# Mixed Martial Arts Training Equipment and Footwear Needs

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**Introduction:**

Martial arts are deeply rooted in many cultures throughout the world. In ancient Greece and ancient Sumeria, boxing and wrestling competitions were common and wildly celebrated (The History of MMA, 2019). Martial arts spread throughout the world, branching into a wide variety of grappling and striking styles that garner competition between one another to find out which is the most effective. As a sport, martial arts can be aggressive and violent while simultaneously rooted in respect and the mutual pursuit of growth (Jeet Kune Do, 2020). Modern mixed martial arts (MMA) continue to pursue that growth alongside the following question- What is the most effective blend of these arts to submit or subdue an opponent? The search for the answer to this question pits competitors against one another in one of the most dangerous sports in the world- Competitive MMA (Health Fitness Revolution, 2020). Competitive MMA demands relentless training to insure the highest level of skills and conditioning possible (Fitnescity, 2020). The training itself requires a certain level of risk, and the equipment used to train needs be as finely tuned as the athletes who use it. This paper will investigate how MMA athletes train by explaining the history of the sport, athlete needs, the current product environment, and the potential for innovative improvement in this product area. This research will lay the foundation for the design and creation of innovative training equipment and footwear that will improve safety in MMA training. **The purpose of this design innovation is to look to the future of equipment and footwear for the elite male MMA athlete to optimize training and reduce injuries. This will be the first project to apply additive and generative design techniques to customize fit and function in MMA equipment, and focus on footwear that adapts to the needs of the elite MMA athlete.** The physical ability of the elite MMA athlete is improving

faster than the equipment that they use, in order to protect them properly their equipment needs to catch up and improve at the same rate.

**Historical review of Mixed Martial arts:**

It is clearer than ever that just one martial art technique does not reign supreme over all others. The base concept of blending the strengths of different disciplines, is not new; for example, the combination of wrestling's strength in controlling an opponent and Brazilian Jiu Jitsu's use of an opponent's force against them creates a more well-rounded grappling game (Surrao, 2018). Bruce Lee's Jeet Kune Do (JKD), which translates to "the way of the intercepting fist," popularized the idea of finding the most effective movement in any situation rather than confining oneself to the set rules of a martial art (Jeet Kune Do, 2020). The concept of JKD is simple, "intercepting and using your opponent's technique or [their] intent… the form of no form" (Jeet Kune Do, 2020). By taking away the limitations of a specific art form, JKD allows the practitioner to use the most effective aspects from any technique. This concept is practiced (at times indirectly) by successful mixed martial artists today.

While MMA allows any form to be used (within The Unified Rules of Mixed Martial Arts), some techniques are more effective; these techniques are split into two categories-grappling and striking. Grappling arts consist of gripping, seizing, or maintaining control of an opponent at a close range (Meehan, 2020). Striking refers to forms that make use of the limbs to hit an opponent (MMA Glossary, 2020). Brazilian Jiu Jitsu, Wrestling, and Judo are the most common forms of grappling, while Muay Thai, Boxing, and Taekwon-do are the most common forms of striking (Surrao, 2018). These forms prove to be extremely useful on their own, but when blended they create an even more dangerous combination (Surrao, 2018). Boxing and wrestling

are historically popular internationally, while the growth in MMA saw the subsequent growth of some of the other more popular arts (The History of MMA, 2020).

MMA was an obscure sideshow through most of the 20th century (The History of MMA, 2020). In 1976 Muhammad Ali fought Antonio Inoki, a Japanese wrestler, in Tokyo, Japan pictured below in figure 1 (Parr, 2020). This match displayed the pitfalls of practicing just one style as Ali refused to grapple, and Inoki remained on his back encouraging Ali to wrestle (Parr, 2020). The confusing and awkward nature of this match did not showcase the potential for MMA as a legitimate sport (Parr, 2020).

*Figure 1. Muhammad Ali vs Antonio Inoki in largely forgotten match between boxer and wrestler (Mckirdy, 2016)*

The rest of the 70s and 80s saw the conception of an obscure United States based fight league called “Tough Guys Contest,” which soon led to the “Tough Guys Law,” placing a ban on competitive mixed martial arts in Pennsylvania (The History, 2019). It was not until the late 80s and early 90s that two important events showcased the potential for MMA’s popularity (Chavez, 2020; Snowden, 2018). The first of these events was a 1988 match between famously unbeaten American kick boxer, Rick Rufus, and an unknown Muay Thai fighter, Changpuek Kietsongrit

(Chavez, 2020). Kietsongrit beat Rufus with strategic leg kicks, a common tactic in Muay Thai used to injure and wear down an opponent rather than attempt more heroic and tiring mid and high kicks toward the body and head (Chavez, 2020). An unfamiliar fighter from Thailand using a little-known fighting style stunned the American public on primetime television and showed the efficacy of Muay Thai (Chavez, 2020). The second and much more impactful event showcased Brazilian Jiu Jitsu in the first Ultimate Fighting Championship (UFC) (Snowden, 2018). UFC One was a turning point in modern MMA (The History of MMA, 2020). It pit martial artists from varying backgrounds against one another in a one-night tournament (Snowden, 2020). The Gracie family, now famous for popularizing Brazilian Jiu Jitsu, used UFC One as a large stage to showcase Brazilian Jiu Jitsu's dominance vs other forms (Snowden, 2018). The Gracie family strategically chose Royce Gracie, a relatively smaller member of the family, as their representative in the tournament (Snowden, 2018). Royce won the tournament easily and introduced Brazilian Jiu Jitsu and the excitement of MMA to the world (Snowden, 2018). The UFC was not an overnight success, but that first event paved the way for stars like Chuck Liddell and Conor McGregor to bring MMA into the mainstream (The History of MMA, 2019).

**MMA Rules and environment:**

Most MMA leagues follow The Unified Rules of Mixed Martial Arts: Fights last either three or five, five-minute rounds (five round fights are primarily saved for the main events on a fight card), and there are three judges around the cage scoring each round separately (Gerardo, 2020). The judges determine their score of a round based on the following criteria in order from most important to least important: effective striking/grappling, effective aggressiveness, and Octagon control which is determined by factors like significant strikes, and submission attempts- the

winning fighter receives 10 points (Gerardo, 2020). The losing competitor will receive 8 points if it is a particularly dominant performance, or, more often, 9 points in a close round (Gerardo, 2020). Competitors can immediately win a match by knockout or by submission. Fouls are in place to protect the competitors and cultivate a safe a fair competition and competitors can lose points by fouling- the list of fouls is compiled in The Unified Rules of Mixed Martial Arts. So, to be successful in mixed martial arts a fighter must be a technically proficient striker/grappler, in peak physical condition to maintain pressure and aggression, and stay sharp to control their opponent's movement around the octagon (Gerardo, 2020). The octagon itself varies between different professional MMA leagues. The UFC uses two different sized octagons; their main octagon has a thirty foot diameter and a six foot high fence, while their smaller octagon has a twenty-five foot diameter and a six foot high fence (UFC Cage Size, 2020). The different sized octagons have a direct effect on the outcome of a match with a higher average finish rate (via submission or knockout) and a shorter average fight time in the smaller cage (UFC Cage Size, 2020). Depending on the competitor's fighting style, this can be extremely advantageous.

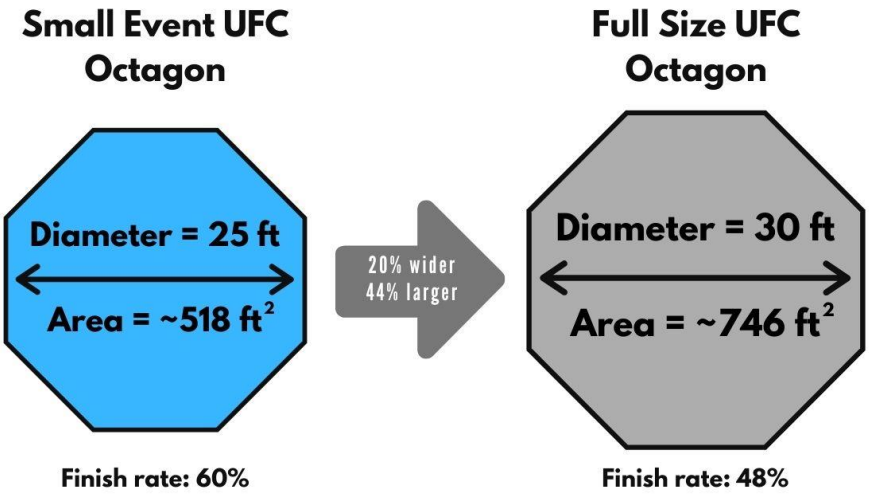



*Figure 2. UFC Octagon sizes (UFC Cage Size, 2020)*

**Weight Classes:**

The main goal of MMA is to pit two equally matched opponents against one another and see which competitor makes more effective use of martial arts (UFC, 2020). Taking size out of the equation helps to even the playing field- MMA is split into weight classes. The accepted weight classes in The Unified Rules of Mixed Martial Arts are as follows:

***Table 1***

*Accepted weight classes-Unified Rules of Mixed Martial Arts (Brandt, 2020)*

| Weight class | Weight (lbs) | Weight (kg) |
|---|---|---|
| Flyweight | 115-125 lbs | 52.2-56.7 kg |
| Bantamweight | 125-135 lbs | 56.7-61.2 kg |
| Featherweight | 135-145 lbs | 61.2 -65.8 kg |
| Lightweight | 145-155 lbs | 65.8- 70.3 kg |
| Welterweight | 155-170 lbs | 70.3-77.1 kg |
| Middleweight | 170-185 lbs | 77.1-83.9 kg |
| Light Heavyweight | 185-205 lbs | 83.9-93 kg |
| Heavyweight | 205-265 lbs | 93-120 kg |

There is a direct correlation between the increase in weight class and the likelihood a fight will end by knockout (UFC Fight Outcomes, 2020). This factor, alongside the difference in speed and rate of fatigue, changes the style and pace of fights between weight classes. The most common weight classes in the UFC are lightweight, welterweight, and middleweight in that order. These weight classes showcase martial arts and physical conditioning at their peak with an exciting

blend of strength and size with speed and skill. Most fighters come from a specialized background in one of the grappling or striking arts- at the highest-level competitors will come from Olympic level Wrestling or Judo backgrounds, and world class Brazilian Jiu Jitsu backgrounds; some are world renown kickboxers or taekwondo competitors. While some athletes see success as a specialist in one style, the most dominant expression of mixed martial arts requires relentless training and mastery of multiple martial art forms. The training that mixed martial arts requires is beneficial to both physical, and (with proper coaching) mental health; these health benefits draw participants beyond professional fighters alone.

