Material choice should serve a long lasting solution. Product must go through repeated uses and be resistant to the strains of its environment.

**Flexibility**

The product must be able to move with the user as well as accompany multiple sized bodies. Material and layout will have a large affect on this area.

**Portability**

As the user will be in multiple locations, the product must be able to transport easily to these locations both in and out of use.

**Discrete**

As this product is a supplement to the user, it must be able to be utilized with the currently implemented gear and clothing of the user. If it is noticeable and bulky, the primary user may find it a distraction and render it useless.

**Style**

Since this solution will likely be taken to a group setting, style is important, as the user needs to want to participate with it and others. Over all look should not be over looked.

### 3.1.3 Categorization of Needs

After determining needs, they must be categorized by level of importance to ensure effort and outcomes are directed to the right regions. These needs will be categorized in order of importance in the following headings, Immediate Needs, Wishes/Wants, Latent Needs.

**Immediate Needs**

- Performance in strength building
- Performance in recovery
- Performance in warming up
- Primary to secondary user interaction
- Integration with the biometrics of the pitch so they work in tandem

- Integration into the human body and ergonomic application
- Primary and secondary user controls
- Ability to be used many times by one or multiple users

**Wishes/Wants**

- Secondary user feedback of product application
- Easy transition between using and not
- Ease of storage
- Portability to multiple environments

**Latent Needs**

- Stylish and desirable to use
- Affordable cost to benefit ratio
- Power supply efficiency
- Ease of maintenance

### 3.1.4 Needs Analysis Diagram

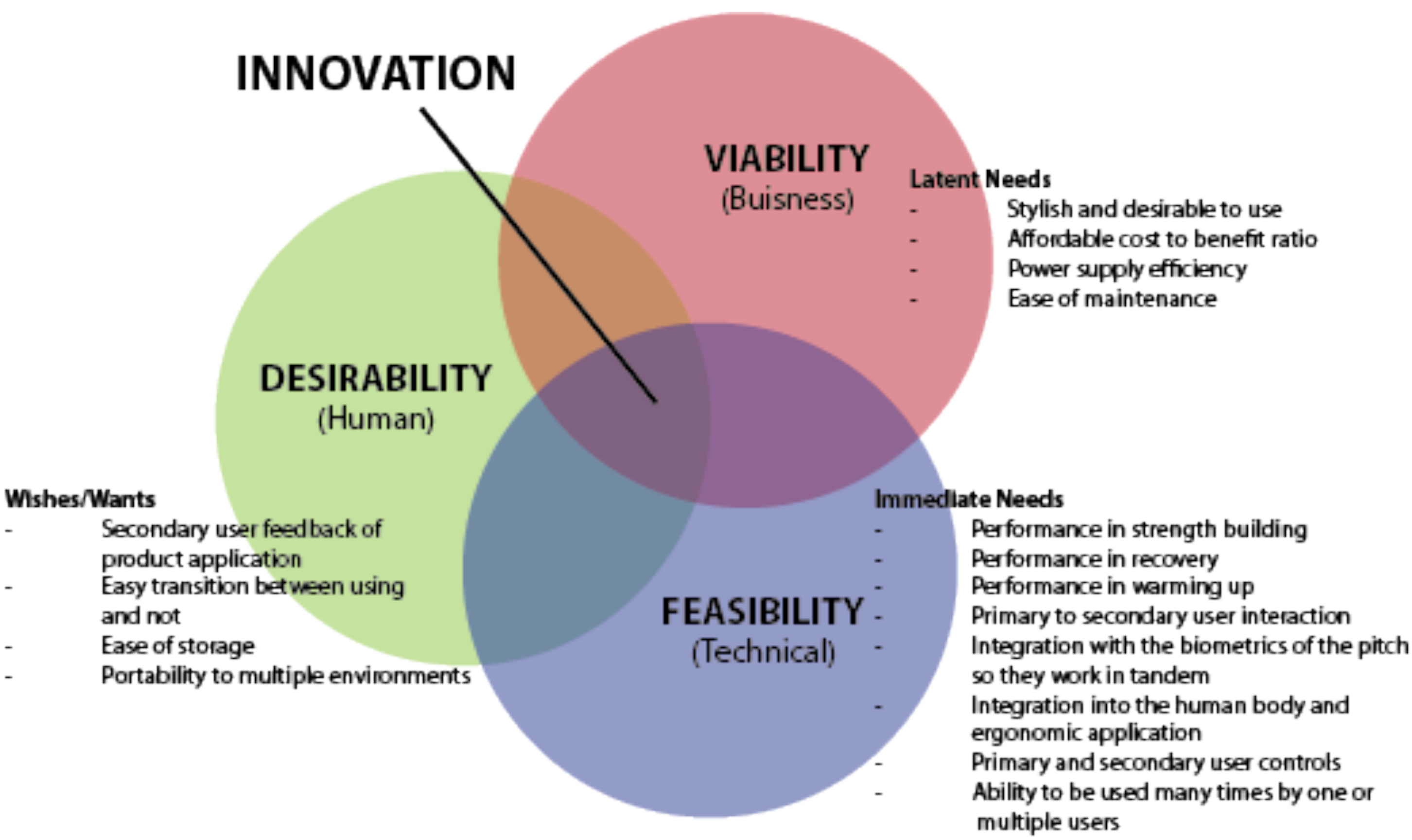



*Figure 17. Needs Analysis Diagram*

## 3.2 Functionality

### 3.2.1 Activity/Workflow mapping

To understand how the user will implement this product into their training routine we first need to understand their training routine. Analysis of a professional pitchers training was completed and the steps broken down. From these we see that the primary areas to include a device are both during the key activity three as below as well as during field training on the baseball diamond after primary throwing drills.

**Key Activity 1: Agility Training**

- Mostly working on footwork and full body movements, this training is seen to increase overall athleticism and is a lesser focus of the thesis topic.

**Key Activity 2: Explosive Movements**

- Mostly focusing on core and leg drive, this training can be a target of the thesis topic.

**Key Activity 3: Strength Training**

- Building strength in muscles, which influence ball velocity greatly. This section will be the most relevant for the problem at hand.

The major observations, which inform design, are how the pitcher trains his strength. In the video, the pitcher used multi joint movements on order to incorporate most of the body. These movements somewhat replicated the motion of throwing through direction, but did not copy it to a point because, it was mentioned, motions that we too close to throwing but still off from throwing might mess up the muscle memory within throwing mechanics. Learning this was a good sign for a potential solution. The main multi-joint movements (that were mentally disconnected from throwing) were the Scrap Six Routine, Flamingos mixed with RDLs, and the balanced Split Squat. These observations need to be combined with the EMS training research and participation that was done earlier, while further look into muscle mechanics of throwing will be researched.

### 3.2.2 Activity Experience Mapping

Since a new technology will be implemented into the routine, study of the experience will be twofold. The user experience of a pitcher as he trains now as well as the user experience of an EMS training program. The user experience map of the pitcher currently is seen bellow.

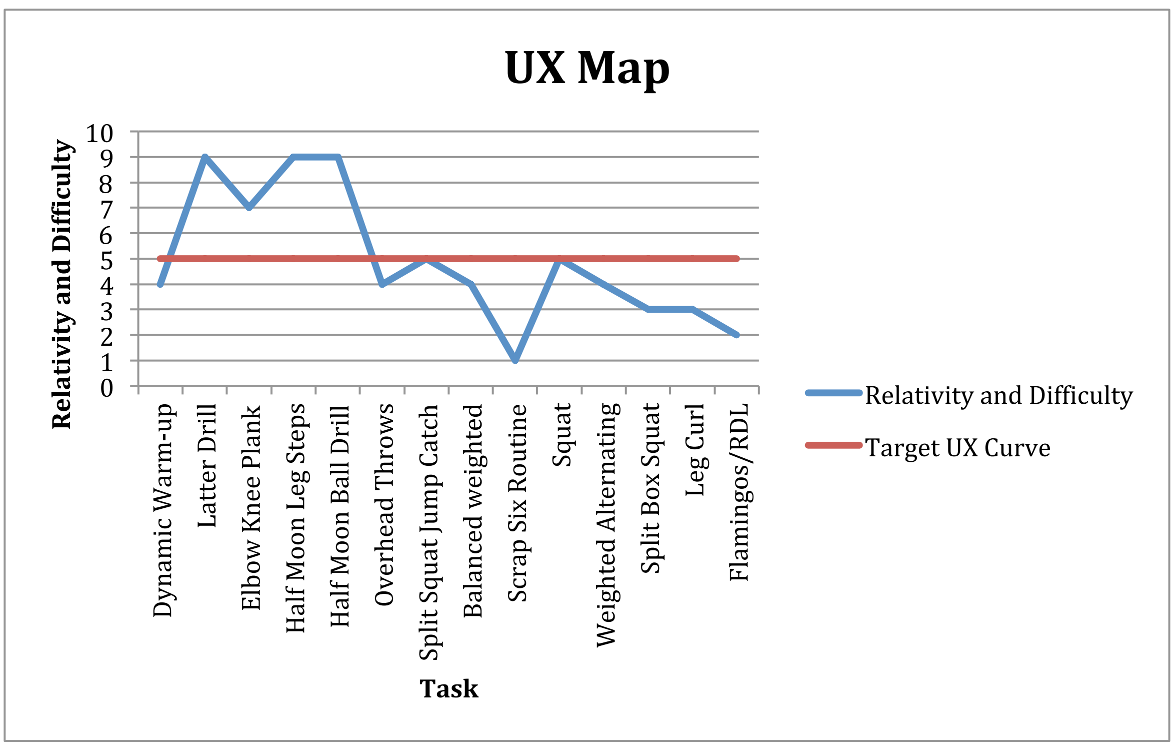



*Figure 9.* UX Map

Although this suit was great at typical body training movements that would be seen in a gym setting, while performing a mock throwing motion, the movements were not as well resisted. This was due to the fact that the layout of the suit was targeted to hit larger muscle groups as well as affect the body equally. As the node concentration was equally sporadic across the body and not focused onto the shoulder, the process of throwing was not well resisted.

## 3.3 Usability

**Introduction**

Of the two previously constructed configuration diagrams for potential solutions, configuration one was selected. This configuration results in a wearable training suit utilizing electronic muscle stimulation. To satisfy the training conditions of the product, electrical currents must flow through the muscles needed to perform a pitching motion. Because of this need, proper mapping of the intended muscles was completed, determining the placement, length and insertion direction of the fibers, ensuring proper node placement.

**User Group**

After researching the heights of Major League Baseball players it was determined that the average height of athletes in the sport is 6'2" (188 cm) with pitchers being one of the leading categories of height (Baseball Players All Shapes, 2018). Due to these findings, the ergonomic study was conducted for male individuals ranging around the 50$^{th}$ percentile height (69" or 175 cm) and 90$^{th}$ percentile height

(6’2” or 188 cm). The subject of the product mockup represents the 50th percentile male height who sits at 5’9” (174 cm) and results will be scaled relatively to suit the 95th percentile male.

**Methodology**

As the potential product will likely be constructed from an athletic material, which stretches to the user, the mockup utilized current elastic compression gear to simulate the final result. Sizes of the gear were a male medium as to simulate the 50th percentile male. This material allowed for visible contour of the human figure, ensuring proper placement of nodes was achieved on the proper muscle groups. A visible yellow tap was applied to the garment to simulate the placement of nodes for the future product. As the tape (nodes) was applied to the garment, not the users skin, relevant feedback of potential movement and displacement of the nodes was reviewed.

**Results**

With use of the Measurement of Man depicted by Dreyfus (Alvin R. Tilley & Henry Dreyfus Associates, 2002), relevant body measurements were recorded for the demographic. The results are as follows.

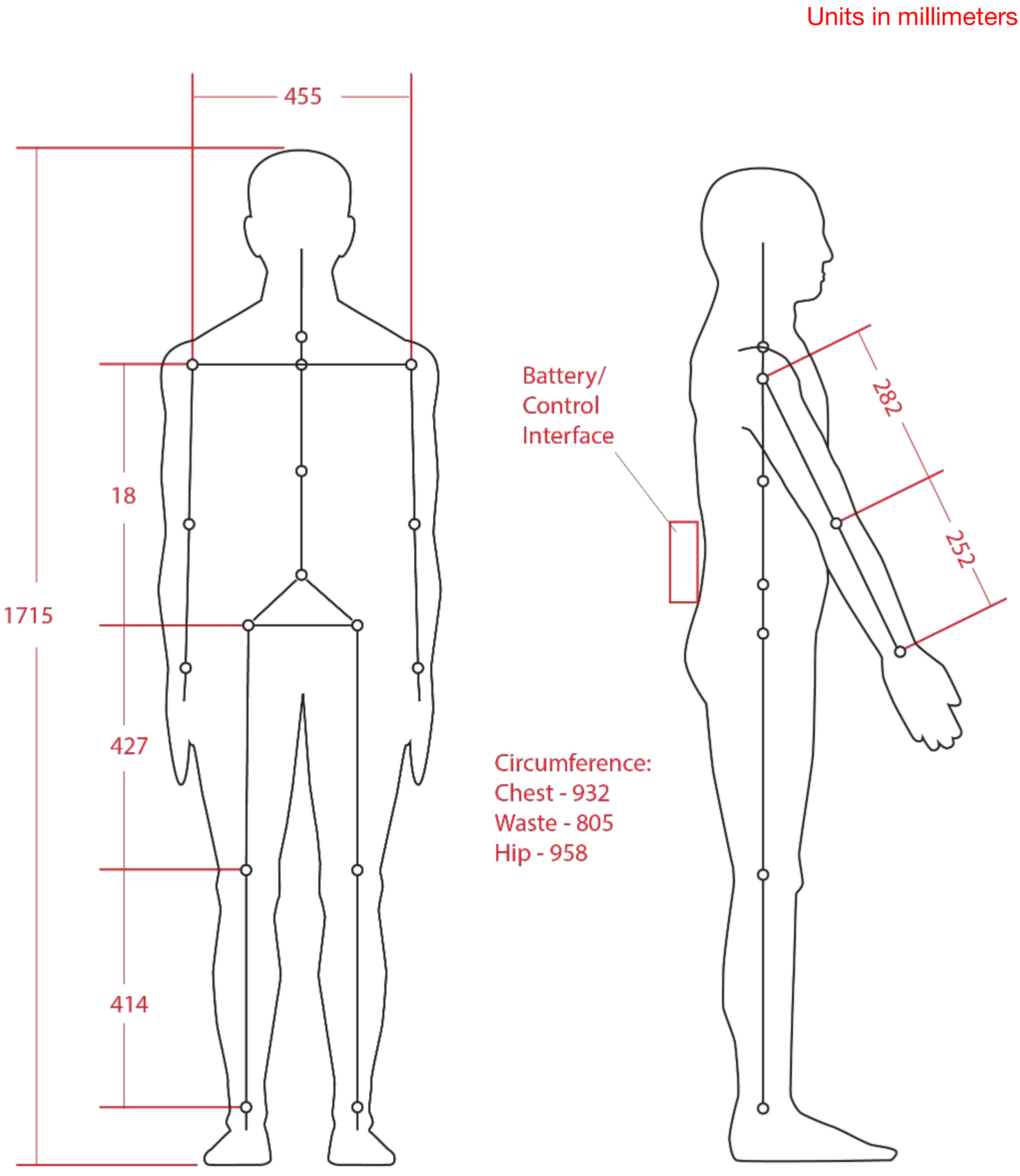



*Figure 18.* 50th Percentile Male

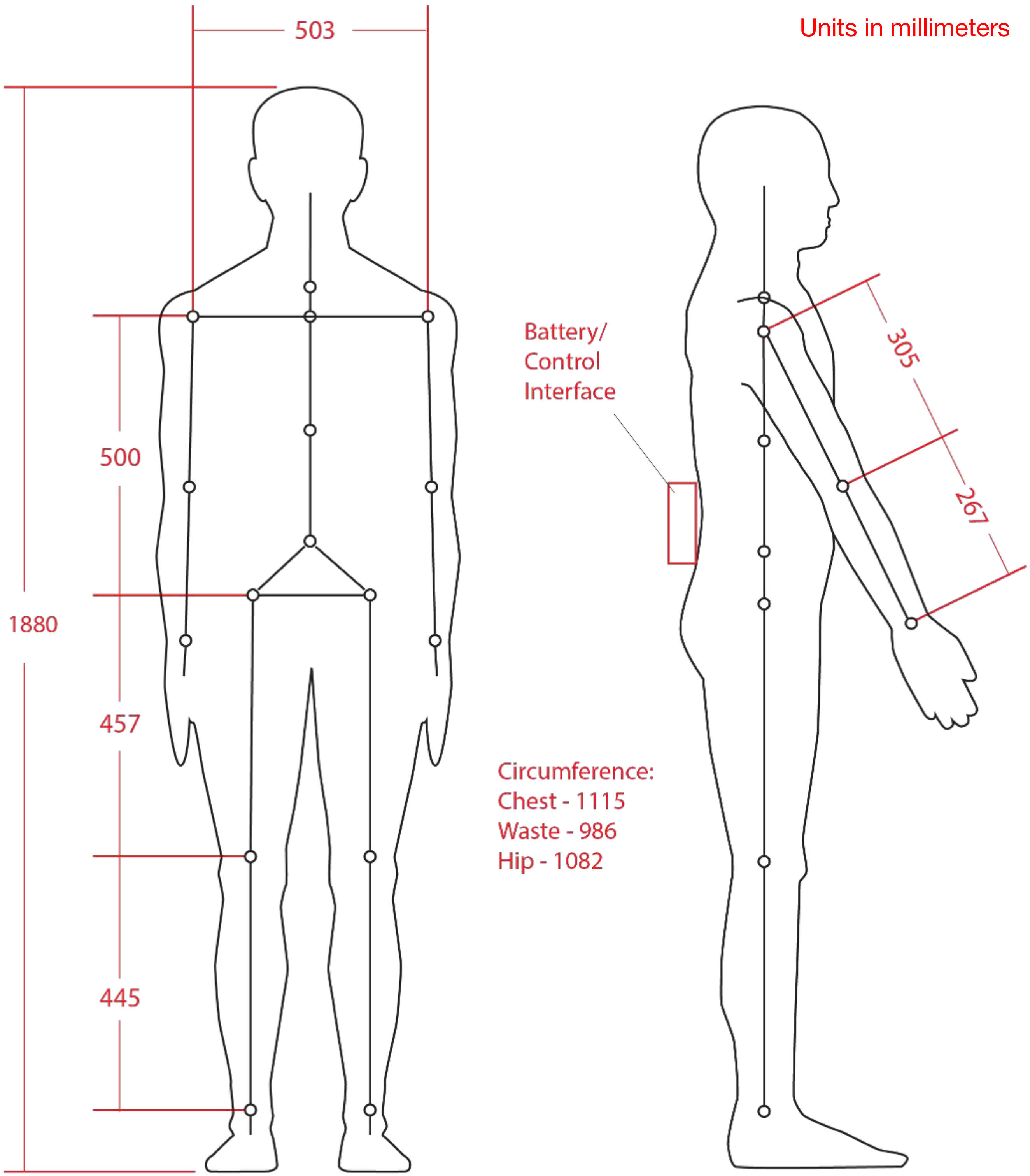



*Figure 19.* 97.5th Percentile Male

Node arrangement was applied to the human figure, mapping out the muscular needs of the pitcher. The results are illustrated in the following images.


1 2 3

*Figure 20*. Node Mapping Human 01


4

*Figure 21.* Node Mapping Human 02

**Analysis**

Nodes represented as tape in on the garment are placed over the intended muscles slightly inset from their insertion points. The nodes were measured and results are placed into a table.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **A** | 90 | 90 | 65 | 124 |
| **B** | 40 | 100 | 112 | 98 |
| **C** | 99 | 80 | 68 | |
| **D** | 115 | 75 | 125 | |
| **E** | 61 | 83 | | |
| **F** | 77 | 72 | | |
| **G** | 78 | 154 | | |
| **H** | 80 | 159 | | |
| **I** | 116 | 128 | | |
| **J** | 90 | 117 | | |
| **K** | 90 | 100 | | |
| **L** | 127 | 95 | | |
| **M** | 91 | 67 | | |
| **N** | 112 | 159 | | |
| **O** | 56 | 125 | | |
| **P** | 56 | | | |
| **Q** | 56 | | | |
| **R** | 60 | | | |
| **S** | 57 | | | |
| **T** | 205 | | | |
| **U** | 76 | | | |

*Results are in millimeters

*Figure 22.* Node Length Chart

Node lengths were determined by the length of the muscle groupings and determined by pitching biometrics. As most of the muscles needed will be on the right (assuming the pitcher throws right handed) some information will be relayed to the left side of the body (i.e. back muscle groups and core) as they are required for torque of the body. This was left out of the measurement and mockup as the body is relatively symmetrical.

Although the length of the node was determined by the length of the muscle, the nodes do not have to be equal in length for the muscle to contract. In order to contract the muscle through muscle stimulation, the current has to go through an insert end and out an exit end, but these ends can be shorter than the muscle and achieve the same results. This will be beneficial for individuals with slightly longer limbs or larger areas of the body, as nodes do not have to be at the very ends of the insertion points of each muscle. As length of the body will not be an ergonomic issue because of this fact, circumference of the body will. As the body groups larger in circumference, areas like the core and upper arms may be affected due to a stretch in the fabric. Due to the varying of human widths, the garment may require adjustment areas.

By having the tape in a vivid colour, it was easier for the user to see how the suit lined up to the body. This visual feedback should be brought further in the process as it helps the user determine if the suit is coming in contact with the proper areas on the body, while also allowing for quick adjustment. The tighter the suit is to the body the smaller the margin for error. The garment should be snug to the human's skin to provide direct contact while flexible enough for the user to participate in it.

Under the arm and with muscles related to rotation of the shoulder, there needs to be a finer tuning of placement detail. This area has smaller muscles that are important for rotation and arm "whip" stabilization among release. As the sizing of the area in question was determined by the study, further interaction with the advisor regarding muscular structure will refine the unique area.

As the 95th percentile male is only 108% larger than the subject and node placement does not have to be at the very ends of the muscles for activation we can see a couple ways off continuing with the solution. The circumference factor may lead to having multiple sizes of the final product in medium and large. Although, since the nodes do not necessarily have to be “longer” in order to work on the 95th percentile from the 50th percentile, there could be a way to enable a solution that can conform to the necessary sizes.

## Conclusion

Having the product layout in a three dimensional space allowed for an easier understanding of how this product may work with EMS technology. Due to the fact that the mockup incorporated an elastic garment similar to what may be used in the final design, information was gathered for the “shrinkage” once the product is removed from the body. The product element’s distance and sizing on the wearer versus off the wearer should be accounted for in the final design. With the mockup design having a slim build, movement and pitching mobility was desirable showing how adding too many adjustable features may interfere with the mobility.

## 3.4 Aesthetics

As users will be interacting with the product in a team setting, aesthetic appearance is important for product longevity. For the product to be utilized, there needs to be a desire from the user to interact with it. This can be done by ensuring the product not only looks appealing, but the product's appearance describes how it is to be interacted with. Study of current EMS suits was conducted for product benchmarking, and information from these pieces of equipment can inform the aseptic appeal of the future product, ensuring a seamless user experience.

As promotional material was mainly to sell a buyer (company) the entire service as a package (suit, control interface, product support, and various service features) suit specs were limited. The main specs that seemed to be apparent and would benefit the thesis would be to have the solution wireless and dry nodes instead of wet nodes as the suit prep time and ease of use would be positively affected. Some battery specs will help with sizing the battery in the design, while making the wire connections magnetic will be a good idea. As suits were intended for use by a population of members, construction seemed to be centered around adjustability and frequent use. The all black colour schemes and cluttered appearance may be off putting to someone who does not know how to fasten or put on the equipment. More visually advanced suits solved this with colour contrast and a sleeker design with hidden components. The thesis solution will take note of both the positives and negatives seen in this comparison.

### *3.5 Sustainability – Safety, Health, & Environment*

As mentioned in Section 2 regarding sustainability, currently it does not appear to be a concern of benchmarked product. This lack of concern derives from the fact that the current EMS suits are marketed to companies seeking to utilize these products across an array of members through as many years as possible. As sustainability of materials and manufacturing are pushed out of the picture, durability and cost efficiency are put in its place.

Looking at this information from a more optimistic approach, it can be seen as a relatively easy area to tackle for means of improvement. One that was looked into was material, specifically flexible materials that were water resistant. As sweat and electricity will be an often occurring dynamic, looking for ways to separate the two will be necessary. An article by Prontera et al. (2019) speaks to a sustainable, low cost, easily processable material for hydrophobic coatings on flexible plastic substrates (Prontera et al., 2019). Basically a barrier that can be put onto flexible materials, for example electrode coverings that will prevent moisture from areas in the product sensitive to it. This will be one of the examples of possible sustainable solutions when it comes to the new final design. Further material improvements chosen will be discussed in chapter 5.

## 3.6 Commercial Viability

### 3.6.1 Materials and Manufacturing Selection

As the resulting thesis will likely be a suit requiring EMS technology similar to those of standard EMS basic training suits, materials and manufacturing could remain similar as well. Though, the choices of materials and manufacturing as seen in section 2 are based around mere function for high use rather than sustainability and product lifecycle, this will be an area that will be improved upon for the final design.

Areas such as the polyamide spandex mix for the majority of the suit, as well as possibly the power supply were looked for potential areas of improvement. Sustainable upgrades such as a grown material called Yulex Pure and a power supply from graphene-based quasi-solid-state lithium-oxygen batteries were found in material research as potential improvements that will not hinder manufacturing methods. These materials will be discussed further in 5.6 Sustainability.

### 3.6.2 Cost

From bench marking research of the standard EMS training suit, retail prices range from around $1200 to $2000 CAD. What will increase the price of the thesis concept from these prices are the products overall coverage, application, and personalization. The benchmarked products are utilized to only target major muscular areas such as the abdominals, chest, back, upper legs and upper arms. As the thesis concept needs to be more intricate, focusing on smaller muscular systems to properly resist the biometric motions of the pitch, more wiring and electrical detailing will be needed and in turn, slightly increase the price. Also, because these suits target only large muscle groups, there is more wiggle room for users of various sizes to fit into a tiered size system of small, medium and large. A more focused and detailed set of electrical nodes on the thesis concept means that the end result needs to be more accurate when it comes to sizing. This customization will be another factor that will increase costs. A full breakdown of the costs can be seen in section 5.

## 3.7 Design Brief

The goal of this industrial design thesis is to design a product around the biometrics of a baseball pitch, which can be utilized to improve athletic performance of the athlete.

**Ten objectives to demonstrate the needs addressed are outlined below:**

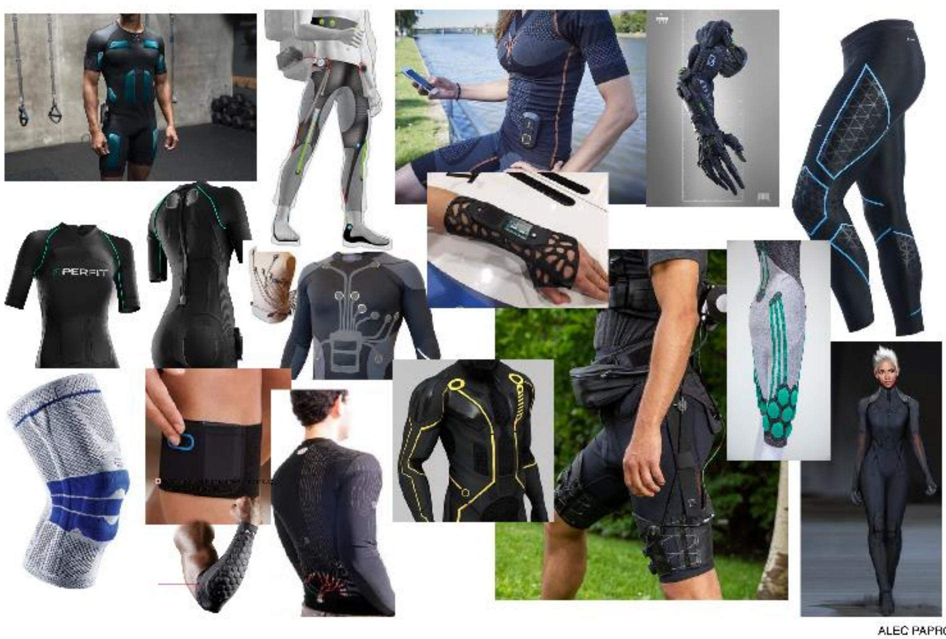
1. Improve athletic performance through increased muscular strength.
2. Conform around the athlete allowing natural ergonomics of the pitch.
3. Be use discretely as to not interrupt the player's way of throwing or practice.
4. Minimize injuries by optimizing efficiency.
5. Have communication of feedback with the primary and secondary user through the device.
6. Be portable so that product can be utilized in multiple user locations.
7. Be resistant to the environment of use i.e. outdoors.
8. Have a way to track progress, analyze and optimize training
9. Fit all athletes from $50^{th}$ percentile height and up.
10. Be designed stylistically so that there is a desire to use.

# 4 | Design Development

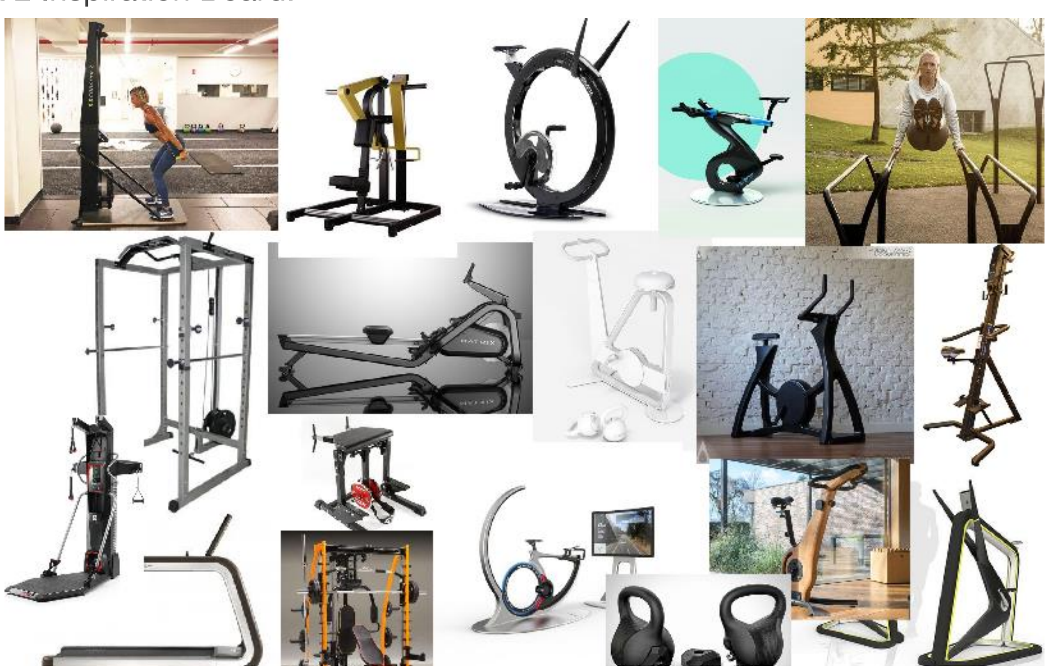
## 4.1 Ideation

Ideation began with a mind mapping technique of brainstorming along with inspiration boards generated from current products, concepts and design language related to the perceived final. For two possible design directions, an inspiration board was constructed and can be seen below.

Concept 1 Inspiration Board:




Concept 2 Inspiration Board:



## 4.2 Preliminary Concept Exploration

Concept exploration commenced looking into ways to resist the human motion of a pitch. Original ideation looked primarily to body-mounted devices that may cause some form or resistance. The three main areas looked into below are resistance through electronic muscle stimulation, tension bands, and air resistance.

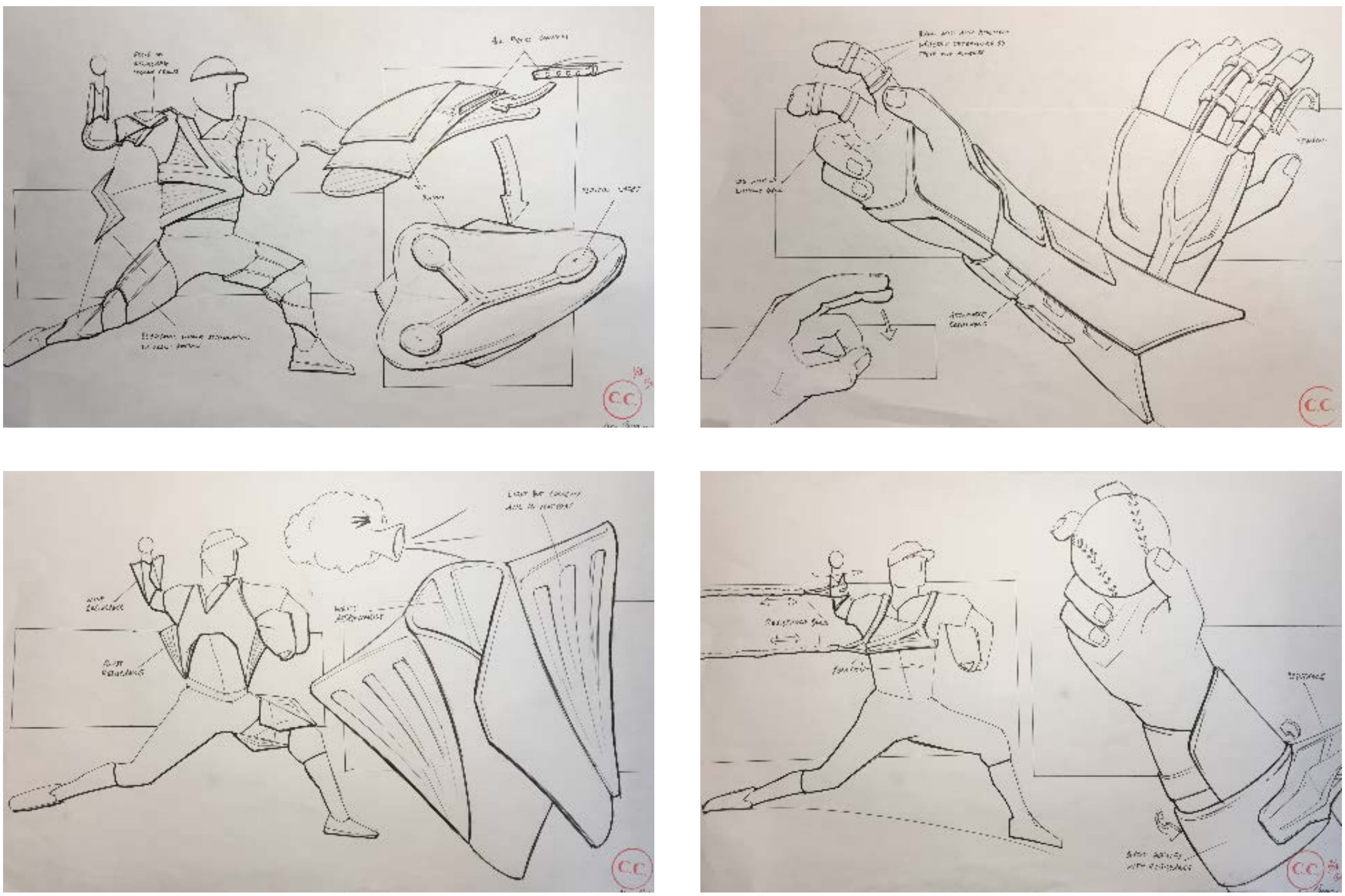


*Figure 23.* Preliminary Concept Exploration

## 4.3 Concept Refinement

As resistance through electronic muscle stimulation proved most applicable and other training benefits could be acquired through this process, this concept was further explored as seen below. As more was learned about the process, variations, styling and application on the body were experimented with.

*Figure 24.* Concept Refinement 01

To broaden the possibility spectrum, off-body applications were explored along side the wearable option. Process, variations, styling and application were explored for this method as seen below. A concept such as this would be more of a stationary application used in an area such as a fitness or recovery room in a baseball related area. Exploration can be seen below, although this direction was not taken as the EMS technology showed greater ability to adapt into more than one benefit.

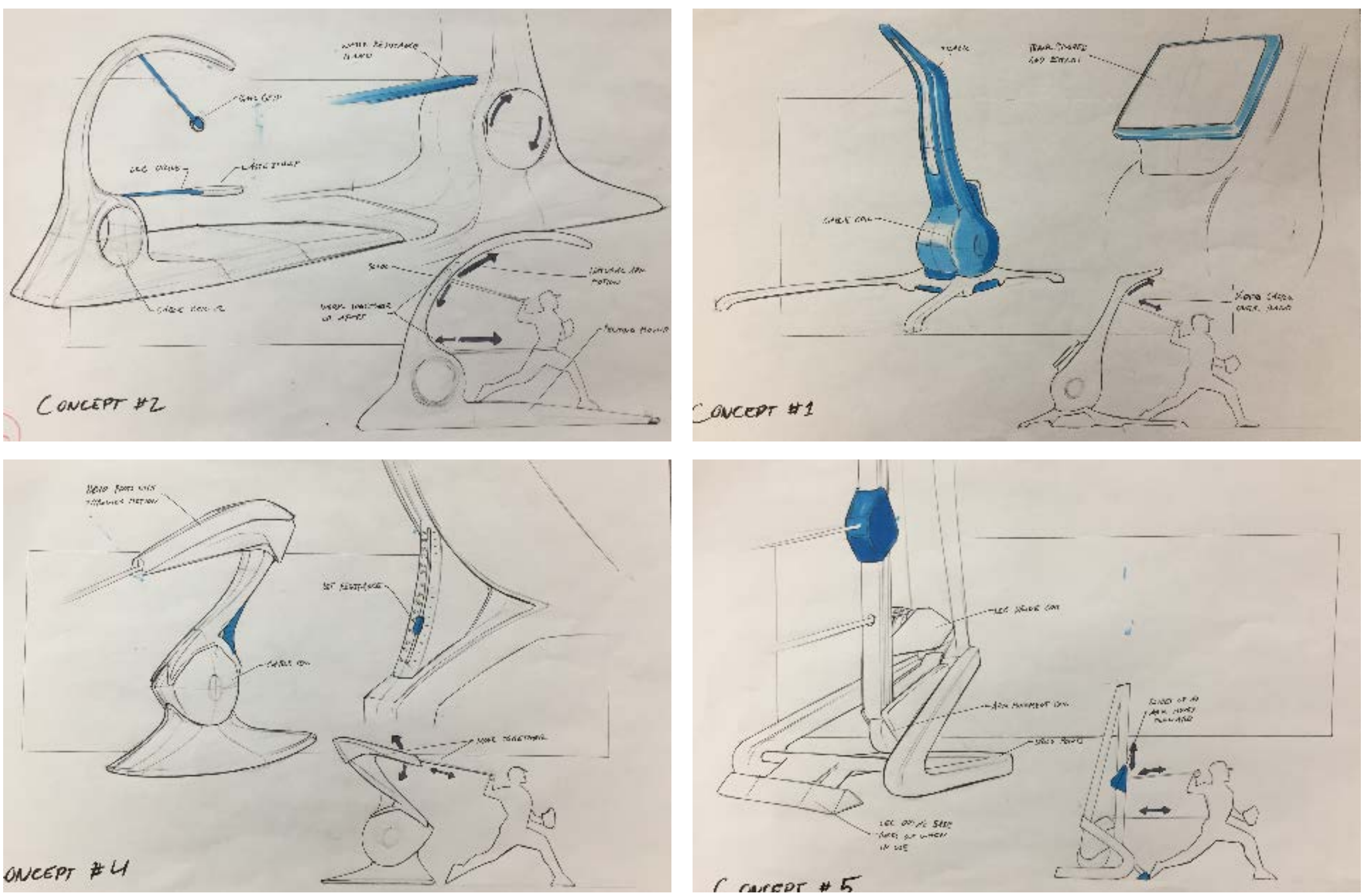



*Figure 25.* Concept Refinement 02

## 4.4 Detail Resolution

After the concept was finalized on a wearable suit utilizing EMS technology for various benefits to a training pitcher and orientation of nodes was determined on the body through ergonomic study, detailing of the suit orientation commenced. There needed to be a way to comfortably house areas such as the battery and CPU, as well as how wiring would get from the CPU to the proper nodes. Also user interaction through primary and secondary communication was developed. Secondary user feedback would be given by a unique lighting system and app interaction through a computer or tablet. This would be used as controls to the suit as well as record keeping for things such as form mechanics, resistance, etc. These details were expressed in the following images.

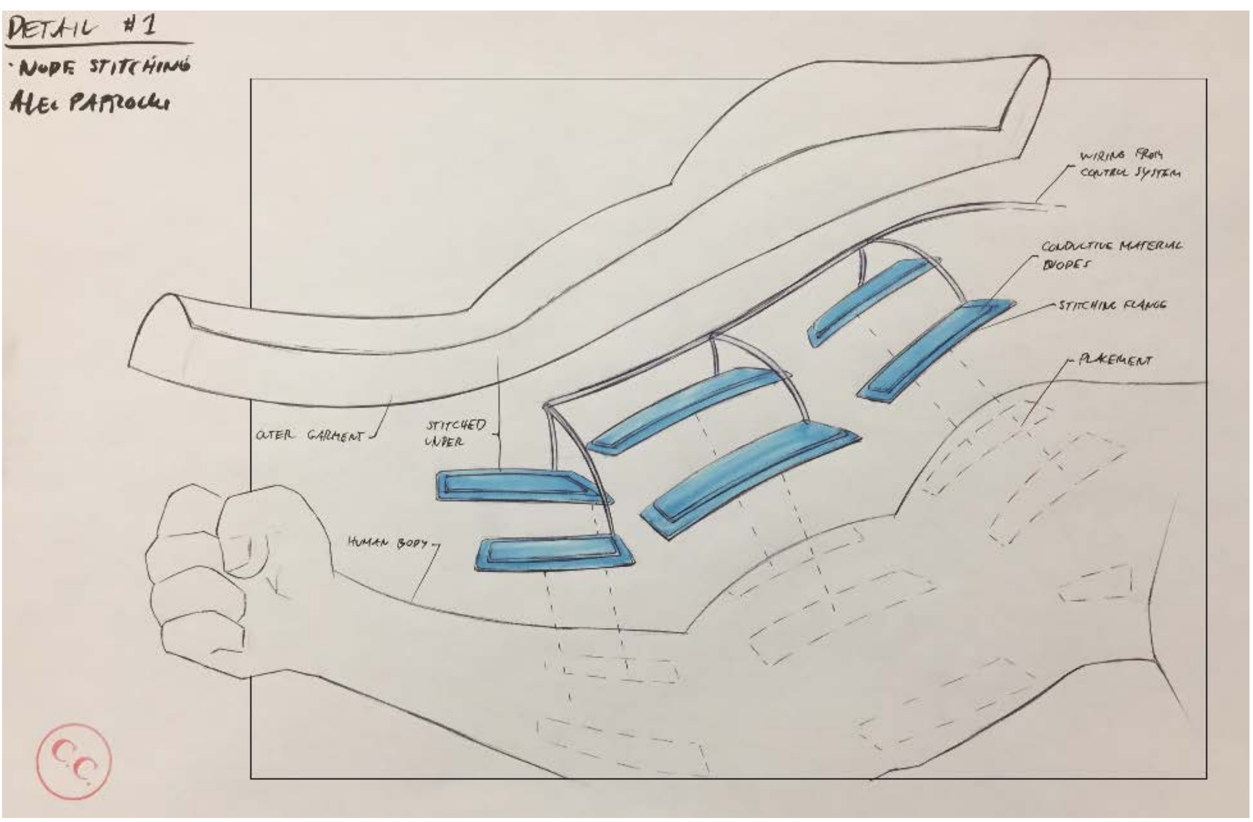
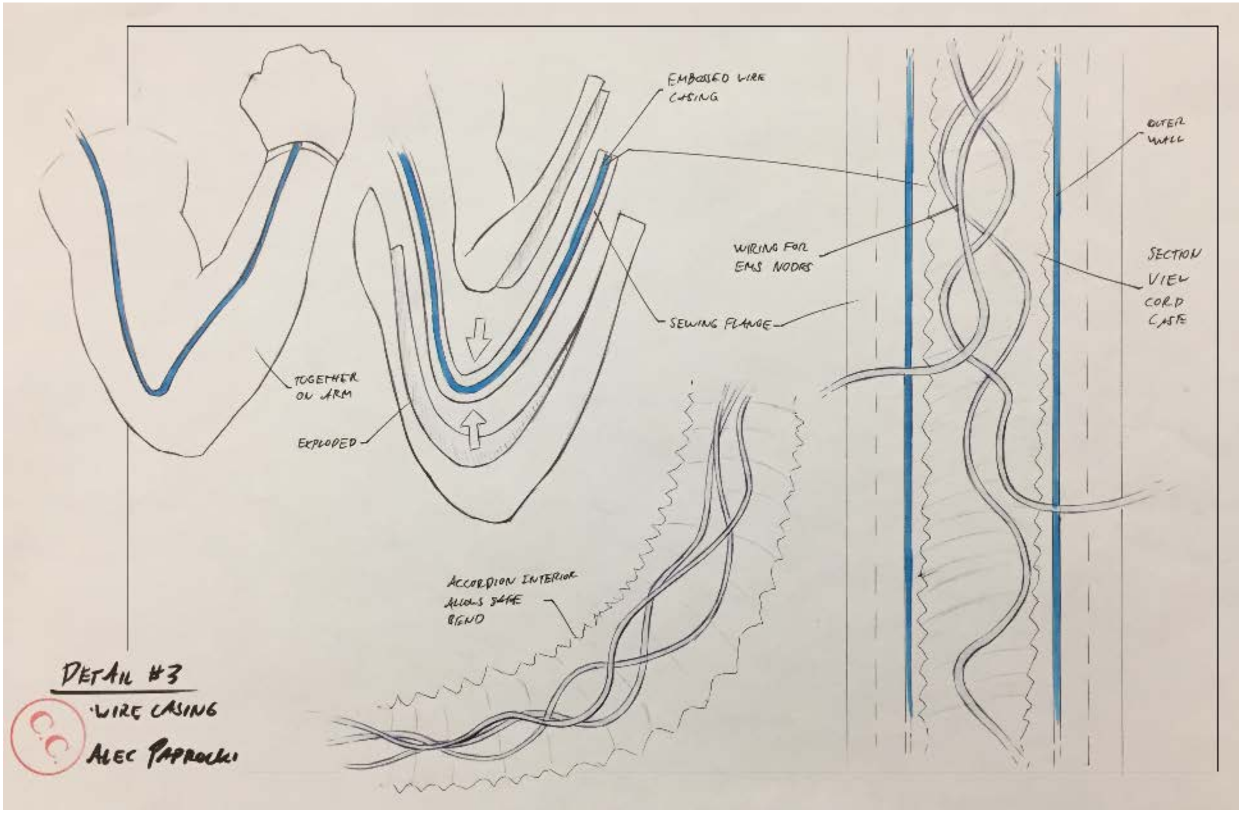