**Athlete/Consumer/User Data and Pertinent/Potential Market Size:**

The MMA market in the United States is the largest in the world and has grown substantially since the rise of the UFC in 1993 (Gaille, 2018). In the United States, California, Florida, and New York maintain the largest markets respectively with over 5,000 martial arts studios all together (Gaille, 2018). Martial arts gyms in the United states pull in over $4 billion in annual revenues with annual growth of around 4%, and equipment wholesale peaked in 2015 with $438 million in sales then dipped down to $418 million by 2017 (Gaille, 2018). The market is trending back up again with a forecasted growth of nearly $400 million (a number calculated before the rise of the Covid-19 epidemic) between 2020 and 2024 (Global Mixed Martial Arts, 2020). These numbers back a large and growing market as Mixed Martial arts participation in the United States saw a similar growth pattern to equipment wholesales- peaking in 2015 at 2.61 million people participating for fitness (Gaille, 2018). Extrapolating numbers from general martial arts participation which show 52% male participation, 48% female participation, and 63% of adult participation occurring between the ages of 18 and 34, there are 855,036 males between the ages of 18 and 34 participating in some form of mixed martial arts (Gaille, 2018).

This is a conservative estimate looking at the largest demographic in the MMA market. Looking at the UFC as a smaller scale representation of elite MMA athletes there is a far higher percentage of male participation vs female participation (Athletes, 2020). 798 (85%) of the UFC's reported 938 competitors are male (Athletes, 2020). While this may not directly correlate to actual participation numbers, based on these percentages the overall male MMA market would be 2,218,500 participants, 1,397,655 between 18 and 34 years old (Athletes, 2020) (Gaille, 2018). Averaging between the conservative and bold estimates (855,036, and 1,397,655) may make up for the inexact data, making the final pertinent market size 1,126,346 male participants in the United States between the ages of 18 and 34 years old. This number is trending upward, pushing an increasingly competitive market to innovate products.

**Current/Competitor Product Research (products, price points, features + benefits)**

The three main product categories that this paper will investigate are heavy bag sparring/training gloves, and zero drop, barefoot cross-training shoes. These products are crucial in MMA training: heavy bag gloves are used to avoid injuries in practice by padding and supporting the hand against repetitive striking, and to protect sparring partners; and barefoot style cross-training shoes offer the versatility needed for training off of the matts in their support and protection from the elements, while maintaining similar barefoot conditions to the matt or octagon. Products in the mid to high level training glove market range in price from the ONX Sports X factor training glove reaching a price above $300 ($130 more than the next highest priced competitor, Hayabusa), to Everlast training gloves at the lower end costing $50 (Everlast, 2020, Elite Prostyle Training; ONX Sports, 2020). Gloves in this market are marked by a wide range of features and complex structure. MMA training gloves require less material because of their lighter weight (generally 8 oz) and open palm construction for grappling; they generally fall

below the $100 mark ranging from $90 for the highest quality to $35 at the lower end. Cross training footwear lives in a very different category, generally coming from companies with greater name recognition, they generally maintain a similar price point close to $100 that is driven by demand and season rather than material and technology.

Some of the most worn or respected heavy bag training/sparring gloves on the market are as follows: The ONX X-factor Training Glove, Title Gel World Bag Gloves, Hayabusa T3 LX Boxing Gloves, Fairtex Universal Gloves, and the Everlast Elite Prostyle Training Gloves (Rogan, 2020; The MMA Guru, 2020).


*Figure 3. left to right, ONX X Factor Training Glove Velcro (ONX, 2020), Title Gel World Bag Gloves (Title, 2020), Hayabusa T3 LX Boxing Gloves (Hayabusa, 2020), Fairtex Universal Gloves (Hayabusa, 2020), Everlast Elite Prostyle Training Gloves (Everlast, 2020)*

The ONX X-factor training glove leads in price because they commit to high quality materials, use of their proprietary x-factor Velcro strap technology, heat moldable foam for a custom fit, name customization, and use of proprietary impact dampening foams (ONX Sports, 2020). Their U.S. based manufacturing and commitment to quality control also drives their high price point. Title and Hayabusa's premium training gloves come in at nearly half the price of ONX X-factor gloves at $129 and $179, respectively (Hayabusa, 2020; Title, 2020). Both companies use high

quality leather and are known for their ergonomic fit. Both gloves also feature proprietary technologies. Title's gel lining underneath layered foam improves fit and impact dampening, while Hayabusa's dual wrist strap and splint support wrist alignment to help protect the carpal bones when striking (Hayabusa, 2020; Title, 2020). The Fairtex Universal Gloves come in at a slightly lower price tag than Title and Hayabusa, $100, because they include less proprietary technology, however, they are known for quality in terms of ergonomics and premium long lasting leather (Fairtex, 2020). Everlast elite pro-training gloves are the least expensive gloves on the list at $50 (Everlast, 2020). This is partially because they use synthetic leather, and as a larger company Everlast can take advantage of economies of scale.

Shifting away from gloves, the cross-training footwear market is led by the larger scale sports companies. Some of the most popular and most innovative cross-training shoes on the market are as follows: The Nike Free X Metcon 2, Reebok Nano X Mens, Vivobarefoot Stealth III Mens, Under Armour HOVR Rise 2, Puma Jaab XT (Poultney, 2020; Vivobarefoot, 2020).


*Figure 4. left to right, The Nike Free Metcon 2 (Nike, 2020), Reebok Nano X Men (Reebok, 2020), Vivobarefoot Stealth III Mens (Vivobarefoot, 2020), Whitin Men's Cross Trainer (Whitin, 2021), Under Armour HOVR Rise 2 (Under Armour, 2020), Puma Jaab XT (Puma, 2020)*

The price points are all generally at or near the low $100s and pertain more so to market expectation than to the cost of materials and manufacture. Having said that, features, functionality, and comfort are still key to a successful product.

The Nike Free X Metcon 2 is very highly regarded and offers a range of sought-after features. The upper is made up of flexible knit fabric in the toe box, a highly durable/resilient midfoot cage, and thicker material for more stability in the heel (Nike, 2020). The midsole features the Nike Free flex grooves in the forefoot to offer flexibility and a dense foam for stability in the rear for heavy lifting (Nike, 2020). The Metcon is a staple in the cross-training world. Reebok's roots in the world of crossfit help them deliver a high-quality product.

The Nano X men's training shoe offers a high-density foam collar for comfort, a minimal drop outsole for secure footing, and their proprietary flex weave technology offering a woven fabric with varying flexibility and support (Reebok, 2020).

The Vivobarefoot Stealth III Mens, and Whitin Men's cross trainer are different from the other footwear on this list in that they take away all the cushioning to offer the most natural foot movement possible (Vivobarefoot, 2020; Whitin, 2021). The Vivobarefoot hex-mesh upper offers both support and stretch zones for comfort and support, with a 3mm barefoot outsole for minimal interference, and optimal feedback (Vivobarefoot, 2020).

The Under Armour HOVR rise 2 uses Under Armour's HOVR technology held in an EVA midsole to offer light weight, impact resistant performance (Under Armour, 2020). The upper uses a lightweight mesh with 3d printed support structure that offers enhanced durability and abrasion resistance (Under Armour, 2020). The collar is flexible, with both heel and tongue

loops to allow easy entry, and the heel is reinforced with a thicker fabric cage for enhanced stability (Under Armour, 2020).

The Puma Jaab XT is stands out from the other training footwear in terms of aesthetic. This boxing inspired shoe is meant for quick lateral movement with a patterned rubber outsole that wraps up onto the sides for additional traction (Puma, 2020). The Jaab XT also uses a "dual webbing support story" so the upper maintains a minimal aesthetic that offers increased support toward the heel (Puma, 2020). Each of these product categories offer varying features and price points, but each category holds typical parts and features that are must haves to be competitive in the space.

**Anatomy of typical state of the art product (parts of the product + function related to the sport)**

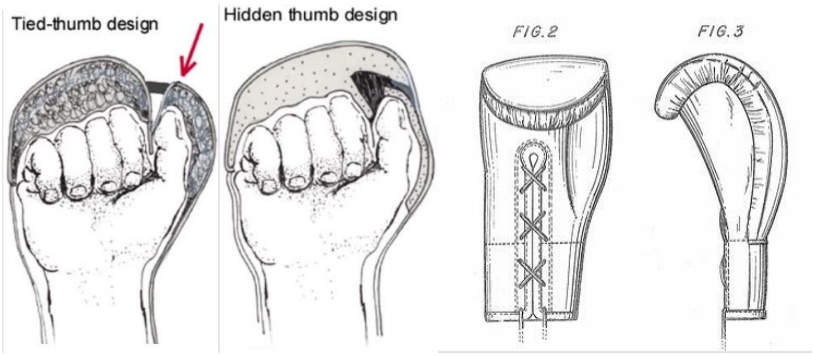
Modern hand protection in the form of boxing gloves dates to 1743 when an English champion fighter named Jack Broughton developed his "mufflers" to reduce serious damage in his training gym (How Products are Made, 2020). Boxing gloves became mandatory in competition in the 1800s and beyond a few minor tweaks, have not changed much since then (How Products are Made, 2020). The anatomy of the modern-day heavy bag training glove, depicted on the following page in figure 18, is essentially the same as a competition boxing glove with the general exception of a few small details including increased padding on the knuckles, and the use of Velcro tension systems in place of laced tension systems.