*Figure 26.* Detail Resolution 01



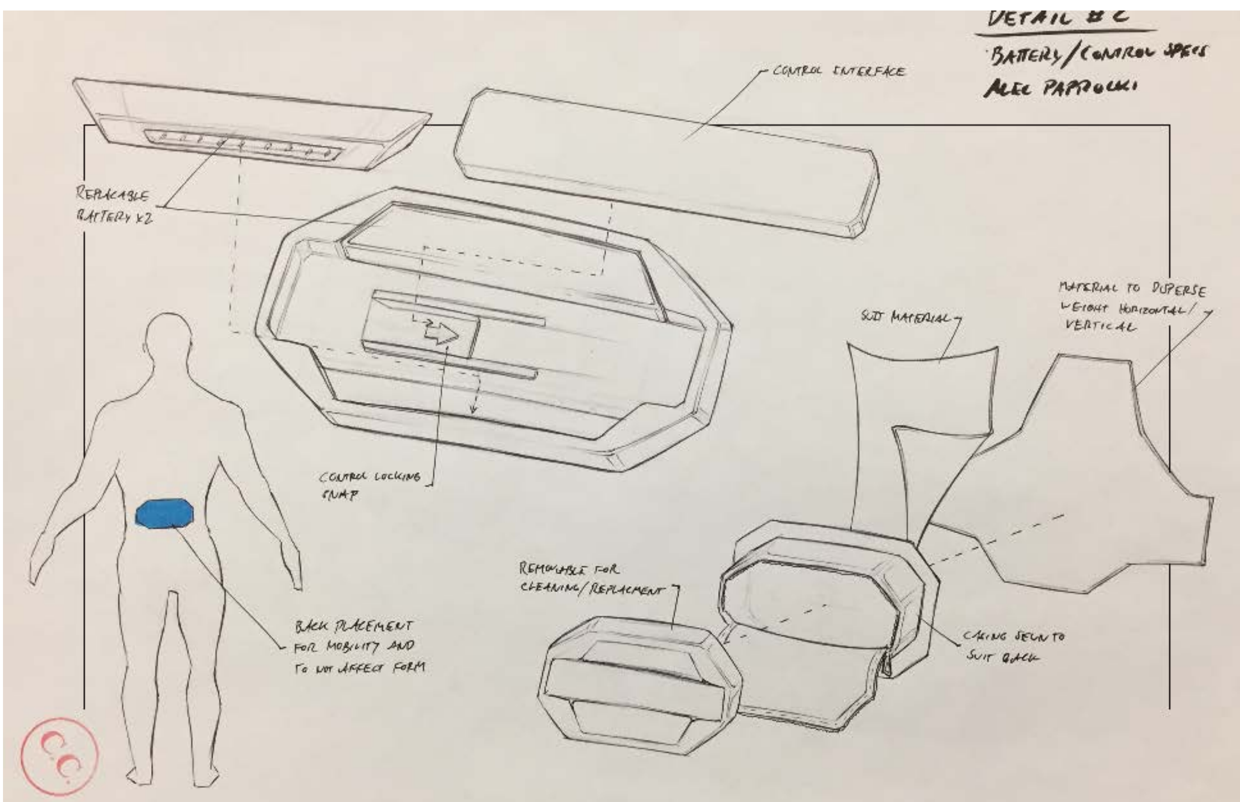
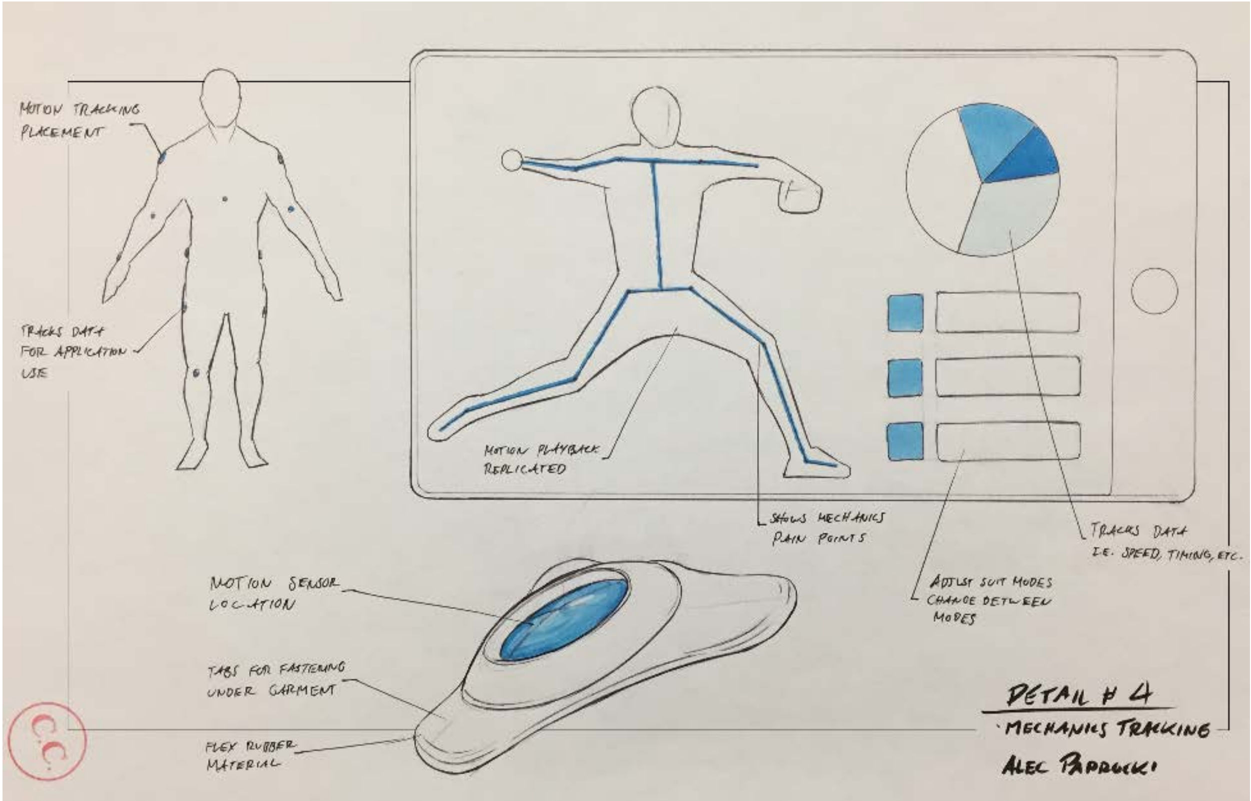




*Figure 27.* Detail Resolution 02



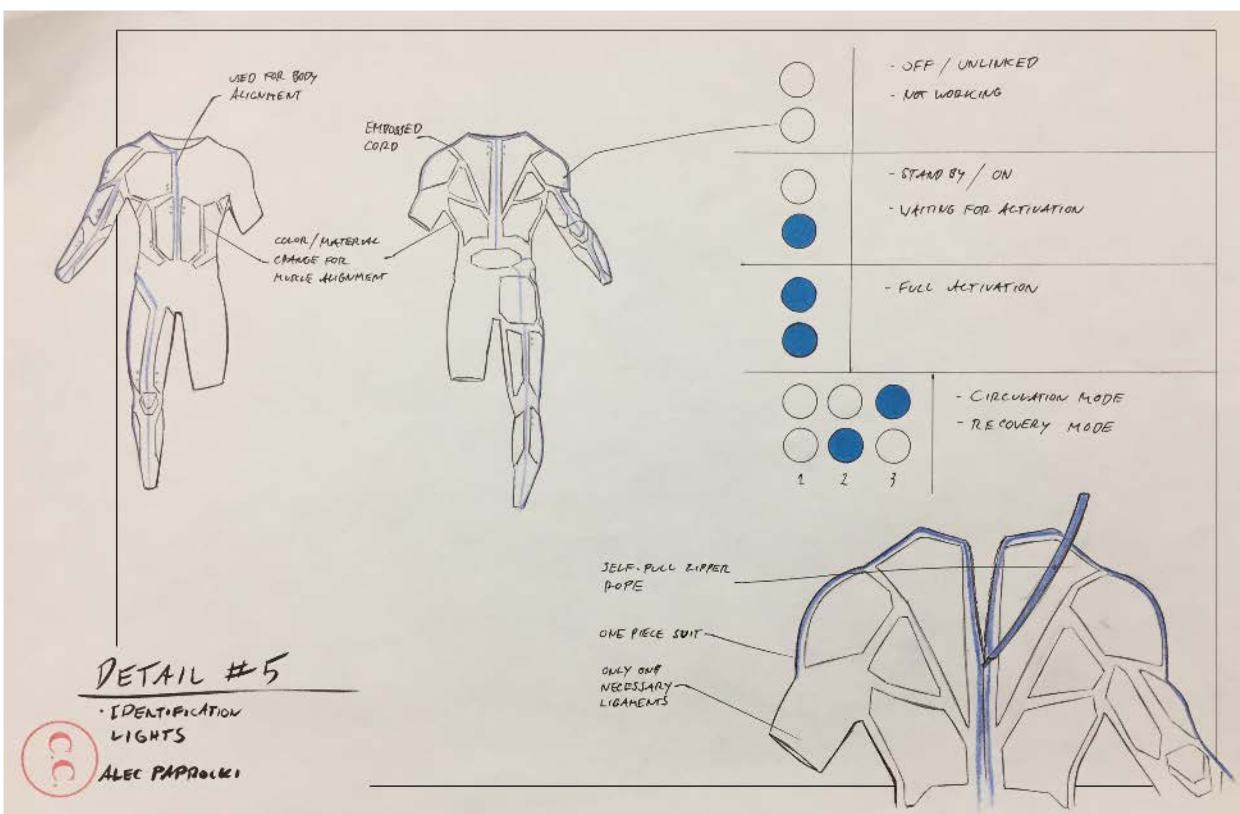




*Figure 28.* Detail Resolution 03

## 4.5 Sketch Models

With what was learned from the ergonomics study and research into the biometrics of the pitch, a configuration diagram was developed for the 50th and 95th percentile male determining electrical node layout and orientation. These measurements were taken into a full-scale 95th percentile male model to determine the outer layer of the suit as well as placement of external compartments such as CPU/battery unit and wire travel casings.

Scale 1:10
Electrical nodes mapped
to required muscles

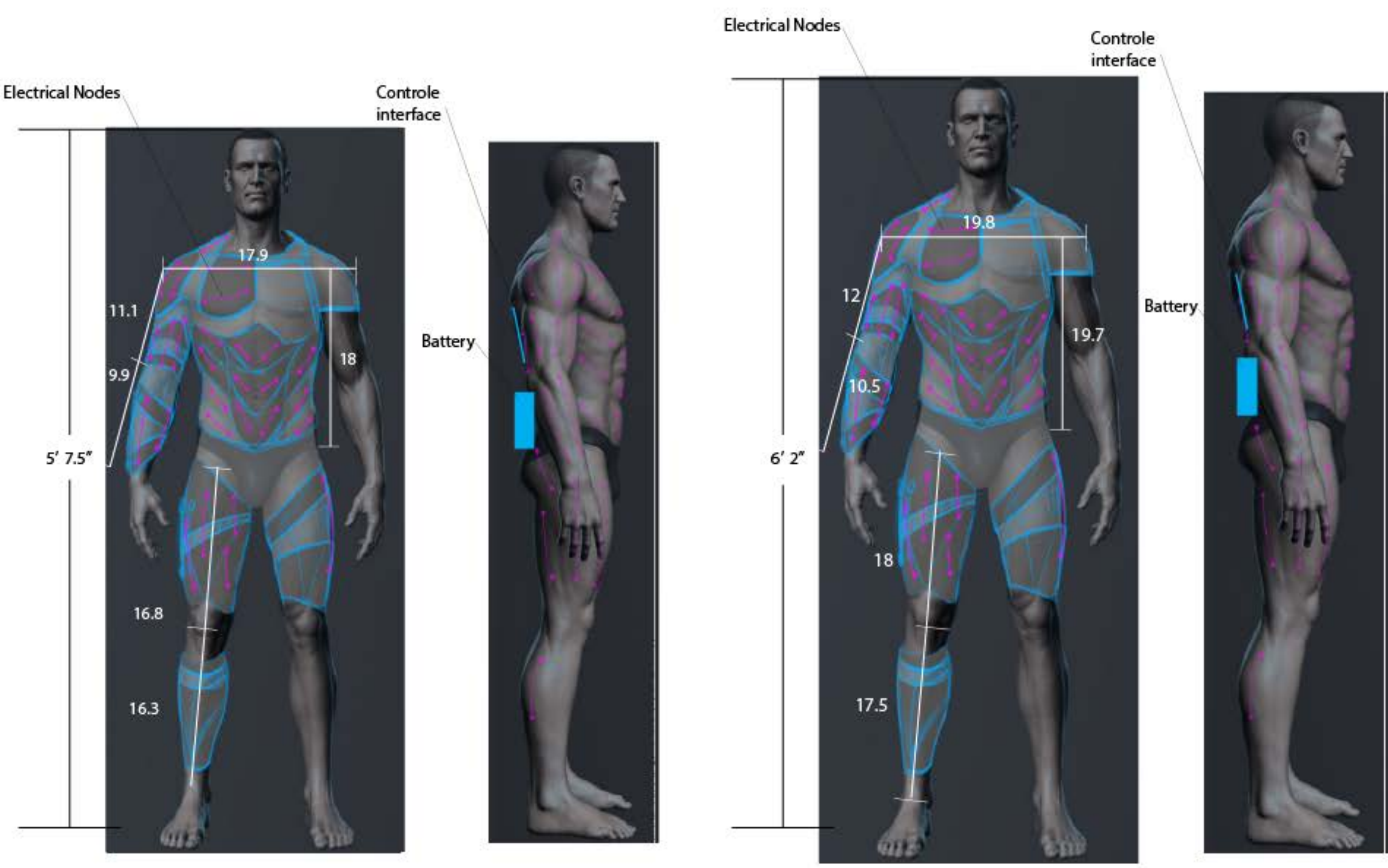



*Figure 29.* Configuration Diagram 01

*Figure 30.* Sketch Model

The configuration diagram was also completed for the dropped concept and was included for marks.

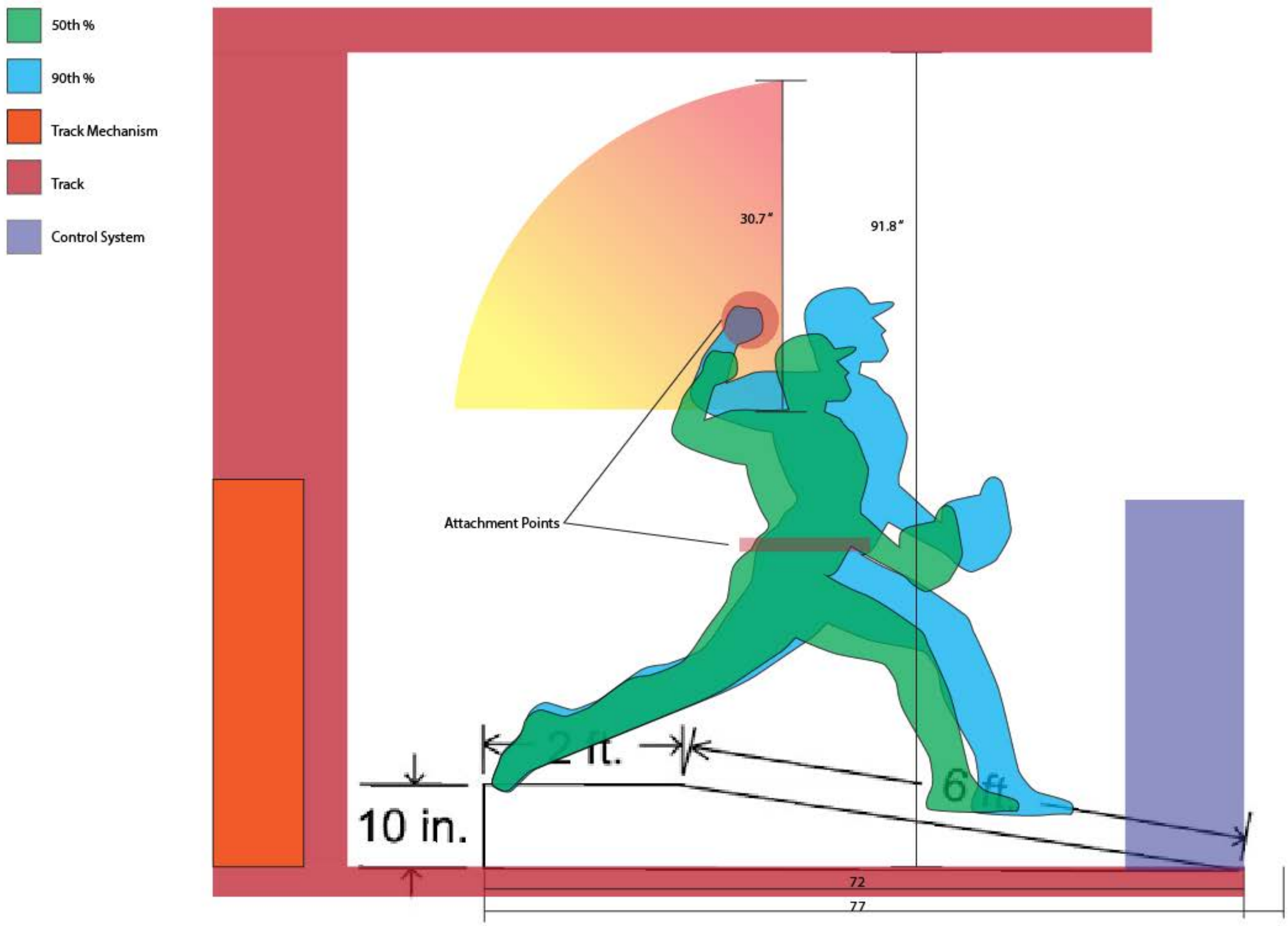



*Figure 31.* Configuration Diagram 02

## 4.6 Final Design

The design was finalized utilizing the ergonomics, aesthetics and user interaction as discussed on their respective sections. The design was overlaid onto a three dimensional map of the human muscular system to ensure accurate placement and the front and back isometric views ensured a more exact representation of what the final outcome would unveil.