*Figures 5. Hayabusa T3 LX Boxing Gloves (Hayabusa, 2020)*


*Figure 6. Image depicting heavy bag glove materials (ONX, 2020; Leather Milk Customer Orders, 2018; Shocktec, 2020)*

The padding is the thickest on the second through the fifth metacarpals where most of the impact occurs. Glove weight varies between different sized athletes; however 16 oz training gloves are the standard at most gyms because they offer more padding and are lighter than 18 oz training gloves (Puncher, 2020). Padding is generally made of high-density polyurethane, latex, or polyvinyl chloride foam, however ONX's X factor training gloves use foam developed

specifically for impact dampening, i.e. Shocktec® Air2Gel (Shocktec®, 2020). This is a major shift in protective glove development seeing as some gloves still use insulative foam, or cotton as padding. The shell of any high-end glove will feature a tucked thumb to protect both the thumb and any opponent from getting poked in the eye. The 1983 invention of the "tied thumb" design which was a concession for the controversial yet more effective thumbless boxing glove is also an essential feature to keep the thumb tucked and protect boxer's eyes (Golomb, 2017).




*Figures 7. left to right, Image of Tied Thumb Design, Image of Hidden Thumb Design, Patent Image of Hidden Thumb Design (Golomb, 2017)*

Solutions that further connect the thumb are becoming more popular. High-end heavy bag training gloves also feature a flexible opening at the wrist to help assist entry, a Velcro strapping system to lock the glove down and support the wrist, curled and tucked finger positioning over a grip bar to optimize hand positioning, and many offer a proprietary system to assist in wrist stability.

State of the art cross-training shoes are designed to offer the flexibility and cushioning of a running shoe, the grounded stability of a lifting shoe, and often offer extra features like a textured and wrapped outsole for extra grip in rope climbs.


*Figure 8. The Nike Free X Metcon 2 (Nike, 2020)*

The dense midsole foam that offers enhanced stability in the heel features Nike's patented flex groove technology in the forefoot to allow the flexibility needed to run comfortably. This is mimicked by the shift from a thicker, more stabilizing material toward the heel of the upper to the midfoot TPU "cage" which locks the foot in place ending in a flexible, lightweight fabric in the forefoot to optimize flexibility. Barefoot trainers are another important area to investigate since MMA athletes compete barefoot. Footwear that trains arch strength and allows as much connectivity to the ground as possible will offer training benefits specific to MMA. Vivobarefoot shoes are at the forefront of barefoot training technology offering protection from environmental elements and necessary stability in the upper specific to the given sport (Vivobarefoot, 2020).


*Figure 9. Vivobarefoot Stealth III Mens (Vivobarefoot, 2020)*


*Figure 10. Image Vivobarefoot Stealth III Mens Training Shoes (Vivobarefoot, 2020)*

Each of these product areas is optimized to improve performance and reduce instances of injury in training, the next section will investigate the physiological and biomechanical needs these products focus on.

**State of the art manufacturing of current relevant products**

All Heavy bag training gloves are made by hand, following similar processes. The glove manufacture process is in the following way on the How Products Are Made website:

1. Leather arrives from the tannery in large pieces and is laid out on large cutting tables (How Products are Made, 2020). The patterns are placed on the leather and arranged to make the most efficient use of that piece (How Products are Made, 2020). The patterns are then traced onto the leather and the pieces are cut with large scissors. Meanwhile, similar patterns are traced onto the lining material and those pieces are cut (How Products are Made, 2020). Pieces are made to line the palm, the thumb, the cuff, and the knuckle area (How Products are Made, 2020).

*Figure 11. pattern and cut leather (1v1 Fight Gear, 2020)*

2. The leather shell of a boxing glove is first sewn together inside out (How Products are Made, 2020). Stitching is often done on an industrial sewing machine with some of the smaller pieces and finish work being completed by hand (How Products are Made, 2020). Many of the higher quality gloves are stitched entirely by hand, and double stitching is used throughout all quality gloves (How Products are Made, 2020).
3. The oversized knuckle piece is stitched to the palm piece (How Products are Made, 2020). The two pieces are fitted over a buck to assure the correct shape and the seam is

gathered so that the knuckle piece balloons slightly (How Products are Made, 2020). Gathering the seam also causes the glove to take on its trade-mark clenched fist shape (How Products are Made, 2020).

*Figure 12. gathering and stitching knuckles and thumb (1v1 Fight Gear, 2020)*

4. Then, the liner pieces are stitched onto this assembled section and the palm is stuffed with padding (How Products are Made, 2020). The liner is left open at the bottom of the glove, where the cuff will be attached (How Products are Made, 2020). On many models, the back halve of the thumb piece is cut as part of the knuckle piece, and the inner half is sewn onto the knuckle and palm pieces (How Products are Made, 2020). On others, the thumb is stitched together separately; its lining is attached, and its padding is stuffed (How Products are Made, 2020). The assembled thumb piece is then stitched onto the glove (How Products are Made, 2020).

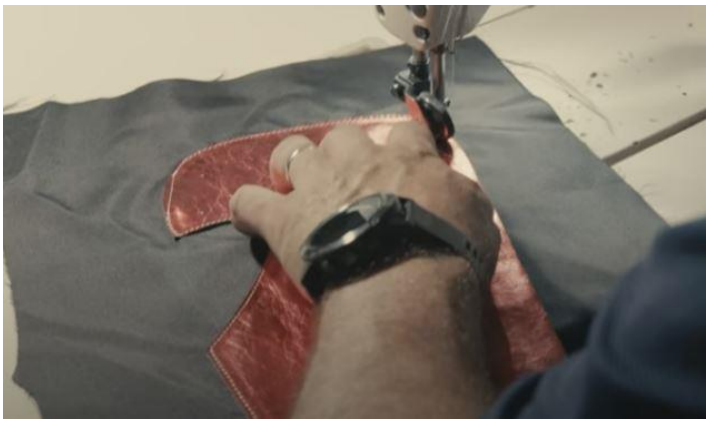


*Figure 13. stitching palm onto lining (1v1 Fight Gear, 2020)*

5. The entire glove assembly is now turned right side out… The padding for the knuckle area is made by layering sheets of the material and then cutting it to the desired shape (How Products are Made, 2020) …
6. The pattern for the glove being made is traced onto the padding material and it is cut (How Products are Made, 2020) …
7. The cut pieces are layered to the specified thickness and are stuffed into the pocket between the knuckle area and its lining (How Products are Made, 2020).

*Figure 14. stitching palm onto lining (1v1 Fight Gear, 2020)*

8. The last piece to be stitched to the glove is the cuff. The cuff and its lining are stitched together, and the piece is stuffed (How Products are Made, 2020). The ends of this assembly are not stitched together as the piece will eventually form part of the gloves closure area (How Products are Made, 2020).
9. The assembly is stitched to the open end of the glove piece, closing off all the open pockets and sealing the glove's padding (How Products are Made, 2020) …
10. If the gloves are to be closed with hook and loop material, the loop side is sewn onto the outside face of the cuff, and the hook side is stitched onto the cuff's opposite edge (How Products are Made, 2020).

11. A single thin strip of leather is folded over the open edge of the cuff and the lace area and is stitched in place to finish the glove (How Products are Made, 2020). The maker's label and any required sanctioning body labels are sewn onto the back of the cuff and the finished gloves are packaged for shipping (How Products are Made, 2020).

*Figure 15. finish and clean up glove (1v1 Fight Gear, 2020)*

This general process is nearly universal in the industry (How Products are Made, 2020).

Footwear requires a similar hand-sewing process however the invention of knit uppers has reduced material waste from some footwear by removing the patterned cutting out of fabric (How Products are Made, 2020). The How Products Are Made website lays out the footwear manufacture process in the following way, keeping in mind that some uppers are knit rather than stamped:

1. First, prepared rolls of synthetic material and rolls of dyed, split, and suede leather (used as part of the foxing) are sent to the factory (How Products are Made, 2020).
2. Next, die machines stamp the shoe shapes, which are then cut out in cookie cutter fashion with various markings to guide the rest of the assembly (How Products are Made, 2020) …

3. The pieces that will form the upper part of the shoe are stitched or cemented together and the lace holes punched out (How Products are Made, 2020). These pieces include the featherline, the vamp, the mudguard, the throat (with eyestay and lacing section), the tongue, reinforcements such as the saddle or arch bandage, the collar (with Achilles tendon protector), the foxing, and the logo (How Products are Made, 2020). At this point, the upper looks not like a shoe but like a round hat, because there is extra material—called the lasting margin —that will be folded underneath the shoe when it gets cemented to the sole (How Products are Made, 2020).
4. Next, the insole is stitched to the sides of the upper. Stiffening agents are then added to the heel region and toe box, and an insole board is inserted (How Products are Made, 2020).
5. The completed upper is heated and fitted around a last, a plastic mold that forms the final shape of the shoe (How Products are Made, 2020). An automatic lasting machine then pulls the upper down over the last (How Products are Made, 2020). Finally, a cement nozzle applies cement between the upper and insole board, and the machine presses the two pieces together to bond them (How Products are Made, 2020). The upper now has the exact shape of the finished shoe (How Products are Made, 2020).
6. Pre-stamped and cutout forms of the midsole and outsole or wedge are layered and cemented to the upper (How Products are Made, 2020). First, the outsole and midsole are aligned and bonded together (How Products are Made, 2020). Next, the outsole and midsole are aligned with the upper and placed over a heater to reactivate the cement (How Products are Made, 2020). As the cement cools, the upper and bottom are joined (How Products are Made, 2020).