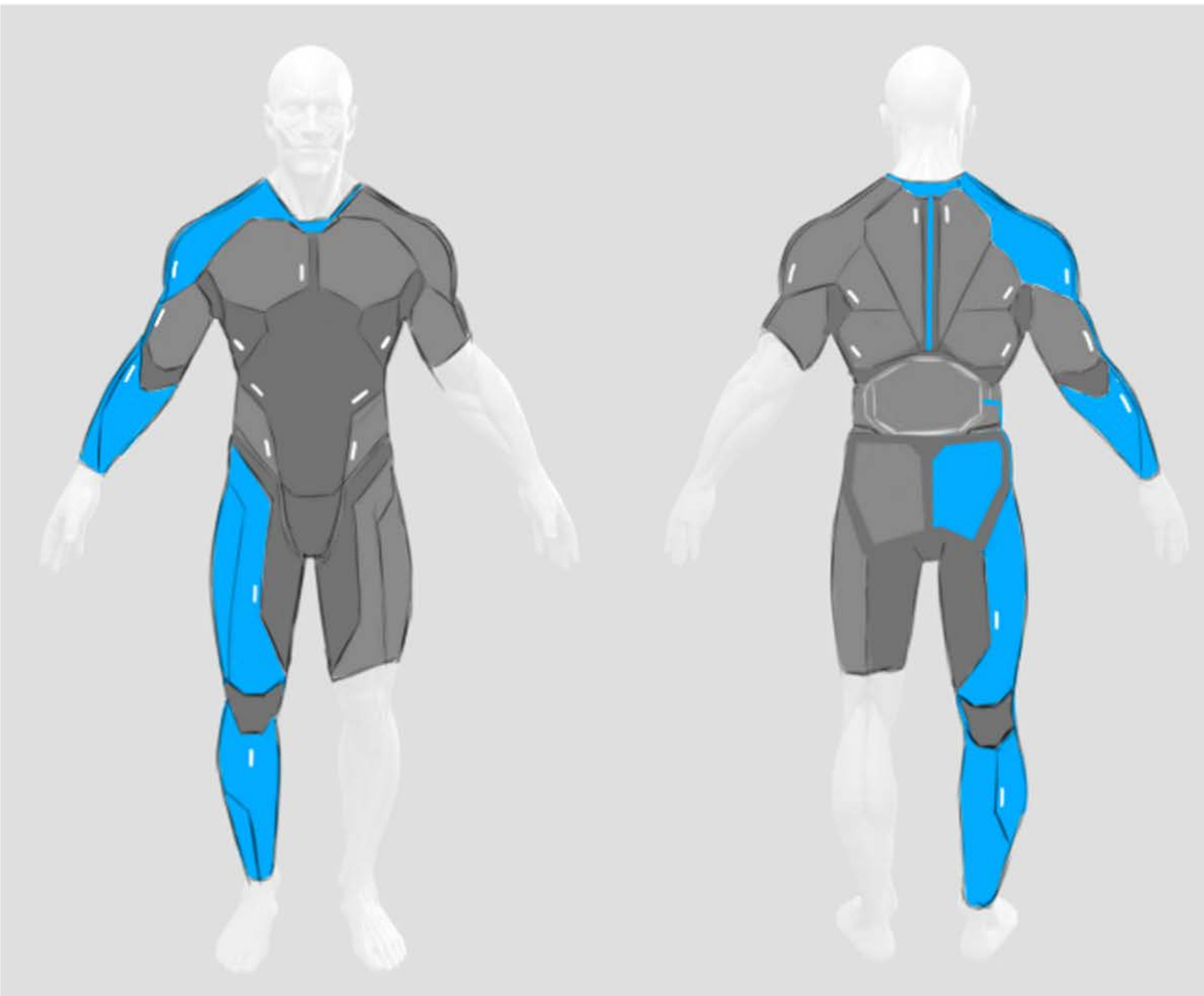


*Figure 32.* Final Design Sketch

## 4.7 CAD Models

Finalizing the design took place in CAD software for an exact look into the layout and aesthetic presentation of the design. The outer layer of the design was constructed in three-dimensional clothing software to ensure proper fit and material simulation. Electronic components were represented in exploded views to show the intricate workings of the areas as well as to express the multiple layers of the suit with their functionalities. The CAD primitive development can be seen below.

*Figure 33.* Primitive CAD 01

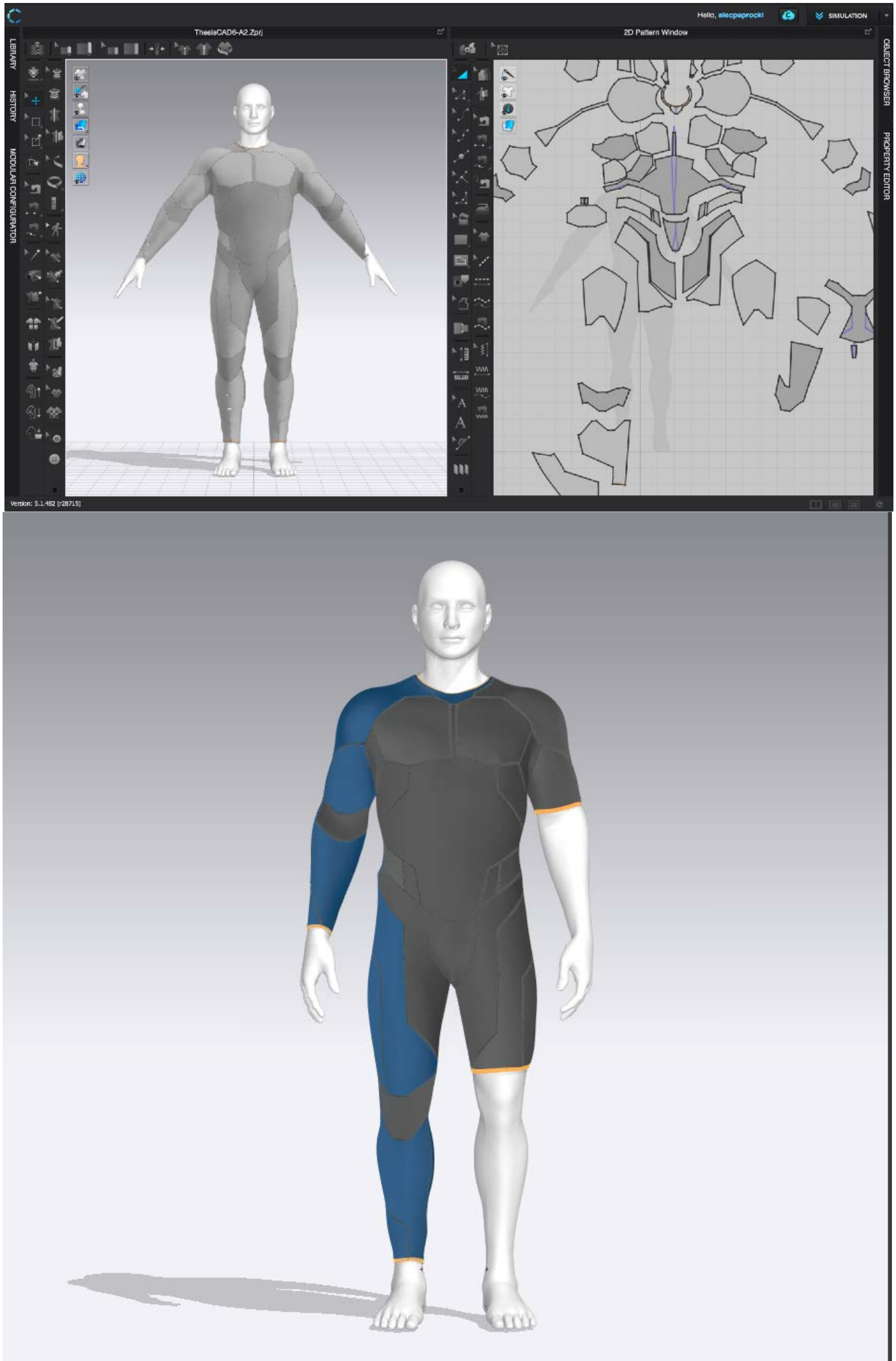



*Figure 34.* Primitive CAD 02

## 4.8 Hard Model Fabrication History

The previously mentioned sketch model was used as a template to create a flat pattern for the outer shell of the suit. To demonstrate the separate areas of the suit, three different colored four-way stretch materials were utilized to simulate the second skin feel of the design. Parts of the flat pattern were cut from their respective materials and sewn together over the sketch model layout. As the type of machinery used to create the suit as one entire weave was not accessible due to manufacturing costs, the suit was constructed in a basic flat pattern sewing method.

*Figure 35.* Model Process 01

The electrical wiring casing down the arms was simulated by weather strip cut and wrapped by the respective fabric. This ensured the maneuverability of the flexible casing that would be used in manufacturing, protecting the wires but allowing it to conform onto the curves of the body. The battery and CPU casing was constructed and bent from EVA foam to simulate the overall size and look to how the component would be placed on the body. This method simulated the softness of the flexible casing and allowed it to be bent to conform to the lower back curvature. To ensure the wearer could easily enter and exit the suit, a zipper not far from a wear suit zipper application was sewn between the ascending wire casings, with a pull string for ease of use. Finally to simulate the vinyl type divider used in athletic wear to complete the suit mapping, a vinyl tape was placed over the seams. This tape also moved the suit away from the classic method of sewing look, to appear more like it would be manufactured as a single weave.

*Figure 36.* Model Process 02

# 5 | Final Design

## 5.1 Summary

### Description

E.M.-T.O.S.S. is wearable pitching technology that aids in a pitchers training routine, worn by the working pitcher and controlled by the pitcher's trainer. E.M.-T.O.S.S. stands for Electronic Muscle Training Operation System Suit.

### Explanation

E.M.-T.O.S.S. utilized electronic muscle stimulation to add resistance to a very unique movement known as the baseball pitch. As traditional resistance methods have failed to add resistance to a motion such as this, trainers resort to external, "roundabout" ways to train a pitcher's throwing strength and power. By having electric muscle stimulation to specific muscles of the body, the electricity will cause contractions of opposing muscles to the pitch, meaning that the pitcher will be working against the resistance of his own muscle contractions, strengthening his abilities over time. As seen in the research conducted in this thesis report, pitchers rely on heavy warm-ups before throwing, also looking for ways to stay warm between throwing breaks. The suit's EMS technology can also be used in a recovery type mode to keep blood flowing through the muscles, in turn keeping the athletes muscles supplied with blood and potentially reducing injuries.

E.M.-T.O.S.S. was designed with trainers in mind allowing easy trainer to athlete interaction. As the trainer controls the suit, he/she will have full control of how E.M.-

T.O.S.S. will fit into their training regimen. App controlled, the trainer can set the suit's resistance, track pitching mechanics through sensor detection, set and complete goals for the wearer, as well as employ various recover/warm-up modes. As the electronic stimulation is inherent to the primary user, but not exactly visible to the trainer, there would be a feed back gap between the two. This was solved by applying activation lights so that the secondary user can visually see when and how the suit is activating, as well as what mode the suit is in.

**Benefit Statement**

As pitchers repeat the same motion constantly in a given day, on top of strength training for arm performance, it is no wonder why Tommy John surgery is the number one surgery conducted on pitchers. E.M.-T.O.S.S. was created to be a more efficient way for pitchers to train for throwing power and recovery. Worn in a practice setting, E.M.-T.O.S.S. can be used and monitored in a resistance mode for strength training, or go through recovery/warm up cycles to help improve athletic longevity. Training for strength while training for throwing mechanics, being more efficient to result in less arm strain over time.

## 5.2 Design Criteria Met

### 5.2.1 Ergonomics

To ensure the wearer is as comfortable as possible, electronic nodes are hidden beneath two layers of four-way stretch material. Between these materials, the wires will be run to ensure that use of the suit is as seamless as putting on a wetsuit. Large clusters of traveling wires are confined in a flexible casing down the arms, leg and back, leading to the battery and CPU compartment. This electrical compartment is placed on the lumbar of the user, minimalizing the impact on pitching biomechanics. Placement of the electrical compartment is most ergonomic to the users mobility and center of gravity, while providing the most optimal pathways to all limbs of the body.

As the primary users of the suit are baseball players and not engineers, having them understand where each node goes would be a lengthy process. This dilemma was avoided by employing semantics and symmetry to the patterning of the suit. While the patterning and color clocking of the suit is an indication of if it is intended for right or left handed pitchers, it is also an indication of how to wear the suit. Since the four-way stretch materials used can be rotated around the wearer, it would not be rare for the nodes underneath to be out of place. The over all look of the suit is a sort of body map so that the user of any intellectual ability can visually see if anything is out of place. With use of the wire casing going straight down the arms and leg, material choice changes for places like the knee, and pattern seams outlining the musculature of the wearer, the overall aesthetic of the suit removes a lot of the headaches when it comes to teaching the user how to wear E.M.-T.O.S.S.

### 5.2.2 Materials, Processes & Techniques

As E.M.-T.O.S.S. is a personalized suit intended for top tier athletes, these suits must fit the user perfectly and not cause any sort of unnecessary strain on their training routine. With improvements in three dimensional mapping and soft good manufacturing, E.M.-T.O.S.S. is able to fit each athlete perfectly with their own custom suit. Similar to how knit shoes are constructed, or high-end athletic leggings, E.M.-T.O.S.S. will be machine knitted, but to a personal three dimensional mapping of a users body, ensuring electrical node placement is in the exact spot and the suits wearer mapping aesthetic forms well to the user's unique body. This knitting process allows the strands of the materials chosen to be patterned onto the suit in a way predetermined by the software, allowing seamless changes from fabric colour was well as type.

The blue and light grey materials of the suit, as well as the dark accent lines will be comprised of the Yulex material so that these areas are slightly more durable as they house most of the electric nodes. The darker fabric seen on the torso and joints however will be comprised of the spandex-like fabric known as T162R. Both Yulex and T162R will be explained in 5.6 of this report. A more dense rubbery variation of Yulex will be used to create the wire casing going down the arms, leg and back, allowing wire protection from liquids while granting user mobility. As for the main electrical compartment, the housing for the battery and CPU will be made of an injection molded flexible PVC variation for mobility and comfort. It can also be backed by the Rubbery Yulex variation for comfort.

### 5.2.3 Manufacturing Cost Report

| | Concept Item | Estimated Cost (total) | Similar, Produced Item | Actual Produced Item Cost Retail |
|---|---|---|---|---|
| A Costs | | | | |
| | CPU | $2000 | i7-6950X | $2600 |
| | Battery | $200 | Dell computer battery | $200 |
| B Costs | | | | |
| | Wiring | $30 | 10 ft. RSS232 cable | 4$ |
| | Yulex blue/grey | $10 | Neoprene sheet | $36 per 51”x83” |
| | Yulex Rubber | $2 | “ | “ |
| | T162R dark. Grey | $7 | Spandex knit | $7.50 per yard |
| | Battery compartment | $1 (after mold cost) | | |
| | | | | |
| Total | | $2070 | | |