7. The shoe is removed from the last and inspected (How Products are Made, 2020). Any excess cement is scraped off (How Products are Made, 2020).

This general process is nearly universal in the industry (How Products are Made, 2020).

**Relevant physiological + biomechanical needs of Mixed Martial Arts athletes**

Mixed Martial Arts is one of the most physically demanding sports. A successful athlete needs to optimize the amount of energy they use and ensure that they have more energy than their opponent; they must maintain composure under the extreme stress of high pressure striking and grappling; they need the stamina to last three to five rounds of competition; and they need the explosive power necessary to quickly dodge, strike, takedown, and potentially knock out or submit an opponent (Meehan, 2020; UFC, 2020). This skillset requires consistent aerobic, anaerobic, and technical training. A fighter can optimize their performance by both increasing their VO2 Max and moving as efficiently as possible through technique (Kirby, 2019). Many MMA athlete's cardiovascular training occurs while drilling, sparring, and shadowboxing but cardiovascular endurance and recovery are so important in MMA that additional training is necessary to improve cardiac efficiency, muscular endurance, and VO2 Max (VO2 Max is defined as the maximum amount of oxygen that a system is able to deliver to the athlete's working muscles to support energy production) (Kirby, 2019). An optimized VO2 Max is essential for an MMA fighter because the higher one's VO2 Max is, the higher their critical power (the highest sustainable work rate for a long duration) (Kirby, 2019). In short, the athlete with the higher VO2 max will be able to outlast their opponent in terms of stamina. Based on data released by the UFC's performance institute, a world class lightweight fighter's VO2 Max should be at or above 70 ml/kg/min; this is very high compared to the average male's "very good" score on the same scale which is around 50 ml/kg/min (Fitnescity, 2020). This elite level

of VO2 Max requires consistent aerobic exercise both on and off of the mats. Technique does play a crucial role; while training to increase one's VO2 max helps to optimize the rate of energy production, training in technique optimizes maximum energy transfer (Kirby, 2019). The more an athlete can train technique in as close to a full speed scenario as possible, the more efficient they will be in their movements. A more efficient athlete is able to regulate their critical power, and deplete their anaerobic work capacity at a slower rate so that they maintain energy and the ability to engage in anaerobic, higher energy consumption states throughout the competition (Kirby, 2019, Exercise). While technique can enhance striking power, anaerobic training is also necessary to increase the amount of both work and power that the athlete can achieve. The more power (work / time) that an athlete can generate (Kirby, 2019, Exercise). The more work that an athlete can produce in a given time period, the more devastating their strikes and takedowns will be. Strength and power training alongside optimal technique will improve an athlete's ability to produce these devastating movements. Versatile footwear that offers the protection and stability necessary for intense weight training, the flexible lightweight comfort of a running shoe, and allows for quick removal for access to the training mats would be a great tool to enhance MMA athlete's training regimen.

MMA is an inherently risky sport, and the numbers back it up- With an average of 286 injuries per 1000 exposures athletes are injured over ¼ of the time they compete; of those 286 injuries, 15% are to the hand or wrist which are some of the most protected areas while practicing; and although more safety measures are taken while training than in competition, over 70% of injuries to MMA athletes occur in practice (Rogan, 2020; Torres, 2018). The hand and wrist are at a high risk of injury in MMA because punching is the most common maneuver in any MMA fight, and the hand and wrist are made up of small bones and ligaments evolved for precise movement that

are not meant to endure repetitive impact (Staff, 2018). MMA athlete's hands are susceptible to a number of injuries including fractures to the carpal and metacarpal bones (fracture to the first metacarpal is the most common in MMA because of the distance at which punches/hooks are thrown), ligament sprains and strains from impact pressure on the metacarpals as well as hyperflexion/hyperextension of the wrist and fingers, and dislocations from powerful impacts on those smaller ligaments (Rogan, 2020; Staff, 2018; Torres, 2018). Figures 19, and 20 shown below represent some of the most common punches thrown in MMA, and how they pose potential risks.

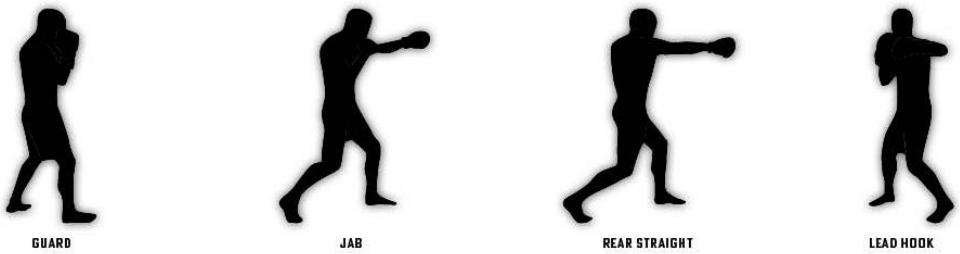



*Figure 16. Images of common punches thrown in MMA*


*Figure 17. Images of potential injuries while striking*

*Figure 18. Meister Elite 180" Elastic Hand-wraps- Black (Meister Elite, 2020)*

The most effective way to avoid injury to the carpal bones is to maintain wrist alignment and offer additional stability. Traditionally fighters use handwraps, pictured above in figure 27, underneath their gloves to offer additional support against the repeated stress of punching a bag. Handwraps also help to align the carpal and metacarpal bones with the larger radius and ulna bones in the forearm. When aligned properly, impact is dissipated through those larger bones, reducing the amount of strain on the wrist (Musclerig, 2019). Properly gauging distance and landing a punch at full extension also helps to avoid strain on the wrist, figure 27 pictured below depicts a full extension punch in competition. Landing a punch too short both reduces the power of the impact by lengthening the time in which the force is applied and increases the amount of stress on the wrist for the same reason (Muscerlig, 2019). It is important to limit padding size in training gloves so that they are as close to the smaller competition size gloves as possible to properly train distance.

*Figure 19, example of a punch at full extension (BensBoxingEquipment, 1970).*

Avoiding fracture to the metacarpals is also based in proper technique. Distributing the force of impact across multiple knuckles rather than isolating one area will decrease the likelihood of a fracture.

In cross-training, proper stability and flexibility are essential in the foot. Athletes will engage in power lifting, strength training, and conditioning training including but not limited to running, jumping rope, and rope climbs. The foot needs the freedom to flex and experience it's full range of motion at the forefoot, to comfortably perform quick lateral movements with increased stability in the midfoot, and to connect to the ground and at the heel to stay balanced during heavy lifts.

Footwear needs to vary in fit from a close grip to a flexible and non-restrictive fit to allow for a comfortable and natural walking gait. These variations in close grip and non-restrictive fit should vary based on areas of low and high sensitivity respectively, as well as areas that offer more and less control respectively (Gray, 2020). Areas that require a firm grip include the region that traverses the top of the instep of the foot (the navicular bone), and the area across the back of the heel below the more sensitive Achilles tendon (Thompson, 2011; Gray, 2020). Without proper

grip in these two areas, the foot will compensate with irregular motion that will lead to an improper gait cycle (Thompson, 2011). The flexing and relaxing of the interossei, lumbrical, and hallucis muscles under the arch of the foot controls the transfer of force from the metatarsals to the phalanges (which endure 75% of the gait cycle) (Thompson, 2011). From the navicular bone downward, a gradient of fit is necessary from firm on the navicular to flexible around the instep so as not to impede the comfort of the foot and action of the muscles that control that transfer of force from the metatarsals to the phalanges (Gray, 2020; Thompson, 2011). If these muscles are impeded or improperly gripped than the toes will attempt to compensate for the lack of grip and control by curling which activates unnecessary muscles for the walking gait requiring more energy, will result in increased force on the MTP joint, and have a negative effect one's gait (Goonetilleke, 2011; Thompson, 2011; Gray, 2020). Fit around the MTP joint and phalanges requires a gradual increase in flexibility as well. For a full range of motion in a natural gait cycle, the MTP joint should be able to flex up to 25 degrees, transferring force from the metatarsals to the phalanges (Gray, 2020; Thompson, 2011). Based on all of this information, footwear that offers varying support that mirrors the soft and hard tissue of the foot with flexible and stabilizing regions, locks the foot in at the navicular bone/instep and low heel, and allows for freedom of motion that does not interfere with one's natural gait is optimal for comfort and performance.

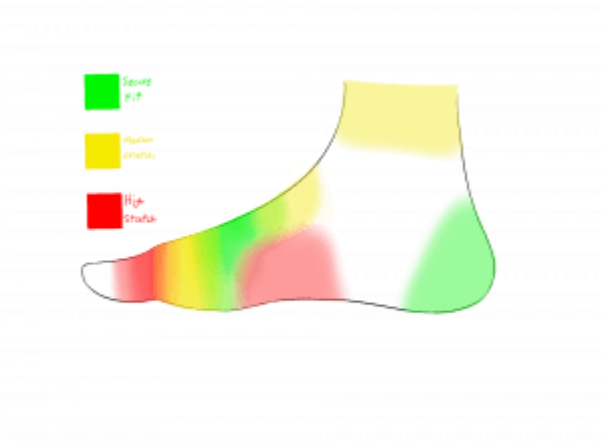


*Figure 20. Image depicting close fit vs flexible fit regions on the foot*

Flexibility, stability, and connectivity to the ground are also important in the insole/midsole/outsole region of the foot. Connectivity, in terms of distance from the ground and sensation felt from the ground, is important in supporting skillful movements and balance (Eils et al., 2002; Meyer, Oddsson, & De Luca, 2004; Vivobarefoot, 2020). Skillful movement is extremely important in dynamic cross-training, and MMA training sessions. Arch strength, and stability in dynamic movement are also supported by a more even distribution of weight between the midfoot and forefoot when striking the ground, which is promoted through minimal heel striking when performing these movements (Stolwijk, Duysens, Louwerens, Ven, & Keijsers, 2013; Mckeon, Hertel, Bramble, & Davis, 2014; Vivobarefoot, 2020). Vivobarefoot spells out the importance of balanced mid to forefoot striking in terms of shock absorption eloquently by explaining "[when] running, your body absorbs more than 2x your body's weight in shock (Vivobarefoot, 2020). The arches and the ankle are designed to absorb 52% of this shock (Vivobarefoot, 2020). Take this away- by heel striking- and that 'shock' needs to be absorbed by the knees and hips (Vivobarefoot, 2020)." While some runners may be heel, or midfoot strikers, MMA striking is performed primarily on the balls of the feet to promote balanced, fast movements (Fagan, 2020). Shoes that reduce heel striking when training and train

a stronger foot arch are even more important and reducing continuous shock to the knee and hip is an added benefit. Freedom and proper utilization of the great toe, first metacarpal, is also very important in supporting dynamic balance (Chou et al., 2009; Vivobarefoot, 2020). Restriction of the great toe impairs balance, especially on one foot, and especially when vision is impaired (Chou et al., 2009). MMA requires constant dynamic balance and cuts and swelling around the eyes is common in competition. Footwear that promotes a wider toe-box allowing a more natural foot shape, and more sensory feedback from the ground will translate to the needs of an MMA athlete, and offer better stability in dynamic training (Chou et al., 2009; Vivobarefoot, 2020).

These physiological and biomechanical factors must be considered before designing new and innovative product in the training glove or footwear space, and proper understanding of materials and their application is essential to address these factors.

**Utility patent landscape or protection of the products' intellectual property**

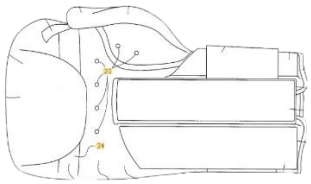


*Figure 21. NAPMA LLC, 2003, US20040177431A1 (Ferrer, 2003)*

A kick boxing glove has an extended rear portion attached to a front section having a thumb, finger, and palm portion (Ferrer, 2003). The extended rear portion has a leather outside layer and fabric inner layer with a molded foam in between for covering; the outer wrist and forearm of a kick boxer (Ferrer, 2003). The kick boxer inner wrist is covered with multiply connected flexible sections, each section having a leather outer layer and either a leather or fabric inner layer with a molded foam in between the layers (Ferrer, 2003).

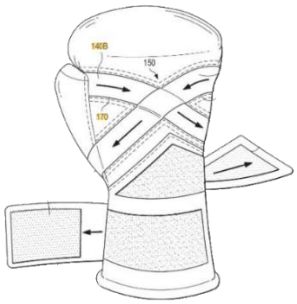



*Figure 22. US10376770B2 (Wittman, 2017)*

A striking glove may comprise an inner glove, an outer shell, and at least one strap at least partially disposed within a dorsal cavity between the inner glove and the outer shell (Wittman, 2017). A portion of the at least one strap disposed within the dorsal cavity may be configured in an overlapped and crossed configuration (Wittman, 2017). The ends of the at least one strap may extend from the dorsal cavity to an exterior of the striking glove (Wittman, 2017).

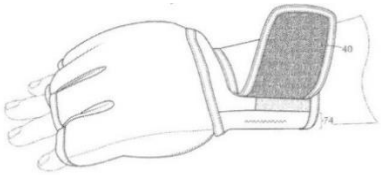



*Figure 23. US20170087438A1 (Bisaillon, 2013)*

An MMA fighting glove is disclosed herein which has a smooth front profile especially at the top and lateral side of the glove when the glove is clenched (Bisaillon, 2013). In this manner, the glove is less likely to cut an opponent's skin or training partner's skin when the lateral side grazes the opponent or training partner (Bisaillon, 2013). Moreover, a sleeve may cover a strap mechanism of the MMA glove described herein or a prior art MMA glove to cover any protrusions or aberrations of the strap mechanism to further mitigate cutting of the opponent or training partner (Bisaillon, 2013).

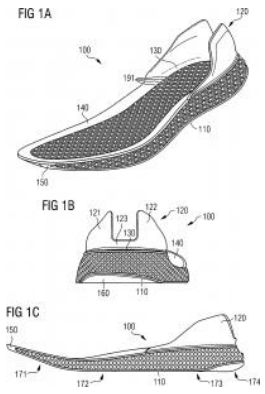



*Figure 23. DE102015212099A1 (Kormann, 2019)*

In one aspect, an additively manufactured sole is provided (Kormann, 2019). The sole has a grid structure (110, 210, 310), the grid structure having a plurality of cell elements (191, 291, 391, 392) (Kormann, 2019). The sole also has a heel element (120; 220; 320) which surrounds the heel in three dimensions (Kormann, 2019). In addition, the sole has a base portion (130; 230; 330) interconnecting the heel member and the grid structure, the base portion having an extension configured to communicate with a plurality of adjacent cell members, the plurality of adjacent cell elements is not positioned along an edge of the grid structure (Kormann, 2019).

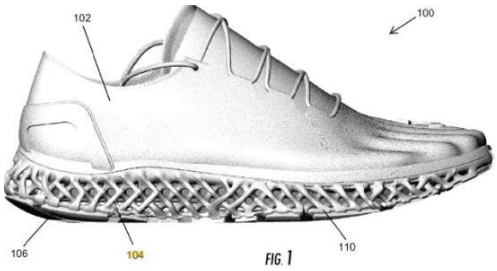



*Figure 25. US10702012B2 (Guyan, 2020)*

The midsole includes a lattice structure having an upper side and a lower side, wherein the upper side is a user-facing side and the lower side is a ground-facing side (Guyan, 2020). A first platform is integrally formed into the upper side of the lattice structure (Guyan, 2020). A second

platform is integrally formed into the lower side of the lattice structure (Guyan, 2020). The lattice structure extends from the first platform to the second platform (Guyan, 2020).

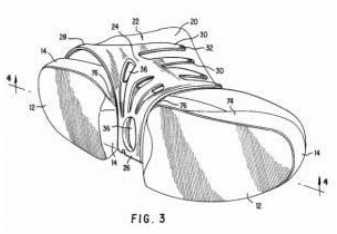



*Figure 26. US5692319A (Parker, 1995)*

An article of footwear includes a shoe sole, a shoe upper having medial and lateral sides, and a closure element which overlaps the shoe upper and has a plurality of fastening projections (Parker, 1995). The closure element extends upwards along each side of the shoe upper as well as beneath the shoe sole (Parker, 1995).

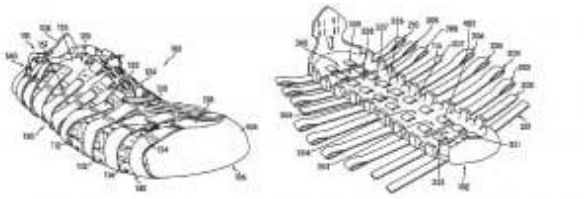


*Figure 27. US8037621B2 (Hooper, 2011)*

An article of footwear including a woven strap system is disclosed (Hooper, 2011). The woven strap system preferably wraps along the entirety of the outsole, including a bottom side and an outer periphery (Hooper, 2011). The article of footwear also includes a midsole that rests inside the woven strap system, just above the outsole (Hooper, 2011).

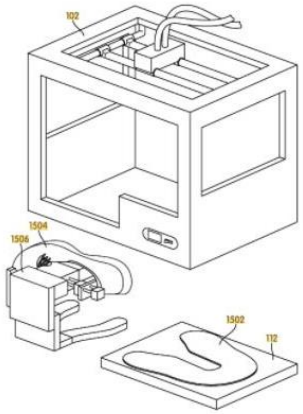



FIG. 30

*Figure 28. US20190315048A1 (Sterman, 2019)*

A system and method for forming 3D printed structures on a base component includes extruding material through a nozzle while moving the nozzle vertically (Sterman, 2019). Extruded material flows from the nozzle and spreads outwardly upon contact with an underlying portion of material (Sterman, 2019). The outward spread of material is controlled to form a desired geometry for the 3D printed structure (Sterman, 2019). An optical sensing device may provide feedback for controlling the outward spread of material (Sterman, 2019). Using a molding component, structures with anchored portions extending through openings in the base component can be formed (Sterman, 2019).

**Graphic, logo + color application on current product space.**

Graphics and style in the MMA community are driven by the UFC, and by the successful individuals in the organization. While the UFC is uses very straight forward, masculine, and aggressive branding, the individual athletes are much more expressive. This idea of individual expression is beginning to creep its way into the equipment; ONX, for example, offers users the option to inscribe any wording they want onto their gloves (ONX, 2020). High level MMA athletes like Israel Adesanya, and Conner McGregor, two of the better-known athletes in the

sport, express their personalities through flashy and exciting displays both in and out of competition.


*Figure 29. Graphic and Trend Board*

Colors are more subdued for MMA equipment. It is rare to move outside of black and white, however red and gold are natural secondary colors in that these athletes leave their blood out on the mats chasing after the coveted gold championship belt.