*Figure 37.* Manufacturing Cost Report

## 5.3 Final CAD Renderings


*Figure 38.* Final CAD Render

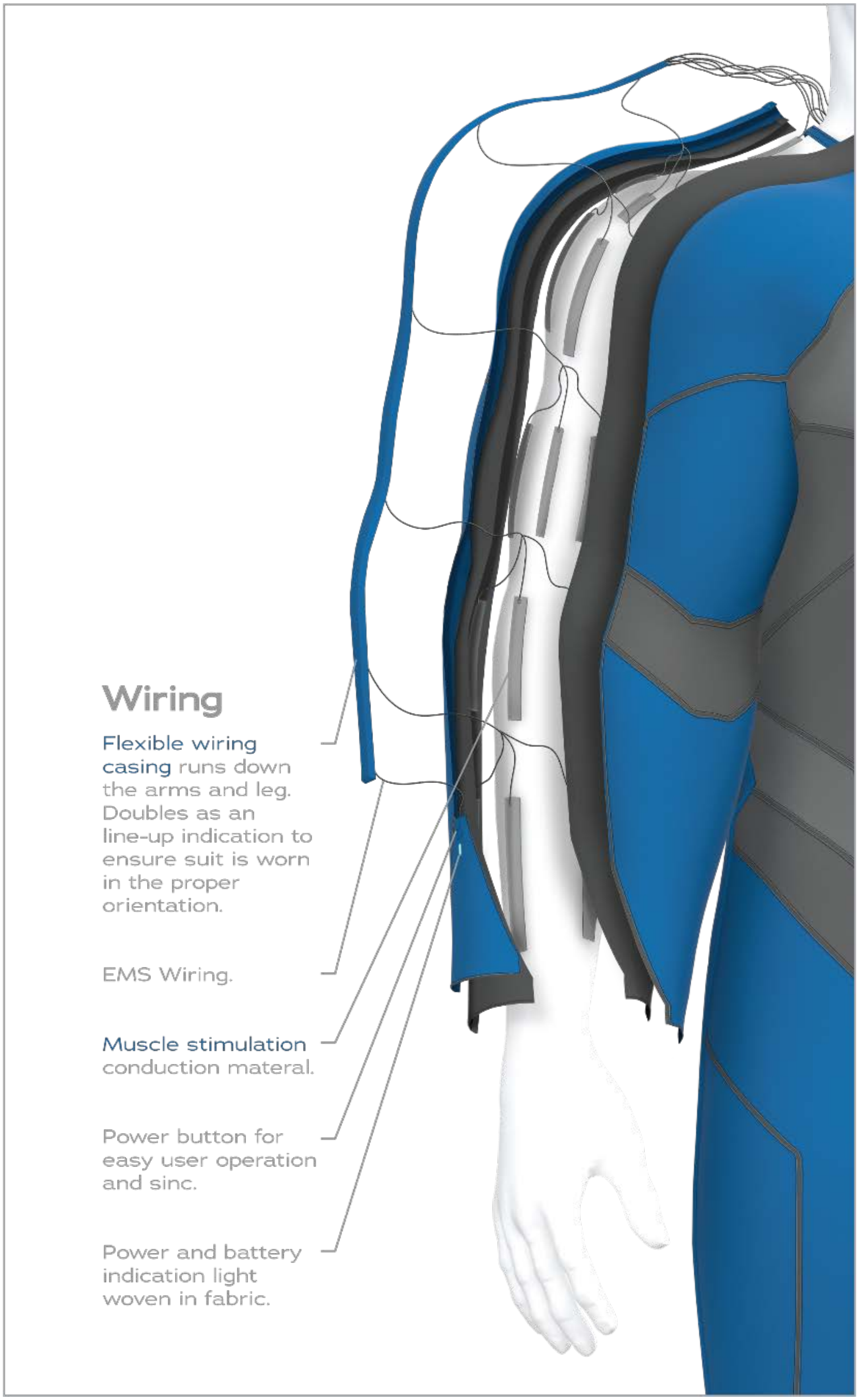



*Figure 39.* Final CAD Exploded View

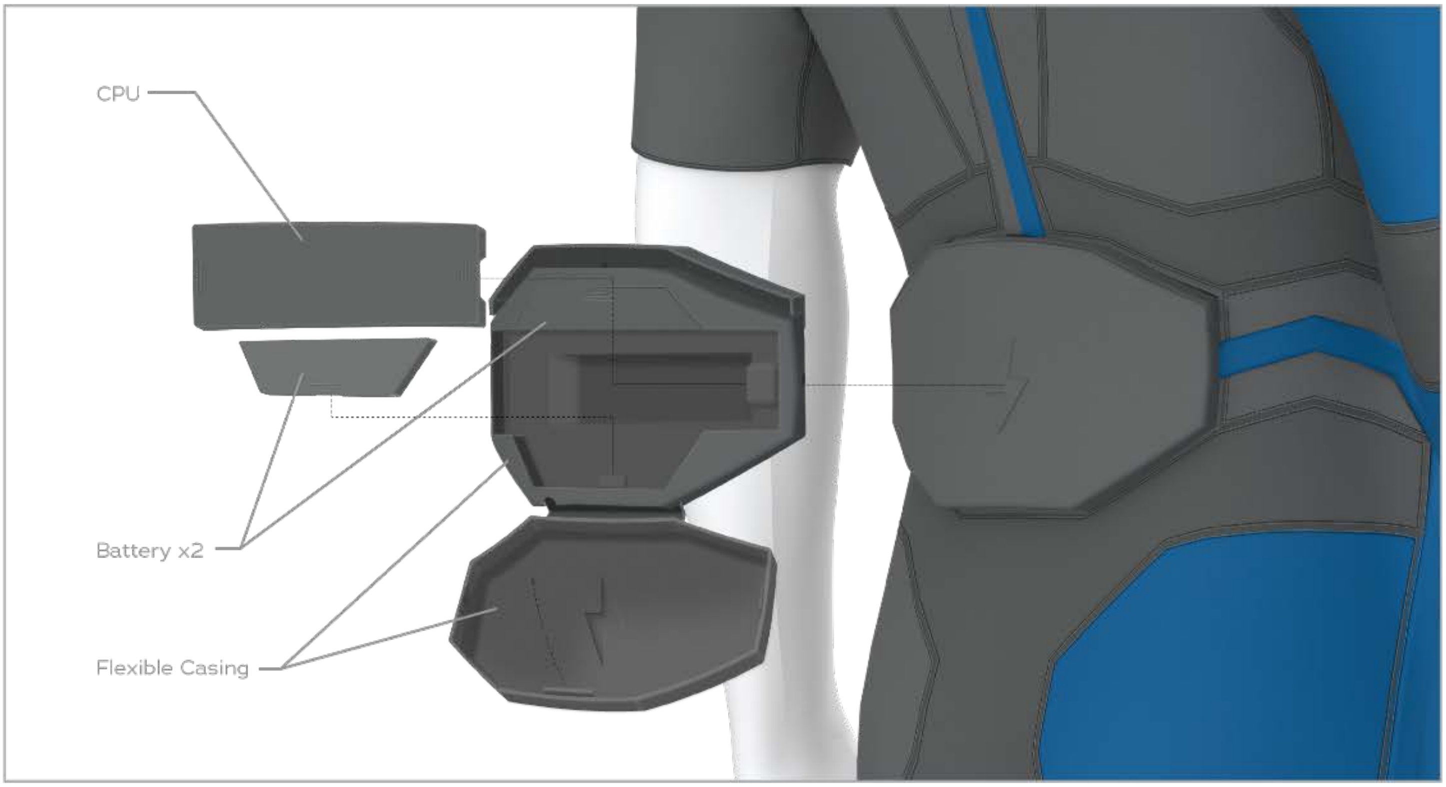



*Figure 40.* Final CAD Electrical Compartment

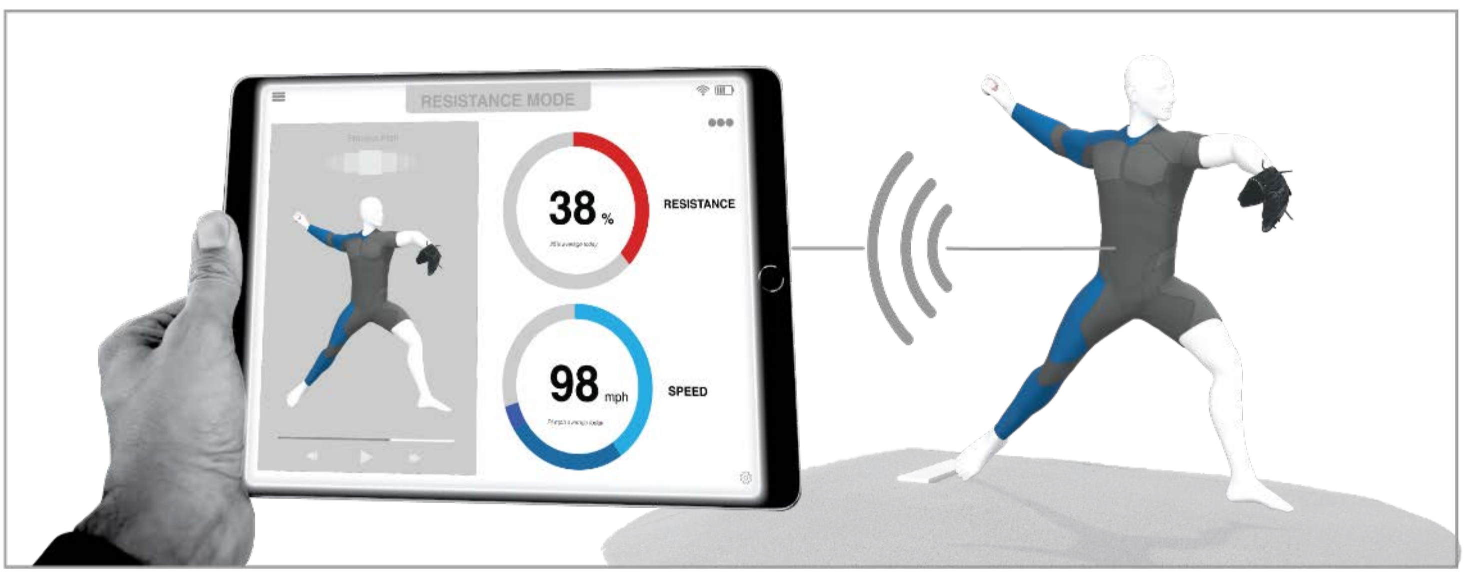



*Figure 41.* Final CAD Secondary User

## 5.4 Hard Model Photographs

*Figure 42.* Physical Model

*Figure 43.* Wire Casing Down Arm

*Figure 44.* Back Power Supply

*Figure 45.* Wire Casing Terminates Into Exterior Shell

*Figure 46.* Wire Casing Runs Along Entrance Zipper

## 5.5 Technical Drawings

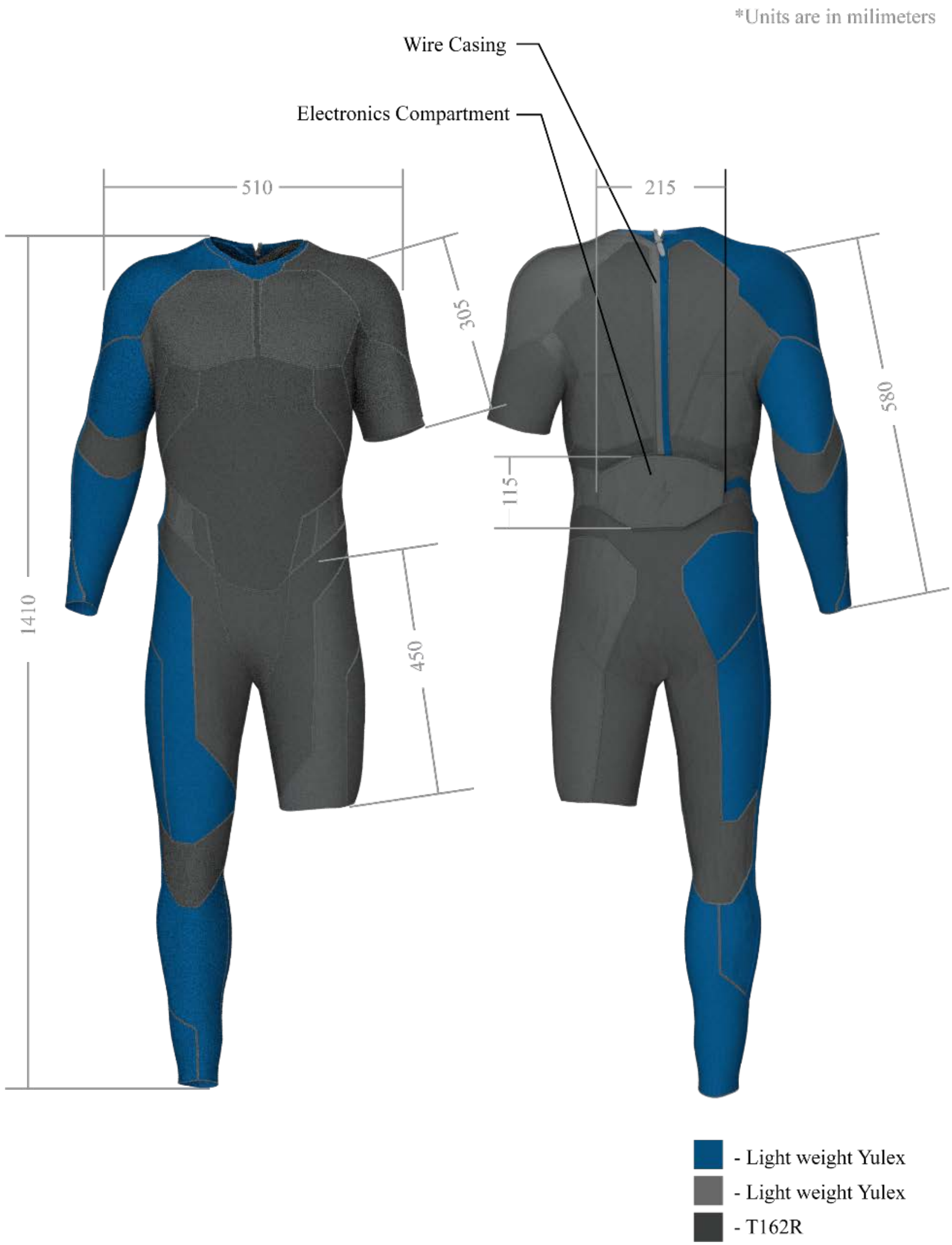



*Figure 47.* Technical Drawing

## 5.6 Sustainability

As earlier mentioned in previous chapters, sustainability of benchmarked products came in the form of product longevity, but was not well addressed in the form of manufacturing or material usage. The following will be a breakdown of the researched and chosen aspects of the new design, driven to improve overall sustainability without risking product longevity.

The areas of the suit that require a tougher material to protect the electrical nodes from impact also need to be flexible and breathable. After researching materials, a product called Yulex Pure by Yulex was discovered, which is a replacement for neoprene: a useful but environmentally damaging material. Yulex Pure is a rubbery fabric made from the guayule plant (Yulex). This rubber-like material can be seen in products currently like an eco-friendly wetsuit line made by Patagonia. “Guayule delivers high tactile performance, absence of allergenic latex proteins and offers renewable sustainability because it is resourced from a domestic plant-based resource. Yulex Pure™ guayule rubber meets the critical performance standards necessary for many medical, industrial and consumer applications and exceeds performance standards of many synthetic lattices” (Yulex). A thinner and breathable variation of the Yulex Pure will be utilized within areas of the outer shell of the suit that require more protection such as the blue areas covering most of the electrical nodes.

With the majority of the garment being comprised of a spandex like material, it has the ability to hold the largest carbon footprint. With sustainability in mind, the fabric still needs to be durable, long lasting and very flexible while remaining breathable. A company called INVISTA produced a sustainable spandex material, virtually identical to the name brand spandex, LYCRA (Donaldson, 2014). "Denise Sakuma, brand communications director for INVISTA, said the bio-derived spandex, called T162R, "is made using a different source of raw materials and is chemically identical to our other LYCRA fiber offerings. The overall lifecycle of a garment using T162R is the same as a garment using other LYCRA fibers, only that the fiber contains renewable raw materials" (Donaldson, 2014). With LYCRA being a reputable brand of spandex utilized by many companies when it comes to wearable's, having a similar yet natural material will keep the high-end feeling of the thesis suit, while increasing overall sustainability. T162R will be a suitable candidate for lighter areas requiring more mobility such as the black colored sections out the outer shell of the suit, as well as the under layer where the nodes are sewn into.

As the final product of this thesis will be a concept for future development, current conceptual opportunities for sustainability have been considered as well. The area being tackled, which this is referring to, is the battery supply. A battery prototype utilizing graphene-based quasi-solid-state lithium-oxygen batteries are currently being experimented with to highly increase energy efficiency, while incorporating a long cycling lifetime (Huang et al., 2018). These batteries can be produced much thinner, be compromised of inexpensive and nontoxic solid electrolytic components, and increase cycle life up to ten years (Shudo, 2017). Although conceptual at the moment, companies are partaking in the technology. For example, Samsung is expecting to release a phone with said battery by 2020-2021. Assuming a successful future, graphene-based quasi-solid-state lithium-oxygen batteries will be used in the suits power pack to keep it lighter and tighter to the lumbar area, while increasing the overall sustainability.

## Conclusion

E.M.-T.O.S.S. is innovative wearable technology to help professional pitchers reach the best of their athletic ability by increasing training efficiency. Providing resistance to a motion that could not be resisted with traditional means, E.M.-T.O.S.S. provides strength training for throwing, directly via the throwing motion. With multiple functions such as throwing mechanics tracking, trainer feedback and input, as well as a recovery mode, E.M.-T.O.S.S. is a personalized all around pitching tool to make top of the line athletes reach a new tier.

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# Appendix

## i Discovery

### Preliminary Information Search

**USER:**

1.

Harding, J. L., Picha, K. J., & Bliven, K. (2018). Pitch Volume and Glenohumeral and Hip Motion and Strength in Youth Baseball Pitchers. Journal of athletic training, 53(1), 60–65. doi:10.4085/1062-6050-323-16

**Objective:**

To examine relationships among cumulative and seasonal pitch volume, ROM, and strength of the GH and hip joints in youth baseball pitchers.

**Main Outcome Measure(s):**

A demographic and pitching questionnaire was used to quantify pitch volume. Glenohumeral internal-rotation (IR) and external-rotation (ER) ROM and strength of the throwing arm; total arc of motion (IR + ER ROM); and bilateral hip IR, ER, and total arc of motion ROM and strength in IR, ER, and abduction were measured. A goniometer was used to assess ROM; a handheld dynamometer, to assess strength. Frequency analyses and bivariate correlations (age covariate) described data and identified relationships.

**Results:**

Correlations between years of competitive play and increased strength in lead-leg hip IR ($r = 0.52$, $P = .02$) and abduction ($r = 0.48$, $P = .04$) and stance-leg hip IR ($r = 0.45$, $P = .05$) were fair to good. The number of months played in the last year had a fair correlation with decreased GH IR strength ($r = -0.39$, $P = .04$) and increased stance-leg hip IR strength ($r = 0.44$, $P = .05$). Limited pitch time had a fair correlation with increased GH ER ROM ($r = 0.40$, $P = .04$) and an excellent correlation with increased lead-leg hip IR ROM ($r = 0.79$, $P < .001$). Increased innings pitched per game had a fair to good correlation with decreased GH IR strength ($r = -0.41$, $P = .04$) and stance-leg hip ER ROM ($r = -0.53$, $P = .03$). More pitches per game had a fair to good correlation with increased GH ER ROM ($r = 0.44$, $P = .05$) and decreased stance-leg hip ER ROM ($r = -0.62$, $P = .008$).

**Conclusions:**

The significant relationships identified in this study suggest the need to further examine youth and adolescent cumulative and seasonal pitch guidelines.

2.

Byram, I. R., Bushnell, B. D., Dugger, K., Charron, K., Harrell, F. E., & Noonan, T. J. (2010). Preseason Shoulder Strength Measurements in Professional Baseball Pitchers: Identifying Players at Risk for Injury. The American Journal of Sports Medicine, 38(7), 1375–1382. https://doi.org/10.1177/0363546509360404

**Abstract**

**Hypothesis:** Preseason weakness of shoulder external rotators is associated with increased risk of in-season throwing-related injury in professional baseball pitchers.

**Results:** A statistically significant association was observed for PER strength ($P = .003$), SER strength ($P = .048$), and SS strength ($P = .006$) with throwing-related injury requiring surgical intervention. Supraspinatus strength was also significantly associated with incidence of any

shoulder injury (P = .031). There was an association between the ratio of PER/IR strength and incidence of shoulder injury (P = .037) and some evidence for an association with overall incidence of throwing-related injury (P = .051). No associations were noted in the subgroup of players with prior surgery.

**Conclusion:** Preseason weakness of external rotation and SS strength is associated with in-season throwing-related injury resulting in surgical intervention in professional baseball pitchers. Thus, preseason strength data may help identify players at risk for injury and formulate strengthening plans for prevention.

3.

Jeran, J. J., & Chetlin, R. D. (2005). Training the shoulder complex in baseball pitchers: A sport-specific approach. Strength and Conditioning Journal, 24(4), 14-31. Retrieved from http://ezproxy.humber.ca/login?url=https://search-proquest-com.ezproxy.humber.ca/docview/212597110?accountid=11530

**Abstract**

The purpose of this paper is to identify exercise performance-related factors which may contribute to shoulder pain and dysfunction and to describe appropriate training strategies for promoting shoulder stability and enhanced function. The intent is not to help the reader diagnose and treat injuries or to prescribe therapeutic interventions. Strength and conditioning professionals should encourage injured clients to consult a physician, physical therapist, or other appropriate health care professional before starting a conditioning program. [PUBLICATION ABSTRACT]

**Conclusion/Discussion**

The overhand throw places considerable and varied load upon the shoulder complex. The rapid transition between eccentric (i.e., cocking phase) and concentric (i.e., acceleration phase) muscle actions during the baseball pitch produces tremendous forces on and around the glenohumeral joint, contributing greatly to soft tissue microtrauma of the shoulder complex. The intention of this article was to inform the reader of the various stresses involved in the baseball pitch, as well as some of the injuries associated with such activity. Additionally, we provided a systematic and comprehensive shoulder training routine focusing on the entire shoulder complex, something that, in our opinion, has been missing from the repertoire of general strength training programs intended for pitchers. Based upon our experience, exercise training for baseball has not been as individualized or position-specific as needed; some training programs for pitchers overemphasize strengthening the rotator cuff muscles, neglecting the fixators of the scapula. Additionally, if activity analysis is not utilized, those professionals responsible for implementing strength and conditioning programs may simply prescribe exercises intended for the general population (2). Training the baseball pitcher is unique, and exercise prescription for this type of athlete should accommodate specific pitching kinematics. It is our belief that facilitating a sport-specific training program for the baseball pitcher may improve performance and reduce the incidence of injury to the shoulder complex.

4.

DeRenne, C., EdD., & Szymanski, David J, PhD,C.S.C.S.D. (2009). Effects of baseball weighted implement training: A brief review. Strength and Conditioning Journal, 31(2), 30-37. Retrieved from http://ezproxy.humber.ca/login?url=https://search-proquest-com.ezproxy.humber.ca/docview/212527258?accountid=11530

**Conclusion:**

Baseball weighted implement training is a unique but essential training protocol that is research based, injury free, and, most important, enhances youth, high school, and collegiate players' performances. These unique training protocols should receive greater attention in resistance exercise prescription for baseball players and should be incorporated into the precompetitive power training phase. Strength and conditioning coaches play the most important role in the resistance training of baseball players because they are, or should be, familiar with the majority of exercise research and throwing injury-related information available. Furthermore, they may not be biased or swayed by past baseball traditional training methods and superstitions. A future topic for baseball research would be to examine in season baseball weighted implement training to see how it affects baseball performance. This would indicate whether players' precompetitive throwing and hitting velocity increases are maintained during the competitive season with injury-free pitchers and hitters.

## Benchmarked Products:

1.

Taking a stroll with Samsung’s robotic exoskeleton. (2019).

Having taken the hip system for a bit of a spin in Samsung’s booth, I can at least say that the assistive and resistance modes do work. A rep described the resistance as feeling something akin to walking under water, and I’m hard-pressed to come up with a better analogy. The assistive mode is a bit hard to pick up on at first, but is much more noticeable when walking up stairs after trying out the other mode.

2.

"Investigators from Samsung Group Target Robotics (Delayed Output Feedback Control for Gait Assistance With a Robotic Hip Exoskeleton)." Journal of Engineering, 2 Sept. 2019, p. 1189. Gale Academic Onefile, https://link.gale.com/apps/doc/A598062168/AONE?u=humber&sid=AONE&xid=c3ddccd8. Accessed 16 Sept. 2019.

The news reporters obtained a quote from the research from Samsung Group, "In this controller, there are no separate estimators for the gait phase nor the environment, yet the controller can be generalized to operate under various walking conditions (e.g., stair and ramp walking). We first define a state variable representing the current leg's movement with hip joint angles. A simple assistance control can be described in closed-loop form with the delayed state feedback. By assigning the appropriate time-delay and self-feedback gain, we can generate assistive torques stably under the interaction between human and exoskeleton. The controller provides immediate and smooth assistance to user movement by reflecting the change of leg motion at every control period. The proposed joint-angle-based delayed-feedback assistance controller can operate under various walking speeds and environmental changes (e.g., stairs and ramps) without the need for additional sensors, computational processing, and parameter adjustment. Using a simple leg swing model, we perform a stability analysis under a simplified condition to provide insights into the effects of the time-delayed feedback in oscillatory systems. Then, we experimentally validate the efficacy of the proposed assistance controller by measuring the metabolic energy expenditure for level treadmill walking."

3.

Bokman Lim, Junwon Jang, Jusuk Lee, Byungjune Choi, Younbaek Lee, Youngbo Shim, "Delayed Output Feedback Control for Gait Assistance and Resistance Using a Robotic Exoskeleton", Robotics and Automation Letters IEEE, vol. 4, no. 4, pp. 3521-3528, 2019.

**Abstract:**

In this paper, we propose a new and simple control strategy for gait assistance with a hip exoskeleton robot. This controller is based on the time delayed, self-feedback known for stabilizing oscillatory systems under certain conditions. In this controller, there are no separate estimators for the gait phase nor the environment, yet the controller can be generalized to operate under various walking conditions (e.g., stair and ramp walking). We first define a state variable representing the current leg's movement with hip joint angles. A simple assistance control can be described in closed-loop form with the delayed state feedback. By assigning the appropriate time-delay and self-feedback gain, we can generate assistive torques stably under the interaction between human and exoskeleton. The controller provides immediate and smooth assistance to user movement by reflecting the change of leg motion at every control period. The proposed joint-angle-based delayed-feedback assistance controller can operate under various walking speeds and environmental changes (e.g., stairs and ramps) without the need for additional sensors, computational processing, and parameter adjustment. Using a simple leg swing model, we perform a stability analysis under a simplified condition to provide insights into the effects of the time-delayed feedback in oscillatory systems. Then, we experimentally validate the efficacy of the proposed assistance controller by measuring the metabolic energy expenditure for level treadmill walking. We also test and analyze the generated assistive torques and power under the different walking conditions to show the generalizability of the controller.

4.

SAMSUNG

Choi, H., Seo, K., Hyung, S., Shim, Y., & Soo-Chul Lim. (2018). Compact hip-force sensor for a gait-assistance exoskeleton system. Sensors, 18(2), 566.
doi:http://dx.doi.org.ezproxy.humber.ca/10.3390/s18020566

**Conclusion:**

Conclusions In this paper, we propose a compact force-sensor system for a hip-mounted exoskeleton for seniors comprising an FSR on both sides of a sensor plate to measure the provided force from hip motion. The FSR sensor measures flexion and extension force of the hip joint caused by hip motion only. Lateral and longitudinal forces are supported by the sensor frame structure while the assistance forces are transferred to the FSR sensors. We experimentally confirmed the feasibility of the developed FSR sensor in the exoskeleton system, the results of which are shown in Figure 7. We are currently working on implementing the sensor with the assisted walking movements of various users and are also planning to implement force control such as admittance control and impedance control in order to provide more transparent force assistance and reduce motion resistance by the exoskeleton for the users. We believe that the developed system makes it possible to achieve natural assistance by driving the appropriate assistive force.

## Expert Interview 1

**Method:**

Research will be gathered on EMS (Electrical Muscle Stimulation) Training. The method of information gathering will be to first try out the system myself, and then have an interview with the manager who operates the system. Video will be taken of set up as well as use of the machine, while any questions that come to mind during the process will be recorded over video. The following interview will be recorded by phone while key notes will be taken in a notebook. Research will mainly be quantitative, as I will be searching for more factual information on the machine and process.

**Background:**

Interviewee – Serge, EMS Fitness Studio Manager

Location – 9441 Jane Street, Vaughn, Ontario, October 7, 2019 - 1:00 pm

**Transcription:**

Q – Does the machine target mostly major muscle groups?
A – It targets 90% of your muscles, not just major but also smaller muscle groups

Q – Are you able to target areas uncovered such as shoulders, forearms, calves?
A – We do have attachments for these areas but because of wiring they would only be added one at a time and they are not usually used or used together

Q – How did it started?
A – started in Olympics in Russian and then moved to rehab clinics and is branching out.

Q – Demographic around here?
A – 20-70 years of age, different majority, people with injuries, lower range of movement or difficulty of movement. Best way to help the increase their training.

Q – Can it target specific muscle, for example upper/lower chest?
A – It cannot target between upper and lower but will target the entire chest, so if you have any injury in there it will recover the entire area.

Q – Is there a way to slow down a movement incrementally throughout a single movement?
A – Yes, based on the contraction of the machine the idea is to slow down the muscle.

Q – So to resist muscle one way is to tighten the muscle the other way?
A – Yes. Because everything is working at the same time as well, the body goes into a kind of correction.

Q – After understanding single vector of motion back and forth, how does this work for a rotation motion?
A – Yes, as the entire area is being contracted, the rotation works as these muscles work together, so the same sensation will be created.

Q – Levels?
A – Cardio 7 Hz, Relax 100 Hz, Strength 80-85 Hz

Q – Can you explain how you would max out the machine?

A – We control individual muscles in muscle level intensity. Depending on the body type you will feel differently. If you have more body fat, more muscle, the machine will react differently. We also control the depth of the pulses based on these body differences.

Q – Is there a reason someone would feel it more in for example the abdominal region?
A – It's a combination of your back, abdominal, whole core movement. So lets say if your intensity of you back is a little higher, you might feel it stronger in your stomach.

**Reflection:**

One thing that I would do differently next time are make more room for storage on my phone as the videos took up a lot of space and often stopped. This interrupted the process as the video had to be continued. A second would be to book multiple EMS Training facilities to ensure that the research is not biased.

**Key Points:**

It actually works. It was a very in tense workout that often made movement extremely challenging. There were moments where I was physically stuck in a position.

The overall feel of being in the EMS Training stats in all of its modes: Strength, Endurance, and Recovery. Realizing how it felt on my own muscles will allow me to apply in better to a product if I go down this route.

- The amount of hertz used for each stage will give me some background on how much Power that I will need. Also how the electricity is focused onto the particular muscles.
- How the feedback was received to the user as well as how the trainer interacted with the machine as information for both the primary and secondary users.

- How the machine works by not just stimulating the working muscles, but the muscles around it. This ensures that the feel is relatable to normal movement, as well as training the entire area. It uses the body to train the body.

## Expert Interview 2

**Method:**

I will be meeting with one of Humber College's varsity baseball pitchers to get an understanding of how the pitchers train. The interview will be conducted one on one, voice recorded. Important notes will be written down with pen and paper. Research will be mainly qualitative as I am seeking a better understanding of the pitcher's experience.

**Background:**

Interviewee – Matt Stoddart, Humber College Varsity Baseball, Pitcher

Location – Humber College, October 9, 2019 - 12:00 pm

**Transcript:**

Q – What is the process of training in your off-season?

A – So off season, doing a lot of weighted balls. So I'm throwing a lot of over and underweight balls. The under weight ones are more to speed up your arm. I do a lot of heavy lifting, not body building, more like 1-5 reps of squats, compound lifts mostly, deadlifts, I'll bench. I do a lot of bands, I use those daily actually, even if its in my room I do a few of them. Also for my arm I'll get five pound dumbbells and do rotator cuff type stuff. That's most of off-season stuff. I do a lot of throwing in the off-season, like 4 days a week. So I do jager long toss where you go as far as you possibly can while throwing on an arch, while throwing max intensity, and then when I finish ill o into like 90 feet. So going from 300 feet to 90 feet but finishing throwing on a dead line, trying to pull it down from doing up. But before that I'll do the weighted ball. So it's like an hour of throwing and then I'll finish with recovery type stuff like the bands and others I mentioned before.

Q – And who are you throwing with?
A – For in the winter we have a smaller facility so I'll throw into a net and use a radar gun to see how far I'm throwing and go out and out. But in the summer I'll throw with any guy that wants to play catch (on the team), like even at practice or anything like that.

Q – Do you have a lot of trainers working with you at Humber? Can you explain how that works?
A – No, we have the HPC program, which is the varsity athletic lifting thing at Humber, and they give us a program to do but a lot of guys want to do their own thing. Plus our season's so short here that you kinda wana stay as fresh as possible like when you start lifting heavy in the season you don't wana be sore or fatigued. I notice sometimes I get fatigued after lifting that week even. That's why the lifting a lot of it is in the off-season while in season it's more like maintenance. Same intensity but less volume as off-season. Same heavy weight but just less volume.

Q – Can you explain your coach interaction? Do you guys have like a pitching coach?
A – Yes we do, he gives us a routine to do. Like do your weighted balls do your long toss do your warm up and then after that well do bull pens which is throwing off the mound for a certain number of pitches that day. You kinda line it up so when you're pitching (game day) your fresh. Usually we get a week into appearances.

Q – In your week off before your game, how does that work?
A – We're almost throwing every day. You're always trying to keep you arm, trying to strengthen it and keeping it in shape. Like I will usually take two days off after I pitch but some guys won't take any, it depends on the guy. I like to take two and then throw every day up until I pitch.

Q – With the weighted ball, what are the positives and negatives of using that?
A – The negative would be, they're just starting the get big now and if you don't know what you're doing and you're just going off how you see what some guy on YouTube or Instagram doing it, you'll probably hurt your arm, which is what I did two years ago. But if you have a structured program when you know exactly when you're doing it and why you're doing it you'll get arm health, you'll be able to recover quicker, you'll throw harder. That's the first thing that happens, you'll throw a lot harder. Your arm just feels better after all after using them. Actually football quarterbacks started doing them before baseball, so baseball caught onto it as well.

Q – Do you know how you hurt your at? Can you explain the process of that?
A – So I wasn't going off a structured program off a professional. I was just going off YouTube videos of just guys doing it. I did that while playing in season and basically over exhausted my tricep. I was just over doing it. When you throw you externally rotate. What the weighted balls do is they increase your range of motion (backwards) so it could have been from over extending but its not a negative of doing weighted balls, I just didn't structure it properly. I should have done less. I ended up having to sit out for 6 months of throwing.

Q – Can you explain the opposite, the underweight ball?
A – The heavy weight works before you let go of the ball and the under weight ball trains the rest. After release of the ball. They say it speeds up your arm, or teaches you to be quicker. Say you're going to lift 500 pounds and then you life 225 pounds it will be super easy. But its like speed training, you're getting faster and faster. Personally I like the underweight balls more just because it teaches my body to move quicker and more athletic. Heavy ball for strength, underweight for fast twitch muscle fibers.

Q – Diamond setting before the game, how does that go?
A – I'm big into warming up. When I pitch I do a full dynamic warm up. Ill go for a two minute jog. Ill do different dynamic stretches like lunges and skips and karaoke, all the arm circles and all that kind of stuff. Then I'll take a two-minute break. Then Ill go from a dynamic stretch to a static stretch and I'll do all the different stuff (stretches). Then I'll do the band prehab stuff (light workout) and then from there

I do weighted balls and then from there I do long toss and then from there I pitch where I warm up in the bullpen. And then I pitch. It takes about half an hour if you do it properly, the whole warm up.

Q – When you're warming up do you practice all of the different pitches you have? How does that work?

A – Up until our bullpen I'll throw only fastballs, but when I get on the mound for the bullpen I'll throw about half fastballs half off speed.

Q – Do you every focus on single muscles? I know you mentioned rotator cuff but anywhere else?

A – Yes, legs. In the off-season it's mostly legs. I do the other parts but I try to get at least two days of legs in a week. Like deadlifts, squats, lunges and all that kind of stuff. And back. I like to keep my back strong, as well as core. Medicine ball rotation stuff.

Q – Do you find strengthening your forearm/grip strength helps?

A – Yea, that's what I need to start doing actually. Whenever I pitch at the beginning of the year, not trained to go deep into games, I'm usually sore, so I think that's something that I need to improve on is grip strength. Especially because when I do deadlifts I use straps (grip support) because I don't want to hurt anything in my arm. So I think it is something that I am lacking, some sort of grip strength workout.

Q – Can you explain post game?

A – I do sprints instead of long distance, just to get the fast twitch muscle fibers again. Ill do bands all over again, rehab bands. I do a lot of foam rolling after not before I just feel like before I do it I feel tired and tight. I'll redo a few weighted ball movements, not all of them though. I try to just hydrate as much as possible. They say the recovery is more important than anything else because of you don't then everything is going to strengthen right up and you're not re-strengthening anything. You're going to wake up the next morning and feel like a rock. I like to stretch everything especially hamstrings and all that, they feel really tight the next day.

Q – In between innings?

A – Ill try to stay hot as much as possible. If our team is having a good inning and scoring a bunch of runs (long inning) ill get a weighted ball and do holds. I wont actually release the ball Ill just hold it and go through the motions of throwing it. Other than that if it's a normal game and innings are going by fast I'll just keep a jacket on and try to stay hot.

Q – Is there anything specific besides deadlifts and squats that you use to try to increase your leg drive?

A – Yea, lunges. I should have said those first, lunges are more important for me. I do a lot of reverse lunges. There's a trainer I follow that believes the higher you lunges the faster you run the harder you throw, its just an athletic movement and ever since I started doing that is worked well for me. I like to do the leg curls for my hamstrings because I feel they're more important. I do calves but it doesn't matter as much. Well do box jumps too, sled pushes/pulls, a lot of explosive movements. Not so many accessory movements for legs, we just try to get as powerful as possible.

**Reflection:**

One thing I would have done differently and what I will end up doing, is providing a survey to the remainder of the team's pitcher to gather more information on the subject to ensure research is not biased. A second thing I would not do is host the interview in Humber's new building's gaming chairs because apparently its not only prohibited to use their computers that are located in an open area on one of their main floors, but it is also forbidden to merely sit on their chairs. Probably to find a quiet interview spot I may have to rent out a quiet study room.

**Key Points:**

- Learning about the weighted ball and how it was used was very beneficial. It showed that pitchers are currently seeking for ways to make the throwing motion more muscular strength dependent. The positives and negatives of this tactic will be taken into account.
- I was unaware that there was such thing as an underweight ball. Seeing the benefits of this could lead to the proof of my secondary use planned for the thesis solution. There is something there when it comes to propelling or making the movement easier and faster.
- A strong leg focus as they are the initial power factor of the baseball pitch. This realization means that the thesis solution should have a strong focus on leg drive.
- Learning how pitchers act mid game could aid into the thesis solution, possible something that could be used in this fast and changing time frame. Pitchers are currently seeking ways to stay warm and put forces on their arms between innings.

As the interviewee had a strong focus on recovery and cool down, it would be beneficial to tackle this area as well. Looking at how the pitcher currently cools down will enable me to figure out it is possible to do it more efficiently

## ii User Research

### User Profile Report

**Demographics**

A search will be conducted of images and articles related to recent baseball demographics. Key word searches include: “baseball demographic”, “baseball pitcher and trainer”, and Blue “Jays Roster”. Note will be taken of age, ethnicity and gender. Income/purchasing power will vary as target is for both professional and amateur pitchers, yet professional pitcher demographic will have a greater influence on amateur pitcher demographic.

**Literature Search**

Data from a study of major league baseball demographics over the years 1947-2016 indicates that the majority are Caucasian (Armour and Levitt). The latest year of 2016 indicated that 2.1% were Asian, 6.7% African American, 27.4% Latino, and 63.7% Caucasian (Armour and Levitt). A second study indicated the difference between Latino and African American, stating that Latinos surpassed African American in 1993 and have been on a stead incline in relativeness ever since (Anzil).

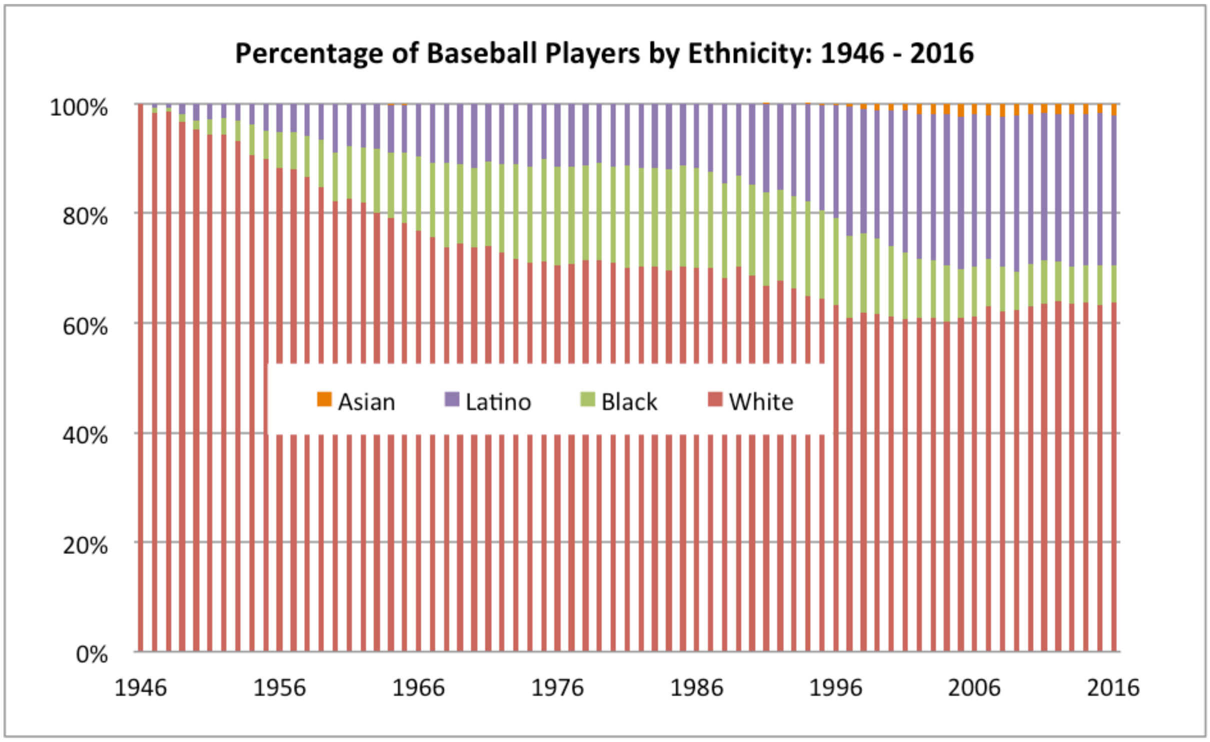



Figure 4. Percentage of Baseball Players by Ethnicity. (Armour and Levitt)

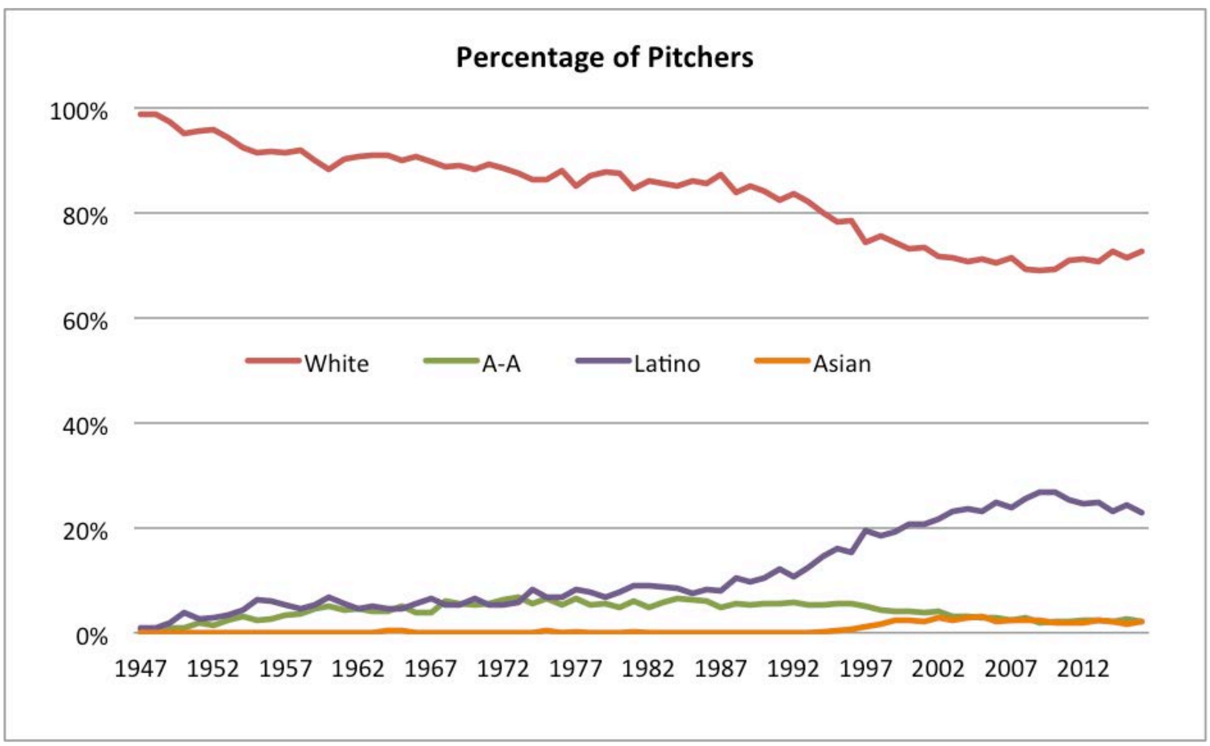



Figure 5. Percentage of Pitchers. (Armour and Levitt)

### Conclusions

Image and literature search conclude that the demographic is dominated by Caucasian males ages 20-35. Latino males are a much lesser influence but seam to have a positive increase of presence in the near future.

### User Behavior

Research will be conducted of user behavior along related activities and products. Key search words include: “pitcher training frequency”, “pitcher off-season training”. The goal will be to determine how often pitchers train during and away from game time performance. How, where and when the pitcher is in training will be key information for future progress.

### Evidence

The Washington Post reported an article about the importance of spring training saying that only pitchers need such a display after coming out of off-season training (Kilgore, 2017). “ They need two months spent in a warm locale, in order to build stamina and strength in their throwing arms slowly enough to limit injury risk (Ellis, 2019).”  During the season, an average pitching/training/rest routine includes:

| Days of rest | Pitcher's routine |
|---|---|
| Game day | Pitch 7-9 innings or throw 90-115 pitches on a pitch count |
| Day after | Full stretching and medi-ball program. Jog 10 polls; 10 sets of 60 yard sprints, run 2, walk 1; 25 pick ups. Light weight maintenance work. Toss easy on side lines. |
| 2 days after | Full stretching and medi-ball program. Jog 10 poles; 10 sets of 60 yard sprints. Light weight maintenance work. Play catch and drill work. |
| 3 days after | Jog - Stretch - Warm Up. Bullpen work at 3/4 speed or 8-10 minutes of BP. Run sprints. |
| 4 days after | Day previous to next start. Jog - stretch - shag B.P for pitcher. Short bullpen work for 5-6 minutes, 1/2 speed, at 52-55 feet. No running or sprint work. |

Figure 6. Pitching on Four Days Rest. (Ellis, 2019)

### Conclusions

The user will be training multiple days a week, varying in frequency dependent on the time of year or games pitched. High volume opposed to other positions is not uncommon. Pitchers will often work with trainers or soft toss with a teammate. Much time is spent throwing after full body exercise is completed.

### User Profile

Research will be conducted from a different perspective looking into future pitcher and what they will or now face. The amount of activity that up and coming pitchers participate in will be tested against MLB pitchers. As well, it will seek to find if there are any obstacles young pitchers face that proven pitchers currently employed do not.

### Evidence

The Washington post constructed an article based around the next generation of pitcher and how they are coming up opposed to current professionals. “When young pitchers are put on the Nationals’ throwing program, they are suddenly throwing every day, upping their workload from what it might have been in the collage when games are less frequent, even for starters, who are used to getting a week of rest instead of the big-league four (Janes, 2017).” A common obstacle stated in the article is in the form of injury awareness saying, “-complicated for young pitchers, most of whom do not want to admit to a brand-new coaching staff – one that, in part, controls their professional future (Janes, 2017).” The New York Times published an article of a Q and A regarding former pitcher Orel regarding changes from when he played. When asked about the banishment of pitch counts by his former team and how this might affect upcoming players he stated: “It’s all about the abilities of the pitchers. So if they start to get unbelievable pitchers in Texas and they allow them to go past 110, 120, 130, 140 pitches, then you’ll have something to evaluate. But until the quality of the pitcher allows somebody to throw Pitch 111 to 140, you’re not really going to get a view of it. It might take a generation of Texas pitchers in the minor leagues to go deeper in the games. But it doesn’t do you any good to let somebody throw 130 pitches in five innings and say he’s tougher, but he gave up 11 runs. (Hershiser, Helping out next generation, 2010)” referring to the expectations of a pitchers extended performance.

### Conclusions

It seams as though the demand for a pitcher’s ability to last long sessions of throwing is increasing as the market for new pitchers increases. Removal of aids to limit pitchers such as pitch counters means that the ability of the pitcher to last in an MLB setting is more gambled.

## Persona

### Persona

The persona of our target demographic is a white male, between the ages of 20-35 who is physically active at least five days a week. He is a pitcher who has large muscular demands in areas like the arm and shoulder when it comes to repetitive movements. This person is frequently met by a trainer, coach or training partner for physical and performance improvements. Focus includes strength, pitching mechanics, and ball velocity.


Figure 7. Jay's Pitcher. (Canadian Press, 2018)

**Conclusions**

Although strictly worded, this persona will waver for reasons like the increase in Latino pitchers as discussed above. Collage level pitchers may also be targeted secondly but as a primary, for the amount of technology used, professional athletes will be the most dominant persona.

## User Observation Report

### Needs Statement

How might we increase a baseball pitcher's muscular strength while they perform pitching mechanics drills, bridging the gap between training for strength and training for throwing ability?

### Description

The reason for doing a user observation will be to determine if the way a pitcher trains can be improved. We will need to decide if this area of research is suitable for a proscribed product solution.

### Research Objectives

The objectives if this observation will be to better understand how pitchers currently train for their sport both on and off the field. Specifically looking into muscular strength, we need to understand the athlete's current process.

### Key Activities

The observation will be to see what drills a pitcher does, what is being worked on, what the difficulties are, and where are the holes in the training. The observation will also look to see if there are any unfortunate disconnects from pitching itself, and if there are any current limitations due to lack of a solution

### Target Users

Users in question are first and foremost the pitchers themselves, but the trainers or people guiding the training and/or results will be a strong primary candidate.

### User Environment

The environment of the main observation will be an outdoor field training session. The training is between a single pitcher (MLB's Justin Verlander who formally played for the Detroit Tigers) and his trainer (who is an MLB pitching trainer for the Detroit Tigers). It takes place in an open field of short cut grass on a flat area, appearing to be windy. It looks to be mildly warm as the pitcher is wearing shorts and a t-shirt while the trainer is wearing shorts and a long sleeve windbreaker jacket. Surrounding bystanders are in pants and a t-shirt. The session then moves to a fitness facility with weighted equipment. It is an indoor controlled environment. In the preliminary video the observation is of indoor training around weighted equipment. It is a controlled environment containing only the trainer (who is a sports specific strength and conditioning trainer), the athlete, and the cameraman.