*Figure 30. Color Board*

**SWOT analysis of current product landscape:**

- **STRENGTHS:**
- ENGINEEREDIMPACT FOAM, HEAT MOLDABLE POLYURETHANE
- X-FACTOR WRIST SUPPORT, NO NEED FOR HAND WRAPS

- **WEAKNESSES:**
- NEARLY TWICE AS EXPENSIVE AS COMPETITORS

- **OPPORTUNITIES**
- CAN INTRODUCE MORE INNOVATIVE PRODUCT SOLUTIONS AND FURTHER DIFFERENTIATE AND IMPROVE

- **THREATS**
- LARGE COMPANIES MAY ENCROACH ON I.P. OR NOTICE THEIR SUCCESS IN INNOVATION AND WORK IN THE SAME MARKET

- **STRENGTHS:**
- TITLE AND EVERLAST ARE THE LARGEST COMPANIES IN THIS SPACE
- HIGH QUALITY MATERIALS, LAST A LONG TIME

- **WEAKNESSES:**
- TREND OF TRADITION OVER INNOVATION

- **OPPORTUNITIES**
- ATHLETES ARE WILLING TO PAY MORE FOR PERSONALIZED PRODUCT IN THIS SPACE AT A HIGHER PRICE

- **THREATS**
- COMPANIES LIKE ONX AND HAYABUSA ARE SUCCESSFULLY PUSHING INNOVATIVE CONCEPTS

- **STRENGTHS:**
- WRIST SPLINT TO AVOID INJURY
- FULL GRAIN LEATHER FOR LONG LASTING QUALITY

- **WEAKNESSES:**
- FUSSIER DESIGN
- EXTRA FEATURES

- **OPPORTUNITIES**
- WAYS TO IMPROVE FIT AND OFFER EXCITING GRAPHIC STYLES.
- MARKET OPEN TO CONTINUED INNOVATION

- **THREATS**
- AWKWARD PRICEPOINT BETWEEN HIGH/MID QUALITY
- MIXED REVIEWS ON WRIST SUPPORT AND BUILT IN SPLINT

- **STRENGTHS:**
- LONG LASTING, QUALITY MATERIALS
- FOCUS ON ERGONOMIC FEEL
- RESPECTED BRAND NAME

- **WEAKNESSES:**
- STUCK IN TRADITION
- NO INNOVATIVE DESIGNS, VERY STRAIGHTFORWARD

- **OPPORTUNITIES**
- IMPROVED INNOVATION IN A MARKET THAT IS MORE EXCEPTING

- **THREATS**
- NO INNOVATIVE DIFFERENTIATION FROM LOW END MARKET

- **STRENGTHS:**
- BIGGEST COMPANY IN THE PRODUCT SPACE
- HIGH VOLUME, LOW PRICE PRODUCTS

- **WEAKNESSES:**
- LOW QUALITY MATERIALS
- PRODUCTS DO NOT LAST LONG
- NO INNOVATIVE TECHNOLOGY

- **OPPORTUNITIES**
- BRANCH INTO HIGH END MARKET AND OFFER HIGHER QUALITY

- **THREATS**
- CONSUMER KNOWLEDGE OF QUALITY PRODUCTS

*Figure 31. Heavy Bag Glove SWOT Analysis*

- **STRENGTHS:**
- HIGH QUALITY MATERIALS
- TPU CAGE AND DENSE/WIDE HEEL PROMOTE ENHANCED STABILTY

- **WEAKNESSES:**
- SLIGHTLY HIGHER PRICE THAN MARKET NORM
- REVIEWS POORLY FOR RUNNERS DUE TO TIGHT FIT/RIGID CAGE

- **OPPORTUNITIES**
- IMPROVE FLEXIBILITY AND NATURAL MOVEMENT OF THE FOOT FOR MORE VERSETILE TRAINING

- **THREATS**
- LOTS OF SIMILAR PRODUCTS ON THE MARKET THAT ARE MORE RUNNING FRIENDLY

- **STRENGTHS:**
- VERY LIGHTWEIGHT CONSTRUCTION
- FLEXIBLE AND VERSETILE
- GOOD FOR RUNNING AND LIFTING

- **WEAKNESSES:**
- WIDE FOOT DESIGN CAN BE LOOSE FOR MORE NARROW FEET.
- SIMILAR DESIGN TO MOST OF CROSSTRAINING MARKET

- **OPPORTUNITIES**
- CURRENTLY VERY GENERIC DESIGN, COULD LOOK INTO FUTURE MATERIALS AND MANUFACTURING

- **THREATS**
- CROSSTRAINING MARKET IS VERY LIFTING ORIENTED AND THESE ARE VERY LIGHT/VLEXIBLE

- **STRENGTHS:**
- MARKET DIFFERENTIATION
- SCIENCE BACKED BAREFOOT DESIGN
- SLEEK, MINIMAL DESIGN

- **WEAKNESSES:**
- TRADITIONAL TRAINING FOOTWEAR KNOWLEDGE GEARED TOWARD CUSHION/MIDSOLE

- **OPPORTUNITIES**
- MARKET FOCUSED ON LONGEVITY AND HEALTH RATHER
- TRAINING THE "FOOT CORE"

- **THREATS**
- LARGER COMPANIES HAVE THE INSENTIVE TO WORK AGAINST BAREFOOT BECAUSE OF HISTORIC USE OF MIDSOLE TECHNOLOGY

- **STRENGTHS:**
- LIGHTWEIGHT SPEED AND AGILITY TRAINING ORIENTED
- DURABLE OUTTER CONSTRUCTION

- **WEAKNESSES:**
- VERY PLANE DESIGN LANGUAGE
- POORLY REVIEWED FOR HEAVY LIFTING

- **OPPORTUNITIES**
- EXPAND INTO MINIMAL FOOTWEAR MARKET
- IMPROVE STYLE TO COMPETE WITH MORE ATTRACTIVE FOOTWEAR

- **THREATS**
- SIMILAR SHOES IN MARKET ARE MORE STYLISH
- CLOSER TO A RUNNING SHOE THAN MOST TRAINING SHOES IN MARKET

- **STRENGTHS:**
- UNIQUE STYLE, VERY VISUALLY INTRIGUING
- FOCUS ON STABLE, DURABLE MATERIAL

- **WEAKNESSES:**
- THICK MIDSOLE REDUCES FEEDBACK FROM GROUND

- **OPPORTUNITIES**
- DESIGN IS INSPIRED BY BOXING FOOTWEAR, COULD TRAINSITION TO MMA ORIENTED TRAINING

- **THREATS**
- HIGHLY SUPPORTIVE FOOTWEAR SUPPLIMENTS ATHLETE RATHER THAN TRAINING TO STRENGTHEN THE FOOT

*Figure 32. Training Footwear SWOT Analysis*

**Explanation of how the project topic aligns to your strengths/core strengths as a product innovator. How will your strengths support innovation for the project topic?**

My core strengths based on the strengths finder analysis were ideation ideation and development. These strengths align well with my history as an innovator and will align well with this project. The ideation strength is all about finding creative connections that are otherwise unexpected. This is essential in a project that looks to innovate in a historically stagnant industry. Ideating on knowledge accrued through years of interest in a wide range of topics will lend itself well to a new and innovative design concept. The development strength is about seeing the strengths in others and guiding them toward success. The development strength aligns with this project directly since it is focused on developing equipment and footwear that helps MMA athletes achieve their goals. These core strengths feed into one another. As I gain a better understanding of the athletes goals I will ideate on solutions that will achieve their goals in an unexpected way that keeps them excited to continue their pursuit. To support these more cerebral strengths, my hard skills in sketching, prototyping, and computer aided design will help legitimize and represent this work in a fresh and innovative way.

The MMA equipment market is historically stagnant because of the traditionalist mindset in the industry and users, and the MMA training footwear market is nonexistent because much of the training takes place without shoes on. The MMA market is becoming more open to innovation in protective equipment to help with the safety and longevity of the athletes. The elite MMA community is a small circle though where one must earn respect through hard work and dedication. A new innovator needs to gain the trust of these athletes and show their commitment to the sport and to their success. As a developer this is where I thrive. I want to see success in others, and am more than willing to dedicate time, effort, and thought to see that success come

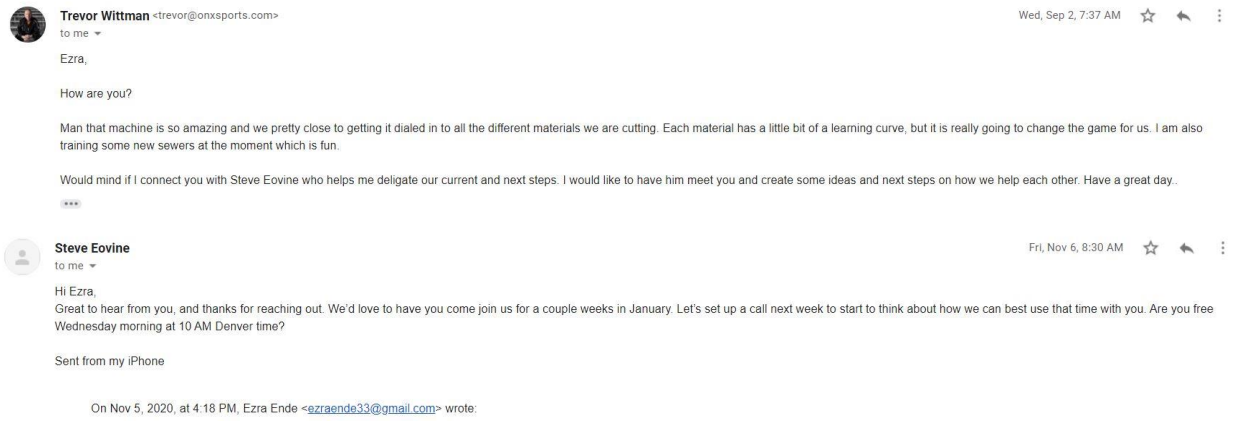
true. My strength as an ideator will allow me to take those insights and conceptualize exciting and intriguing solutions that achieve my goal of supporting these athletes.

**How do you see this body of work supporting your career in the industry?**

My goal is to help improve the safety and performance of MMA athletes through innovative product, and the high-end MMA equipment industry is starting to take innovative thinking more seriously. This body of work will show companies that I can think outside the box to push the future of MMA product and meet the demand for higher quality products. This body of work will showcase new and innovative designs that are unfamiliar to this industry and improve the athlete experience in unexpected ways. The high-end MMA equipment market, ONX Sports in particular, is pushing innovation forward in ways that literally shift user expectations of what a quality glove can be. I plan to come out with design work that showcases my ability to do the same thing.

**Mentor Mapping**

Emails from Trevor Wittman Founder of ONX Sports, and Trevor Wittman, head of finances at ONX Sports



**Trevor Wittman** <trevor@onxsports.com> Wed, Sep 2, 7:37 AM
to me

Ezra,

How are you?

Man that machine is so amazing and we pretty close to getting it dialed in to all the different materials we are cutting. Each material has a little bit of a learning curve, but it is really going to change the game for us. I am also training some new sewers at the moment which is fun.

Would mind if I connect you with Steve Eovine who helps me deligate our current and next steps. I would like to have him meet you and create some ideas and next steps on how we help each other. Have a great day..

**Steve Eovine** Fri, Nov 6, 8:30 AM
to me

Hi Ezra,
Great to hear from you, and thanks for reaching out. We'd love to have you come join us for a couple weeks in January. Let's set up a call next week to start to think about how we can best use that time with you. Are you free Wednesday morning at 10 AM Denver time?

Sent from my iPhone

On Nov 5, 2020, at 4:18 PM, Ezra Ende <ezraende33@gmail.com> wrote:

*Figure 33. Email from Trevor Wittman*

**Benchmark Analysis and Testing:**

Identifying Parts of the Product

*Hayabusa T3 Boxing Glove, and ONX X Factor Training Glove:*

Outer composite leather shell (thumb tab, tucked thumb), outer strapping/pulls, Inner foam padding, internal heat moldable polyfoam, internal lining.

"How could we," improvement areas: Protection, Fit, Breathability

*Hayabusa T3 7oz Boxing Gloves:*

Outer full grain leather shell, closure, internal splint and padding, dorsal lining, dual hand grip and palm

"How could we," improvement areas: Protection, Fit, Breathability

*Whitin Men's Cross Trainers, and Vivobarefoot Stealth III Men's Footwear:*

Upper (recycled PET fabric, TPU "cage," Recycled PET knit, laces, tongue) TPU eyelets, TPU toe reinforcement, TPU heel reinforcement, algae-based foam insole, rubber outsole.

"How could we," improvement areas: Fit, breathability, comfort

**SWOT ONX X Factor Training Gloves, and Hayabusa T3 MMA Gloves:**

**Protection:**

Strengths of outer shell and protection-

Durable to help maintain padding, thick material can assist with impact, thick material can offer some rigid support at wrist.

Weaknesses of outer shell and protection-

Rubbery feel might offer friction when striking and impede striking motion, gap from thumb and hand impede natural fist, any construction that adds mass increases the moment arms and increases chances of wrist flexion.

Opportunities of outer shell and protection-

Pattern to bring thumb as close to hand as possible, offer slick treatment so it protects and slides off sparring partners, material that initiates impact attenuation before the foam.

Threats of outer shell and protection-

User's may not be receptive to a new material that is highly untraditional, a denser material may reduce natural movement, more slick material may make training harder/use energy faster and take away from technique training, texturing may be dangerous to partner.

Strengths of strapping system and protection-

Offers added support for the carpal bones, pulls thumb closer to hand reducing moment arm/thumb bruising potential, pulls lateral padding in tight reducing moment arm.

Weakness of strapping system and protection-

Offers supplemental support that may hinder adaptation in terms of wrist strength/natural alignment, may lead to injuries in situations without extra support (in competition), challenging to use without a partner to strap you in, multistep process, could get caught on partner, plastic slides could contact/injure partner.

Opportunities of strapping system and protection-

Reduce steps in the process but offer the same result, make more accessible while training alone (teeth? Automatic?) vary support over time to allow wrist adaptation, reduce external pieces to limit possibility of it catching (lace through internal porous generative structure), wrist support adapts to when a fist is made and allows looseness while resting.

Threats of strapping system and protection-

May go unused when training alone, may go unused when in a hurry, overtechnical may scare away users, ONX strapping is highly coveted and proven useful (may be challenging to compete).

Strengths of foam padding and protection-

Engineered EVA impact foam dampens impact extremely well, Engineered EVA padding can be molded into multiple useful forms, can vary in density between foams.

Weakness of foam padding and protection-

Cannot vary the density throughout the foam, requires a thick layer to be useful which increases the moment arm.

Opportunities of foam padding and protection-

Using a varied density EPU 41 3d printed lattice padding the density can be varied to offer increased padding where necessary (e.g., fifth/first metacarpals) and increased flexibility where necessary.

Threats of foam padding and protection-

New material/process may not be as effective in terms of impact attenuation, without visual design aspects this may not be understood as different.

Strengths of heat moldable polyfoam and protection-

Improved immediate fit allows for more comfortable hand position when striking, more natural thumb position, varying rigid/flexible fit, allows ease of "fist."

Weakness of heat moldable polyfoam and protection-

Increases layers/thickness of padding and therefor moment arms, could lead to over flexibility at wrist.

Opportunities of and protection-

More integrated method of flexibility/3d fit through 3d method.

Threats of heat moldable polyfoam and protection-

ONX is the first to do I, must be done in a new way.

Strengths of lining and protection-

Allows variable and comfortable hand positioning.

Weakness of lining and protection-

Least durable portion of the glove, tears/etc... can lead to unanticipated hand motion (think hand version of Zion shoe bursting), bacterial buildup in poly-material over time can be unhealthy for hands.

Opportunities of lining and protection-

Antimicrobial material (silver thread in elastane?) or treatment, reinforce material with outer thin leather (like ONX).

Threats of lining and protection-

ONX reinforces material in a smart way with palm leather.

**Comfort:**

Strengths of outer shell and comfort-

The patterning reduces the amount of foam material and can allow ease in some areas, places the hand in working position, tucks the thumb, guides the overall fit/silhouette.

Weaknesses of outer shell and comfort-

Larger shell means more material underneath that can squeeze hands, improper size may squeeze finger/thumb tips making fit and proper hand position tough to attain.

Opportunities of outer shell and comfort –

Custom fit after 3d scanned sizing, not requiring as much ease and therefor a tighter possible silhouette based on 3d generated padding.

Threats of outer shell and comfort –

There are a few accepted norms in patterning that are tough to deviate from both functionally and stylistically.

Strengths of strapping system and comfort-

Locks in for a comfortable fist position both for thumb and lateral hand.

Weakness of strapping system and comfort-

May be restrictive of free movement while glove is on. May put lateral/medial pressure on metacarpals.

Opportunities of strapping system and comfort-

Changes in tension in different hand positions so that pressure is relieved when athlete's hands are relaxed.

Threats of strapping system and comfort-

Strapping system is patented by ONX.

Strengths of foam padding and comfort-

Can be cut and molded quickly to approximate hand shape.

Weakness of foam padding and comfort-

Does not conform to hand uniquely, only comes in specific patterns that are die cut.

Opportunities of foam padding and comfort-

3d scanned and mapped 3d generated lattice structure padding will contour perfectly to form of the hand. Allow for weaving a low-profile tension system into the padding.

Threats of foam padding and comfort-

New material/process may not be as effective in terms of impact attenuation, without visual design aspects this may not be understood as different.

Strengths of heat moldable polyfoam and comfort-

Molds to the users hand immediately and directly.

Weakness of heat moldable polyfoam and comfort-

Requires heating process, requires extra foam layer which adds thickness.

Opportunities of heat moldable polyfoam and comfort-

Removed layer for 3d generated lattice style padding structure that is 3d mapped to hand shape.

Threats of heat moldable polyfoam and comfort-

Weight needs to be made up for with the new lattice padding.

Strengths of lining and comfort-

Flexibility form fingers/thumb/palm. More comfortable material on skin

Weakness of lining and comfort-

ONX applies second, reinforcing layer. Needs more pattern pieces and stitching.

Opportunities of lining and comfort-

Using a more durable/strong material would allow fewer stitches interacting with the palm

Threats of lining and comfort-

This is the accepted material/way of applying the lining.

**Breathability:**

Strengths of outer shell and breathability-

Large palmer ventilation holes are the primary source of airflow. Antimicrobial treatment is not necessarily helpful for airflow but keeps from bacterial buildup/smell/health issues.

Weaknesses of outer shell and breathability-

There are no dorsal ventilation holes both because this is the striking surface, and the foam is not breathable.

Opportunities of outer shell and breathability–

Introducing ventilation on the medial and lateral sides of the outer shell to take advantage of internal lattice padding that allows for increased airflow.

Threats of outer shell and breathability–

Any ventilation on the striking surface is less durable and may cut a sparring partner.

Strengths of strapping system and breathability-

Could potentially cover breathing points/plastic slides could allow airflow.

Weakness of strapping system and breathability-

Does not directly interact much, if laced through the lattice padding it could reduce newfound breathability.

Opportunities of strapping system and breathability-

Use more slide ports both for their purpose and for ventilation.

Threats of strapping system and breathability-

May be confusing as a new concept/not be a believable feature.

Strengths of foam padding and breathability-

Porous foam may offer some semblance of breathability.

Weakness of foam padding and breathability-

EVA foam is generally full density and not breathable at all.

Opportunities of foam padding and breathability-

3d scanned and mapped 3d generated lattice structure padding will be porous and offer newfound airflow through the padding.

Threats of foam padding and breathability-

The more airflow/porous the structure is, the less durable/padded it may be. Also unsure of the antimicrobial properties of the material, however it is used in future craft so it cannot be bad.

Strengths of heat moldable polyfoam and breathability-

If perforated, could offer enhanced breathability.

Weakness of heat moldable polyfoam and breathability-

Cuts off breathability further with second layer of dense foam.