**Preliminary Video Observation**

**Preliminary Scoping**

“Baseball Specific Upper Body Training – Overtime Athletes”

URL: https://www.youtube.com/watch?v=VCsWLFnsZYQ

10:02

“Trevor Bauer’s Training Regimen at Driveline Baseball”

URL: https://www.youtube.com/watch?v=p5rg6b2Am-U

2:31

“6 Steps to Pitch Like a Pro – Pitching 101”

URL: https://www.youtube.com/watch?v=yKEECB9S150

9:47

**Video Observation**

Overtimeathletes. (2018, April, 15)). *Baseball Specific Upper Body Training – Overtime Athletes*

[Video File]. Retrieved from https://www.youtube.com/watch?v=VCsWLFnsZYQ

**Activities in order:**

- Overhead medicine ball momentum throws for sets rotating stance leg
- Alternating medicine ball twist throws from kneeling position alternating kneeling legs
- Same but on upward angle and then same but on downward angle
- Medicine ball momentum throws from hip replicating leg drive from core and lower body strength
- Explosive medicine ball vertical pushes from laying down position on back to focus on explosive arm strength
- Strength building low rep high weight bench press for decreasing sets
- Static bench press for time
- Cable one arm incline twisting pulls focusing on core shoulder and arm strength
- Band incline core twists focusing on core and slight shoulder activation
- Same but decline
- Band triceps push-downs single are alternating

Of the activities, the candidates for observation would be anything that revolves around full body interaction, mainly core, leg and shoulder development as these are the most prudent areas for increasing pitch velocity. Especially looking into twisting motions replicating movements in pitching. Four would be activities 1, 2, 4, and 8.

## User Observation

Chronology

**Agility**

*Figure 1.* Agility (Stack, 2013)

1 – Dynamic warm-up

- Waling toe touches
- Walking foot grabs
- Walking knee ups
- Huggers
- Lung cross-overs
- Side steps

2 – Latter foot rotation Drill

- 90 degree rotations of the trunk for time
- 180 degree rotations of the lower body for time and speed

3 - Planked elbow to knee for mobility and balance

**Explosive**

*Figure 2.* Explosive (Stack, 2013)

4 – Half moon single leg steps in and out

- Each movement the trainer tosses a ball which the pitcher catches
- The ball is a football to make catching easier and removing focus of the catching aspect and placing it more towards the movements

5 – Half moon ground ball pickup

- Pitcher moves around semi circle stepping in with one leg as the trainer rolls a baseball to the pitcher
- The drill incorporates movement speed and agility to a more refined motor skill training
- Focus on explosiveness of the drive leg

6 – Overhead med ball throws

- Ball placed on ground, pitcher grabs with both hands and swings ball into air over head
- Working on shoulders back, core and legs for explosive power through the hips
- Using lighter weight that can be moved very quickly
- Full body movement

7 – Split squat switch jump with medicine ball catch and toss

- Working on core especially with legs while using the med ball to work on coordination
- The lower the ball was thrown the deeper the athlete had to lung, increasing leg requirement
- Plyometric intensity, trying to stimulate multiple areas by incorporating the ball

*Session moves indoors to weight room*

**Strength**

*Figure 2.* Explosive (Stack, 2013)

8 – Balanced dumbbell lunge toe touches

- While balanced on a 2 by 4 in a lunge position, the athlete touches a single dumbbell to his front foot
- Working on controlled strength as well as balance
- Somewhat replicating the motion of reaching for a ground ball
- Front foot and hands are alternated between sets of 6

9 – Scrap six-pack routine

- Stomach on a physioball on top of an incline bench, the athlete is bent over holding resistance cables in each hand
- Hands are stretched over head, out to the side, and then out to the back
- Each held for time and then repeated the group of three motions six times
- Focus on shoulder strength as well as balance providing a static load on the shoulder while load increases as muscle tightens

10 – Squat

- High rep warm up moving to higher weight strength training for leg dominant strength
- Large compound movement for strength building
- Pyramid sets up to high weight and then dropped back down to initial starting weight
- Improving leg power for pitch drive

11 – Weighted alternating lunge

- Weighted vest and dumbbell in each hand
- Lunging alternating down the length of the gym
- Improving one leg power and strength

12 – Box split squat

- Balanced single leg balance and strength exercise
- On box, squat down to just over ground level without touching the ground

13 – Same thing with slight weight bar placed horizontally in both hands out front

14 – Physioball leg curl

- Multi joint stability in hips focusing on glute and hamstring strength
- Superset with glue ham raise focusing on same but with more lower back and glute activation

15 – Flamingos superset with ball catching RDL

- Flamingos are stability, catching and resisting the impact of catching the weighted ball
- Mixed with rear deadlift of same ball that is caught and thrown between trainer

16 – End of video, which is probably followed by a small cool down

## iii Product Research

### Product Research I Benchmarking

#### 1 BODYTEC: AQ8

https://theemstraining.com/?gclid=Cj0KCQiA-4nuBRCnARIsAHwyuPrppVg-voDySGXj0yMxIeHYfiMfP0MXeySP-TkhFF8Tcil7Q6OV8dwaAkdpEALw_wcB

Description

The AQ8 is a full-bodied electronic muscle stimulation suit developed and sold by BODYTEC Technologies. The suit is hooked up to a battery on the body and controlled wirelessly. The suit sends electrical currents throughout the body to stimulate and contract muscles in a similar way to how the brain communicates with the muscles of the body. This suit is designed for universal wear to fit many body types and sizes. Intended for commercial use, the suit is marketed as so, toward owners of EMS training fitness centers as well as personal trainers. Marketed as a faster and more efficient way to train the body, the suit can affect the user in strength, cardiovascular and recovery aspects of their training with its separate modes. The suit is compatible with a separate interface system. This system is intended for use by the secondary user (trainer) and controls all aspects of the suit.

**Specifications (Features and Benefits)**

- Up to 8 simultaneous users
- 5 year warranty
- 72 hour battery life
- 6800mA 6 cells lithium
- 5 km wireless signal range
- 20 minutes per workout
- Activate 300 muscles at a time
- Rapid weight loss, toning, muscle building, rehabilitation, cellulite reduction and rejuvenation
- Carbon rubber electrodes
- Odourless and antibacterial

#### 2 Visionbody: TRA NIN3

https://www.vision-body.com/en/powersuit-eng


Description

The TRA NIN3 is a full-bodied electronic muscle stimulation suit developed and sold by Visionbody. The suit is hooked up to a battery on the body and controlled wirelessly. The suit sends electrical currents throughout the body to stimulate and contract muscles in a similar way to how the brain communicates with the muscles of the body. This suit is designed for universal wear to fit many body types and sizes. Intended for commercial use, the suit is marketed as so, toward owners of EMS training fitness centers as well as personal trainers. Marketed as a faster and more efficient way to train the body, the suit can affect the user in strength, cardiovascular and recovery aspects of their training with its separate modes. The suit is compatible with a separate interface system. This system is intended for use by the secondary user (trainer) and controls all aspects of the suit.

**Specifications (Features and Benefits)**

20 pulse patches
Waterless
Quick dry
Washes easily
Bi-elastic high-tech fibres
Precisely times muscle stimulation
Duty cycle variation
Compensate imbalances
Automatic frequency adjustments
Easy put on without help

### 3 XBODY: XBODY Training Suit

https://xbodyworld.com/xbody-accessories/#xbodyonline


Description

The XBODY Training Suit is a full-bodied electronic muscle stimulation suit developed and sold by XBODY. The suit is hooked up to a battery on the body and controlled wirelessly. The suit sends electrical currents throughout the body to stimulate and contract muscles in a similar way to how the brain communicates with the muscles of the body. This suit is designed for universal wear to fit many body types and sizes. Intended for commercial use, the suit is marketed as so, toward owners of EMS training fitness centers as well as personal trainers. Marketed as a faster and more efficient way to train the body, the suit can affect the user in strength, cardiovascular and recovery aspects of their training with its separate modes. The suit is compatible with a separate interface system. This system is intended for use by the secondary user (trainer) and controls all aspects of the suit.

**Specifications (Features and Benefits**

- Built for professional studio use
- Shoulder attachment
- Front and back separation
- Extra large electrodes
- Maximum comfort and durability
- Modular system provides flexibility
- Unisex fit
- Modular design for customization
- 5 year warranty
- 12 channels
- Durable structure
- Vast array of sizes from XXS to XXL
- Miniaturized EMS device
- Wireless
- Magnetic cable
- Quick pairing with NFC
- Indoor outdoor
- 12 hour battery life

## 4 BODYTECH: Model-907/906

https://www.bodytech-emsfitness.com/ems-fitness/ems-fitness-machine/ems-training-suit.html

Description

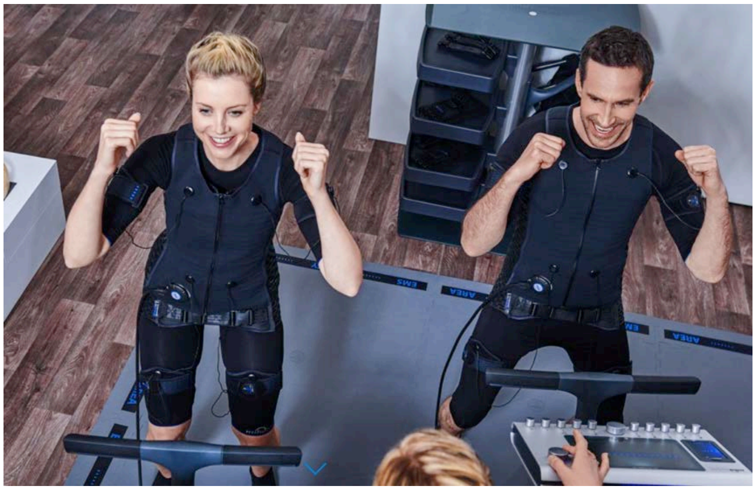
The Model-907/906 is a full-bodied electronic muscle stimulation suit developed and sold by BODYTECH. The suit is hooked up to a battery on the body and controlled wirelessly. The suit sends electrical currents throughout the body to stimulate and contract muscles in a similar way to how the brain communicates with the muscles of the body. This suit is designed for universal wear to fit many body types and sizes. Intended for commercial use, the suit is marketed as so, toward owners of EMS training fitness centers as well as personal trainers. Marketed as a faster and more efficient way to train the body, the suit can affect the user in strength, cardiovascular and recovery aspects of their training with its separate modes. The suit is compatible with a separate interface system. This system is intended for use by the secondary user (trainer) and controls all aspects of the suit.

**Specifications (Features and Benefits)**

- Water needed
- Wear resistant and durable
- Android or IOS
- Six training programs
- Bluetooth
- Magnetic attachment
- 300 meters connection
- Adjustable straps
- Hidden cables and nodes
- Removable nodes
- Comfortable, flexible, versatile
- 150g
- Battery capacity: 2650mAh – 3.8V
- Output voltage: 0-50V DC square wave
- 3 month warranty
- Indoor outdoor

## 5 Miha: i-body

https://www.miha-bodytec.com/en/products/i-body/



Description

The i-body is a full-bodied electronic muscle stimulation suit developed and sold by Miha. The suit is hooked up to a battery on the body and controlled wirelessly. The suit sends electrical currents throughout the body to stimulate and contract muscles in a similar way to how the brain communicates with the muscles of the body. This suit is designed for universal wear to fit many body types and sizes. Intended for commercial use, the suit is marketed as so, toward owners of EMS training fitness centers as well as personal trainers. Marketed as a faster and more efficient way to train the body, the suit can affect the user in strength, cardiovascular and recovery aspects of their training with its separate modes. The suit is compatible with a separate interface system. This system is intended for use by the secondary user (trainer) and controls all aspects of the suit.

### Specifications (Features and Benefits)

- Durable electrode material
- Permanently elastic stretching areas made of latex free silicone
- Magnetic connection
- Anti-bacterial materials
- Compression pads used for placements of nodes
- Spun-dyed yarn and special knitted structure for high flexibility and durability

## 6 Easy Motion Skin

https://easymotionskin.com/easy-motion-skin-tour/

**Description**

The Easy Motion Skin (Studio Edition) is a full-bodied electronic muscle stimulation suit developed and sold by Easy Motion Skin. The suit is hooked up to a battery on the body and controlled wirelessly. The suit sends electrical currents throughout the body to stimulate and contract muscles in a similar way to how the brain communicates with the muscles of the body. This suit is designed for universal wear to fit many body types and sizes. Intended for commercial use, the suit is marketed as so, toward owners of EMS training fitness centers as well as personal trainers. Marketed as a faster and more efficient way to train the body, the suit can affect the user in strength, cardiovascular and recovery aspects of their training with its separate modes. The suit is compatible with a separate interface system. This system is intended for use by the secondary user (trainer) and controls all aspects of the suit.

**Specifications (Features and Benefits)**

- Indoors and outdoors
- Wireless
- Bluetooth
- App controlled
- Antibacterial
- Light, durable, washable fabric
- Dry electrodes or damp options

## 7 Innline: EMS PRO FULL

https://innlineglobal.com/ems-innline-pro-full


### Description

The EMS PRO FULL is a full-bodied electronic muscle stimulation suit developed and sold by Innline. The suit is hooked up to a battery on the body and controlled wirelessly. The suit sends electrical currents throughout the body to stimulate and contract muscles in a similar way to how the brain communicates with the muscles of the body. This suit is designed for universal wear to fit many body types and sizes. Intended for commercial use, the suit is marketed as so, toward owners of EMS training fitness centers as well as personal trainers. Marketed as a faster and more efficient way to train the body, the suit can affect the user in strength, cardiovascular and recovery aspects of their training with its separate modes. The suit is compatible with a separate interface system. This system is intended for use by the secondary user (trainer) and controls all aspects of the suit.

### Specifications (Features and Benefits

- 22 muscle stimulation points
- Unisex suit
- Suit personalization for brand
- Additional calf stimulation
- Magnetic connection
- Independent stimulation (biceps to triceps)
- Individual suit combinations
- Large electrodes
- Replicable battery
- 6 hour battery life
- 6 participants at a time
- Indoor outdoor
- Up to 125hz
- Unisex fit
- Impulse bipolar, positive and negative

## 8 SKILZ: Weighted Baseballs

https://innlineglobal.com/ems-innline-pro-full/


**Description**

Over weight and under weight balls are a common current technique for training a pitcher's arm. The over weight ball is used for strength and dynamic stretching while the under weight ball is used to work on the fast-twitch muscle fibres in the arm. It is a simple but effective method used often in pitchers training regimens.

**Specifications (Features and Benefits)**

- 12 and 10 oz.
- Standard size for feel
- Training and warm up use
- Colour coordinated

## Product Research II Benefits and Features

### Method

A frequency analysis of the features and benefits seen in the promotional material will be conducted. We will first see the top five most commonly used words/phrases of each and then record the amount of time these phrases are seen. This data will be used to see what the most important elements that marketing thinks will sell their equipment and in turn provide a focus for the thesis solution.

### Key Benefits

| Benefit | Times Seen |
|---|---|
| Muscle Development | 13 |
| Comfort | 12 |
| Clean./Hygiene | 8 |
| Short training time | 7 |
| Mobility | 5 |

### Key Features

| Feature | Times Seen |
|---|---|
| Wireless | 15 |
| Battery Life | 8 |
| Magnetic | 6 |
| Dry Nodes | 6 |
| Indoor/Outdoor | 6 |

## Summary/Discussion

### Overall Feature Comparison

As promotional material was mainly to sell a buyer the whole service as a package (suit, control interface, product support, and various service features) suit specs were limited. The main specs that seemed to be apparent and would benefit the thesis would be to have the solution wireless and dry nodes instead of wet nodes as the suit prep time and ease of use would be positively affected. Some battery specs will help with sizing the battery in the design, while making the wire connections magnetic will be a good idea. As suits were intended for use by a population of members, construction seemed to be centered around adjustability and frequent use. The all black colour schemes and cluttered appearance may be off putting to someone who does not know how to fasten or put on the equipment. More visually advanced suits solved this with colour contrast and a sleeker design with hidden components. The thesis solution will take note of both the positives and negatives seen in this comparison.

### Features Comparison

For functionality, most suits preformed similar. Suits with wired attachments (i-body) greatly suffered in freedom of movement while suits with strong muscle coverage (XBODY) often needed a bump in freedom of movement. The winter of the form category being the TRAN NIN3 had a well-rounded and attractive look but accomplished this by sacrificing the “one size fits all” claim. The same garment that was successful with form was also successful with its interfaces, as the two seem to coincide with each other. Although a trainer for help will accompany most of the member’s interaction of these, i-body does not market it this way nor need it. While the thesis solution will be used by a primary (pitcher) and secondary user (trainer), it will also be intended for solo use. The interface of the solution should follow in the top right of this chart, being visually sound with high colour contrast to help indicate points of importance.

**Key Benefits/Features**

Key benefits for promotion include muscle development, comfort, cleanliness, shortened training time, and mobility. As muscle development and shortened training time are the purpose of the garment, they should be displayed in the final solution but will not be much of a selling point for these products as they all complete this task quite equally. Areas that stood out for thesis improvement are cleanliness, comfort and mobility in order of most informative to least. Research into proper materials will satisfy these areas. Key Features in these promotions include wireless technology, battery life, magnetic connections, dry nodes and outdoor capabilities. Wireless technology and battery life are a must for the thesis solution, but battery capacity will play a role in properly sizing the schematic of the thesis product. The ability to have the nodes dry instead of wet was a new discovery and very beneficial for the interaction of the design. Magnetic connections will need to be implemented to ensure longevity of the connections, as dynamic movements will be repeated while in use of the suit. Looking into what makes the outdoor products “outdoor” will inform design, as use of the thesis solution will need to also accompany a baseball diamond environment.

# iv Needs Analysis

## Needs Statement 1 – Data

**Objective:** To generate a needs statement for your product.
To identify main benefits for comparable products.
To relate product benefits with fundamental human needs.

**Method:** Promotional media (literature/internet) of comparable products are researched and evaluated to determine benefits and design opportunities for your product category.

Product benefits are linked to latent needs (in this case consider fundamental human, and their relative importance to the design of a new product).

**Topic:** Baseball pitcher strength training

**Preliminary Needs Statement**
Product for practicing pitcher which:

- Strengthens fundamental muscles needed for specific athletic movement
- Does not have same mental disconnection as training at a fitness center, while being discrete on the user

**Purpose:** Training / Competition / Recovery

### *360 initial inquiry*

**Who** are your target market group? Professionally MLB Pitchers
**What** does it do? Strengthens specific muscles for athletic movement
**Where** will it be done? Practice grounds and on diamond
**When** is it done/used/needed? Day time/training time
**Why** is it needed? Athletic performance increasing and possibly recovery

***Thesis Topic***
*Product that improves athletic performance of baseball pitchers*

***Benefits that bracket topic***
1. Improves athletic strength in a simulated gameplay setting
2. Is discrete for the user

**Benefit #1: Products that offer strength training for user**:

- Bat weight
- Weighted baseball
- Resistance bands
- Free weights

**Benefit #2: Products that are discrete for the user:**

- Samsung GEMS-H
- Harvard multi joint exoskeleton

***Statement of Need***

Strength training device, which affords:

1) Durability
2) Use of individual or entire team

Specific needs to be considered include:

- Social belonging
- Durability of use
- Flexibility of what it can be used with
- Portability
- Flexibility of who it can be used by

**Table: Benefits and Corresponding Fundamental Human Needs**
**Pitcher Strength Training**

| | ***Benefit*** | ***Possible Corresponding Fundamental Human Needs (FHN)*** | ***Relationship between Benefits and FHN*** |
|---|---|---|---|
| | Comfort | Control, security, self-esteem (mastery) | strong |
| | Style | Esteem, belonging, aesthetically pleasing | moderate |
| | Efficiency | Accomplishment, autonomy, self-esteem | strong |
| | Ease | Accomplishment, autonomy, protection, security, control, self-esteem (mastery) | strong |
| | Fun | Leisure (excitement), Participation, Belonging (shared fun) | moderate |

**Comfort** in this context is increasing the sensory experience for the user of being able to pitch normally while using the product. It means that the product does not weigh down the user in a way that was not intended.

Comfort also includes the control the user has on the resistance or lack of when using the product.

**Security** is knowing the product will work, and work well.

**Style** is important as to make the user want to use it. It needs to look the part as well as be functional

**Efficiency** is the most important as it has to aid the user correctly and better than what is currently available.

**Ease** is related to efficiency, but more in terms of how the user is able to get what they want out of the product effortlessly.

**Fun** related to **leisure** can be achieved by the product and is a good way of making sure that it will be continue to be used.

***Statement of Need***

A product for professional pitchers that will help increase fundamental strength (**control and mastery**) while being discrete on the body and possibly having a rehabilitation aspect (**comfort and security**).

Strength training in sports is often done in a team setting, which means **esteem** can be achieved from good styling/quality of the device.

**Control** and **mastery** of the device is granted from the performance of the device onto the user (**effectiveness, ease** and **comfort).**

## Activity-Experience Graph – Data

**Organizing the Data**

**Key Activity 1: Agility Training**

Mostly working on footwork and full body movements, this training is seen to increase overall athleticism and is a lesser focus of the thesis topic.

**Key Activity 2: Explosive Movements**

Mostly focusing on core and leg drive, this training can be a target of the thesis topic.

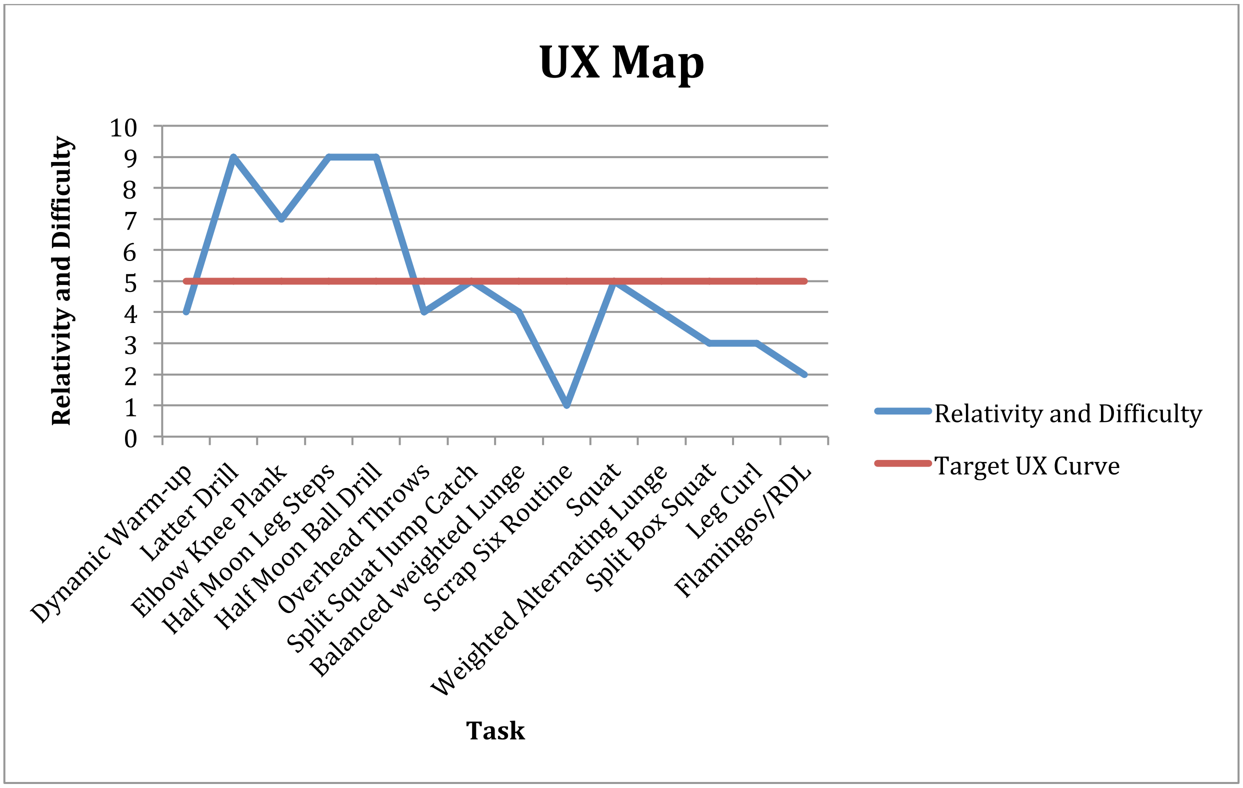
**Key Activity 3: Strength Training**

Building strength in muscles, which influence ball velocity greatly. This section will be the most relevant for the problem at hand.

**User Experience**

**User Experience Map**

Due to the fact that the observation was not of an existing product, data collection could not be determined based on the difficulty on the user experience of that non-existent product. Because this thesis will yield a new solution to athletic training of pitchers, the 0-10 was instead a depiction of the relativity and difficulty of the tasks relative to the potential solution. If the currently task was sufficient and not relative to the thesis then it received a higher mark. If the task was relative to the thesis objective and had areas where it could be looked at to be improved or implemented, then that tasked received a lower mark. This ensured that the graph still had the same idea and functionality, but was more relevant and usable for the type of research being done.




**Potential User Experience Improvement Chart**

| Task | Current UX | Potential Improvement |
|---|---|---|
| Dynamic Warm-up | 4 | 1 |
| Overhead Throws | 4 | 1 |
| Balanced Lunge | 4 | 1 |
| Scrap Six Routine | 1 | 4 |
| Weighted Alt. Lunge | 4 | 1 |
| Split Box Squat | 3 | 2 |
| Leg Curl | 3 | 2 |
| Flamingos/RDL | 2 | 3 |

**Overall Analysis**

The major observations, which inform design, are how the pitcher trains strength. In both videos, the pitcher used multi joint movements on order to incorporate most of the body. These movements somewhat replicated the motion of throwing through direction, but did not copy it to a point because, it was mentioned, motions that we too close to throwing but still off from throwing might mess up the muscle memory of throwing mechanics. Learning this was a good sign for a potential solution. The main movements they used to improve these areas that were mentally disconnected from throwing were the Scrap Six Routine, Flamingos mixed with RDLs, and the balanced Split Squat. These observations need to be combined with the EMS training research and participation that was done earlier, while further look into muscle mechanics of throwing will be researched. Although the task was to do physical observation, I do believe that this video was a better choice given the circumstances. Since baseball is out of season, there is no user observation to be found. Beside the point, finding a full-length training session of a very popular MLB pitcher was more than I could have asked for with any kind of physical interaction. As if baseball was in season, I maybe could have sat in on some Humber Baseball training for example, but it would not have been nearly as informative as this uncut training of a professional player by a professional trainer with deeper insight speeches. Although it says 10% off if the observation is over video, I ask for you to reconsider.

## v CAD Models

## vi Hard Model Photos

## vii Technical Drawings

## viii Manufacturing Cost Report

| | Concept Item | Estimated Cost (total) | Similar, Produced Item | Actual Produced Item Cost Retail |
|---|---|---|---|---|
| A Costs | | | | |
| | CPU | $2000 | i7-6950X | $2600 |
| | Battery | $200 | Dell computer battery | $200 |
| B Costs | | | | |
| | Wiring | $30 | 10 ft. RSS232 cable | 4$ |
| | Yulex blue/grey | $10 | Neoprene sheet | $36 per 51”x83” |
| | Yulex Rubber | $2 | “ | “ |
| | T162R drk. Grey | $7 | Spandex knit | $7.50 per yard |
| | Battery compartment | $1 (after mold cost) | | |
| | | | | |
| Total | | $2070 | | |

## ix Sustainability Report

***Benchmarking – Materials & Manufacturing***

Current EMS suits tailored for basic fitness member training utilize standard materials devoted to low manufacturing costs and high durability or longevity of use. The separate parts of the suit include:

**Suit Materials Used**

- Polyamide spandex mix
  - Delivers flexibility allowing movement

**Electrode material make-up**

- Silver electrodes
  - Delivers pulse to the body allowing low impedance

**Power Unit**

- Direct pulse generator
  - Ensures a steady pulse of electricity to the muscles
- Lithium-ion battery
  - 2650 mA – 6800 mA

***Benchmarking – Sustainability***

Due to the fact that these suits are marketed to companies and/or personal trainers, their agenda is linked to selling a long-lasting product. With this in mind, materials and processes are made in cost efficient ways, utilizing materials that won't break down over multiple user wear and tear. Because of this, sustainability is not a well-achieved goal in these current benchmarked products. Instead sustainability through material and manufacturing means, sustainability is instead touched upon by product longevity.

***Sustainability – Safety, Health & Environment***

As mentioned in Chapter 2 regarding sustainability, currently it does not appear to be a concern of benchmarked product. This lack of concern derives from the fact that the current EMS suits are marketed to companies seeking to utilize these products across an array of members through as many years as possible. As sustainability of materials and manufacturing are pushed out of the picture, durability and cost efficiency are put in its place.

Looking at this information from a more optimistic approach, it can be seen as a relatively easy area to tackle for means of improvement. One that was looked into was material, specifically flexible materials that were water resistant. As sweat and electricity will be an often occurring dynamic, looking for ways to separate the two will be necessary. An article by Prontera et al. (2019) speaks to a sustainable, low cost, easily processable material for hydrophobic coatings on flexible plastic substrates (Prontera et al., 2019). Basically a barrier that can be put onto flexible materials, for example electrode coverings that will prevent moisture from areas in the product sensitive to it. This will be one of the examples of possible sustainable solutions when it comes to the new final design. Further material improvements chosen will be discussed in chapter 5.

### *Sustainability*

As earlier mentioned, sustainability of benchmarked products came in the form of product longevity, but was not well addressed in the form of manufacturing or material usage. The following will be a breakdown of the researched and chosen aspects of the new design, driven to improve overall sustainability without risking product longevity.

The areas of the suit that require a tougher material to protect the electrical nodes from impact also need to be flexible and breathable. After researching materials, a product called Yulex Pure by Yulex was discovered, which is a replacement for neoprene: a useful but environmentally damaging material. Yulex Pure is a rubbery fabric made from the guayule plant (Yulex). This rubber-like material can be seen in products currently like an eco-friendly wetsuit line made by Patagonia. “Guayule delivers high tactile performance, absence of allergenic latex proteins and offers renewable sustainability because it is resourced from a domestic plant-based resource. Yulex Pure™ guayule rubber meets the critical performance standards necessary for many medical, industrial and consumer applications and exceeds performance standards of many synthetic lattices” (Yulex).

With the majority of the garment being comprised of a spandex like material, it has the ability to hold the largest carbon footprint. With sustainability in mind, the fabric still needs to be durable, long lasting and very flexible while remaining breathable. A company called INVISTA produced a sustainable spandex material, virtually identical to the name brand spandex, LYCRA (Donaldson, 2014). “Denise Sakuma, brand communications director for INVISTA, said the bio-derived spandex, called T162R, “is made using a different source of raw materials and is chemically identical to our other LYCRA fiber offerings. The overall lifecycle of a garment using T162R is the same as a garment using other LYCRA fibers, only that the fiber contains renewable raw materials”(Donaldson, 2014). With LYCRA being a reputable brand of spandex utilized by many companies when it comes to wearables, having a similar yet natural material will keep the high-end feeling of the thesis suit, while increasing overall sustainability.

As the final product of this thesis will be a concept for future development, current conceptual opportunities for sustainability have been considered as well. The area being tackled, which this is referring to, is the battery supply. A battery prototype utilizing graphene-based quasi-solid-state lithium-oxygen batteries are currently being experimented with to highly increase energy efficiency, while incorporating a long cycling lifetime (Huang et al., 2018). These batteries can be produced much thinner, be compromised of inexpensive and nontoxic solid electrolytic components, and increase cycle life up to ten years (Shudo, 2017). Although conceptual at the moment, companies are partaking in the technology. For example, Samsung is expecting to release a phone with said battery by 2020-2021.

Although not touched on by previous benchmarking products, incorporating the improvements stated above will bring the final product to a higher level of user respectability. The needed to be done without sacrificing the intent of being a long lasting, durable and a daily-use garment these material improvements have made the end product respectively sustainable, though sustainability was not the initial intent of the concept.

## x Topic Approval Form

Humber Institute of Technology & Advanced Learning
School of Applied Technology
Bachelor of Applied Technology – Industrial Design
iDSN 4502 Senior Level Thesis Project II
Dennis L. Kappen/Catherine Chong/Sandro Zaccolo

Winter 2020

**THESIS DESIGN APPROVAL FORM**

→ MUSCLE STIMULATION
E.M.
↳ ELECTRONIC

**NAME**

Alec Paprocki

**TOPIC TITLE (Brand)** Name: ? → EM-TOSS
project topic: ? → PROFESSIONAL PITCHING STRENGTH EQUIPMENT

How might we increase a baseball pitcher's training efficiency, bridging the gap between training for strength and training for throwing ability, while limiting the chances for injury?

Week#4 Jan 28

**Thesis design is approved to proceed for the following:**

cl **CAD Design Phase** → 360 CLO. → need detailing – stiching – patterns – components/graphics placement. 1:1

cl **Rapid Prototyping and model building phase**
↳ pending to review CAD.

**COMMENTS:**

Week#5 → Design approve.
Feb 4 → Model making proceed.

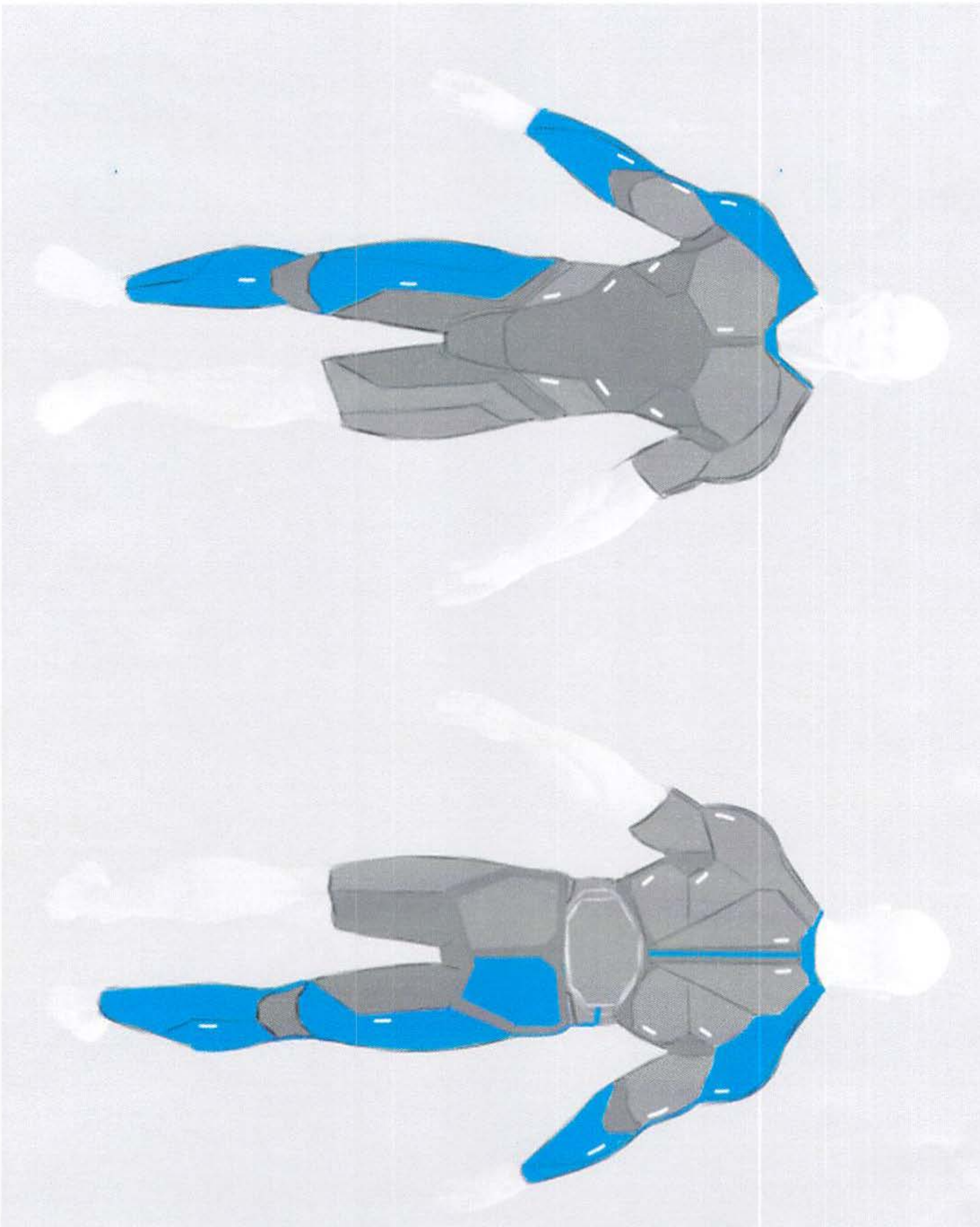
Week#7 Feb 18
→ refined patterns, in progress.
→ plan for model fabrication over RW.

**Signed** Cl

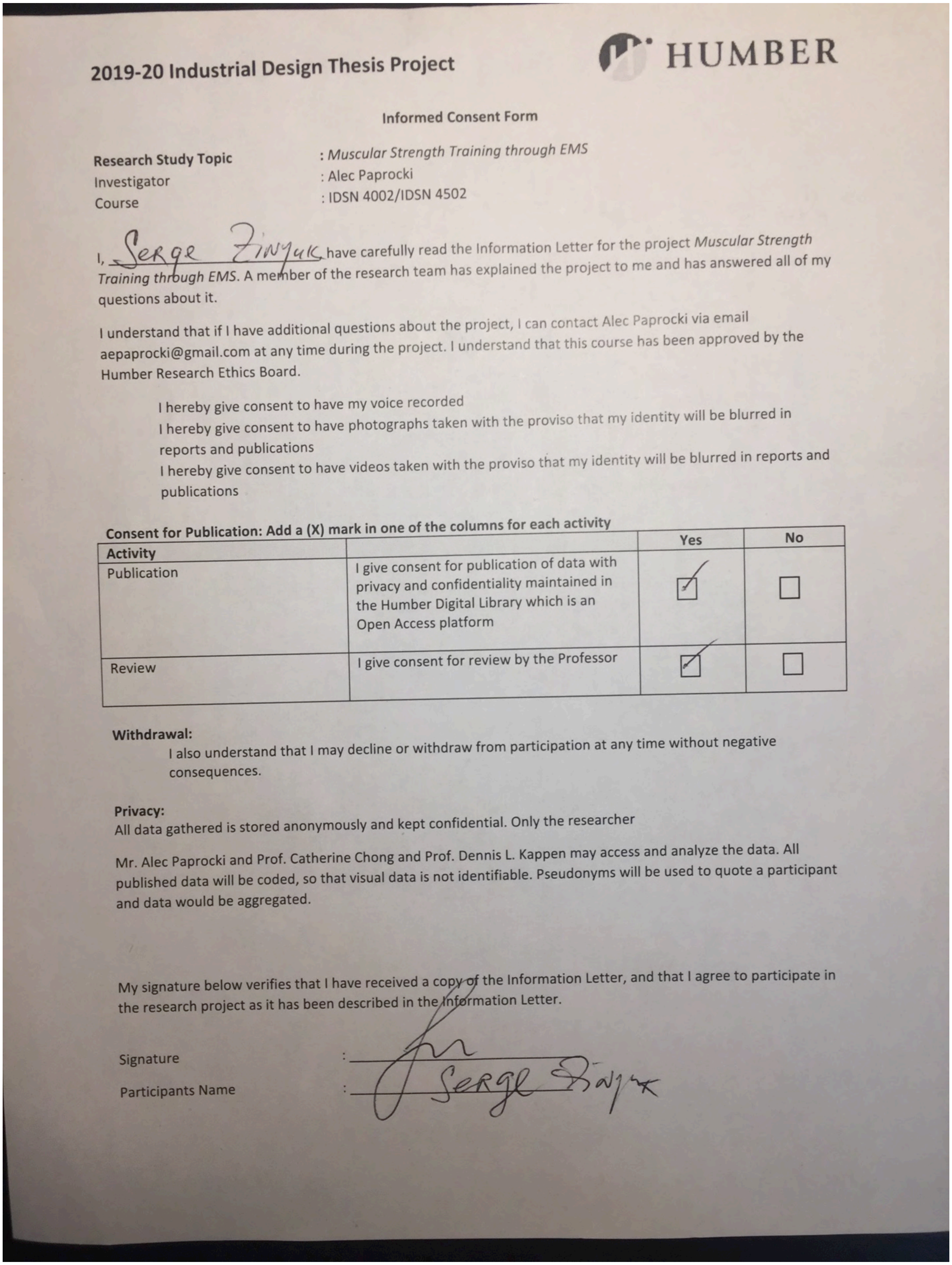
**Catherine Chong / Dennis L. Kappen**

Week#9 Mar10
→ CAD / design finishing good progress.
→ model building in progress.
→ Banner → behind, need to start.
→ Report progress okay.

Week#6 Feb 11
→ clo → patterns built - good progress.
→ ready for model making.



## xi Advisor Meetings & Agreement Forms



**2019-20 Industrial Design Thesis Project** HUMBER

**Informed Consent Form**

**Research Study Topic** : *Muscular Strength Training through EMS*
Investigator : Alec Paprocki
Course : IDSN 4002/IDSN 4502

I, Serge Zinyuk have carefully read the Information Letter for the project *Muscular Strength Training through EMS*. A member of the research team has explained the project to me and has answered all of my questions about it.

I understand that if I have additional questions about the project, I can contact Alec Paprocki via email aepaprocki@gmail.com at any time during the project. I understand that this course has been approved by the Humber Research Ethics Board.

I hereby give consent to have my voice recorded
I hereby give consent to have photographs taken with the proviso that my identity will be blurred in reports and publications
I hereby give consent to have videos taken with the proviso that my identity will be blurred in reports and publications

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

| **Activity** | | **Yes** | **No** |
|---|---|---|---|
| Publication | I give consent for publication of data with privacy and confidentiality maintained in the Humber Digital Library which is an Open Access platform | ☑ | ☐ |
| Review | I give consent for review by the Professor | ☑ | ☐ |

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

**Privacy:**
All data gathered is stored anonymously and kept confidential. Only the researcher

Mr. Alec Paprocki and Prof. Catherine Chong and Prof. Dennis L. Kappen may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant and data would be aggregated.

My signature below verifies that I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Signature : [signature]
Participants Name : Serge Zinyuk

**2019-20 Industrial Design Thesis Project** HUMBER

**Verification of having read the informed consent form:**

☐ I have read the informed consent letter

I, ______________________ *(First Name, Last Name, Signature)*, have read this document and give consent to the use of the data from questionnaires and interviews in research reports, publications (if any) and presentations with the proviso that my identity will not be disclosed.

Signature : ______________________

Participants Name : ______________________

**Humber Research Ethics Board**

This course has been approved by the Humber Research Ethics Board.

> If you have any questions about your rights as a research participant, please contact Dr. Darren Lawless, REB Chair, 416-675-6622 ext. 3226, darren.lawless@humber.ca.

**Project Information**

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more, please contact me at Ph: 905-902-1310, email: aepaprocki@gmail.com.

My supervisors are:

> Prof. Catherine Chong, catherine.chong@humber.ca, 416 675 6622 xt. 4672
>
> or Prof. Dennis L. Kappen, dennis.kappen@humber.ca, 416 675 6622 xt. 4832

**2019-20 Industrial Design Thesis Project** HUMBER

**Informed Consent Form**

**Research Study Topic** : *Muscular Strength Training* ~~*through EMS*~~ PITCHERS
Investigator : Alec Paprocki
Course : IDSN 4002/IDSN 4502

I, Matt Stoddart, have carefully read the Information Letter for the project *Muscular Strength Training through EMS*. A member of the research team has explained the project to me and has answered all of my questions about it.

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My signature below verifies that I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Signature :

Participants Name : Matt Stoddart.

**2019-20 Industrial Design Thesis Project**

HUMBER

**Verification of having read the informed consent form:**

☑ I have read the informed consent letter

I, Matt Stoddart (*First Name, Last Name, Signature)*, have read this document and give consent to the use of the data from questionnaires and interviews in research reports, publications (if any) and presentations with the proviso that my identity will not be disclosed.

Signature : [signature]

Participants Name : Matt Stoddart.

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## 2019-20 Industrial Design Thesis Project

HUMBER

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Investigator : Alec Paprocki
Course : IDSN 4002/IDSN 4502

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|---|---|---|---|
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My signature below verifies that I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Signature : [signature]

Participants Name : Joseph Brown

## 2019-20 Industrial Design Thesis Project

HUMBER

**Verification of having read the informed consent form:**

☑ I have read the informed consent letter

I, Joseph Brown ____________________________ *(First Name, Last Name, Signature)*, have read this document and give consent to the use of the data from questionnaires and interviews in research reports, publications (if any) and presentations with the proviso that my identity will not be disclosed.

Signature : ____________________

Participants Name : Joseph Brown

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