Opportunities of heat moldable polyfoam and breathability-

Removed layer for 3d generated lattice style padding structure that is 3d mapped to hand shape and increase breathability immediately.

Threats of heat moldable polyfoam and breathability-

Taking away this new feature that people really enjoy would be a mistake, so the 3d mapped comfort needs to be perfect.

Strengths of lining and breathability-

Perforated is breathable and offers a more breathable materiality than composite leather.

Weakness of lining and breathability-

If not properly ventilated or without proper antimicrobial properties/treatments, there are concerns with this material bacterial buildup.

Opportunities of lining and breathability-

Using a high tensile strength, double knit mesh may be preferable in this area for increased ventilation.

Threats of lining and breathability-

Adding perforation will risk even worse durability in a thin material.

**Whitin Men's Cross Trainers:**

Upper (Polyester Knit, TPU midfoot support, laces, tongue) TPU eyelets, TPU toe reinforcement, TPU heel reinforcement, algae-based foam insole, rubber outsole

**Stability:**

Strengths of Upper and stability-

Upper has varying density "hex mesh" with three layers, top of RPET mesh, middle of a varying density (maybe TPU) film and third of RPET knit with reinforcement at the heel and toe (heel slightly denser to cup). Using classic lacing system allows for varying fit and the thin film eyelets offer unobtrusive reinforcement.

Weaknesses of Upper and stability-

This could be done with one layer in a varying knit sock liner with one layer of film.

Opportunities of Upper and stability-

Moving in a prime knit direction, or in a single layer 3d print direction (waterproof) with an internal lining could minimize materials. Offering a full sock liner could offer a more comfortable feel due to the proprioceptive nature of the ankle.

Threats of Upper and stability-

Minimizing too much could compromise stability when cutting, so ensuring that the varied 3d upper is strong enough is very important, secondly, removing layers with the idea of the 3d upper could make it less comfortable to the touch/pool sweat so ventilation would need to be ensured.

Strengths of insole and outsole and stability-

While the insole molds to the foot, taking away the midsole allows for a better feel for the ground and more flexible fit at the foot. This outsole is highly flexible with multidirectional grooves which also offer Omnidirectional grip and varied flexibility that conforms with the foot's comfort.

Weaknesses of insole and outsole and stability-

The algae mased insole may take time to mold to the foot shape, and, if the upper is not secure enough at the navicular, since there is a purposeful lack of arch support there is concern for the arch to bottom out (will need testing)

Opportunities of insole and outsole and stability-

If the outsole climbed up the sides of the shoe slightly it might offer a more secure, cage like fit. If the insole were heat moldable (taking a note from ONX) it could break in and form to the foot immediately. If the shoe itself is mapped to a specific foot that would offer the ultimate fit as

well as stability regions. Great opportunity to use a 3d foot scan rather than a shoe last. If the upper and outsole can all be one connected piece that would leave less area for instability.

Threats of insole and outsole and stability-

The 3mm thickness does not offer much reinforcement. Using any form of 3d scanning makes the shoe more customized and therefore less universal.

**Lightweight:**

Strengths of Upper and weight-

Very minimal material usage, most reinforcement is either the internal varying “cage” or via film. There is purposefully minimal material.

Weaknesses of Upper and weight-

The use of film and generated reinforcement makes it very lightweight, however questionably durable. Also, the three-layered upper system seems like one too many for ultimate light weight flexibility.

Opportunities of Upper and weight-

Removing materials further, like the fit, if the upper can comfortably be a single layered 3d print that would be ideal. This would also decrease drying time to 0 and maybe make socks unnecessary. Is there a way to use this structure as the tension system, too and remove the laces?

Threats of Upper and weight-

Removing laces is tricky because it must be much tighter which makes entry/removal hard which puts strain on the opening. Also, removing all textiles from the upper may be too farfetched for performance footwear… sandals?

Strengths of insole and outsole and weight-

The 3mm rubber outsole is very thin and minimizes weight by taking away the bulky midsole.

Weaknesses of insole and outsole and weight-

Although there is not much of it, rubber is not the lightest material so some weight reduction could be there.

Opportunities of insole and outsole and weight-

Bring in graphene composite, this would make this outsole durable, puncture resistant, long lasting, light weight… Also offers thermoregulating properties, can we use it in the upper to?

Threats of insole and outsole and weight- It is already extremely lightweight, bringing in graphene would be expensive and may not be noticeable.

**Comfort:**

Strengths of Upper and comfort-

Upper density variability is mapped to mirror foot tissue density (in reverse, dense upper matches with soft tissue…) The heel cupped reinforcement focuses on one of the most important areas for fit.

Weaknesses of Upper and comfort-

Lack of focus on navicular bone, layering of the tongue is unnecessary when it can be a sock. The low top is rather lame looking, bringing in a sock liner will hype it up a little

Opportunities of Upper and comfort-

Focusing more directly on tissue mapping and navicular fit alongside the heel cup. Removing laces and having a fully neutral upper. Can we remove creasing at MTP joint? Can we connect the upper and the outsole as one piece?

Threats of Upper and comfort-

Removing laces/tongue is tough to do comfortably and reliably. Removing too much reinforcement for freedom of movement can tip the scale too far and make a flimsy shoe.

Strengths of insole and outsole and comfort-

Taking away the midsole forces the foot to strengthen its “core” (the arch) which is immensely important in MMA, and trains as close to barefoot movement as possible (how MMA athletes compete) also allows for enhanced sensory feedback from the ground, and the highly flexible outsole offers optimal motion. Shock absorption pattern is more natural and will reduce injuries over time.

Weaknesses of insole and outsole and comfort-

Necessary to start slow and retrain the foot otherwise could lead to injury from overuse of an undertrained muscle. Even the insole causes added disconnect from the ground… can it be removed?

Opportunities of insole and outsole and comfort-

Connecting it to the upper is an interesting option with 3d tech, the issue there would be clean up and comfort. Can it all be one piece? Full density printed outsole that forms into a lattice “insole” that is immediately formed to the foot.

Threats of insole and outsole and comfort-

Would the outsole connect to the lattice “insole,” connected to the upper limit motion?

The following are the three products that I selected for benchmark testing, and the attributes performance areas that the testing focused on.


*Figure 34. Benchmark Products*

## Fieldwork Planning

## A. Introduction and Background

Mixed Martial arts is a very risky sport with studies showing athletes instance of injury at 286 injuries per 1000 exposures for participants. Of those 286 injuries, 45 were found to be to the hand or wrist due to striking or grappling. According to Trevor Wittman, a professional coach and founder of ONX Sports, over 70% of Mixed Martial Arts Injuries occur in practice when the athletes are theoretically the most careful and protected. The lack of well-designed protective equipment leads to many of these injuries. This research is an effort to better understand the impact dampening and collapsibility of the protective materials used in both heavy bag training gloves and MMA sparring gloves, understand the form and fit, understand the mobility of MMA sparring gloves, and understand the stability of barefoot training shoes used in dynamic strength and agility training off the training mats. This research will help to inform future product innovation in MMA protective equipment and the stability of barefoot training footwear to protect and elevate MMA training.

## B. Specific Aims/Study Objectives

As stated in Part A, the proposed research is an attempt to better understand the protective qualities of MMA equipment and training footwear. This research will include multiple studies, the first of which (study a) will test the impact protection of baseline gloves on the market. Many gloves in the MMA equipment industry use generic foams that reduce impact to some extent but ignore the potential for impact resistant foams specifically engineered to dissipate force across the entire surface. This study aims to test different foams and foam combinations for impact dampening qualities to find a baseline for future foam or impact resistant material use in

products. The findings in this study will apply to both heavy bag training gloves, and MMA sparring/training gloves. The next study (study b) will test the fit of the heavy bag training glove through 3D scanning technology. While many studies of fit use a DEXA scan of a closed fist with and without a glove on and compare the differences in finger position, this study aims to take the fist test and look at hand measurements in 3 dimensions through hand scanning. By scanning both a bare hand in a closed fist, and a hand clenched in a training glove and then taking cross sections of each scan in 3d this study aims to better understand the placement of the hand in a training glove, and how to improve that hand placement. The 3D scan will offer a very accurate sizing and measurement of the participant's hand than traditional methods of measurement. The third study (study c) will test the discrepancy in dexterity between a user without gloves on and a user with open palm MMA sparring/training gloves. The subject will participate in multiple timed peg board tests using the grooved pegboard and manipulation test by Fabrication Enterprises both with and without the MMA sparring/training gloves on to find a baseline for how these products hinder their natural hand movement. The fourth study (study d) will test the stability of training footwear using slow motion analysis of subjects through a dynamic lower body workout with the subjects usual training shoes on, with bare feet, and with the baseline test footwear. This study will include video of the subject's feet and knees from the front view and take note of any deviation of the knee from its neutral position, any slippage of the foot within the shoe, and any deformation of the upper textile. This study will offer insights into the stability that the platform and upper of the shoe offer.

The aims/objectives for the proposed study, include to understand:

- How does the impact resistant material used in current MMA equipment perform in terms of impact dampening?
    - How do different combinations of materials dissipate impact when layered together?
- How do current heavy bag training gloves fit the hand, and do they allow for a natural fist?
    - In what ways does the hand deviate from a natural position?
    - How does the user perceive their mobility as being different?
- How do current MMA sparring/training gloves effect the user's mobility?
    - How does the user perceive their mobility is different?
- How does current training footwear effect the user's stability?
    - How does the user perceive their stability as being different?

## C. Methods, Materials and Analysis

### METHODOLOGY

Location of Study: Test A will take place at PDX (70 NW Couch Street, Portland OR 97209) the data will be analyzed at the researcher's home. Test B will take place at SBG's Portland location (1812 NE 43rd Ave Portland Oregon 97213) where the subject trains, and the results will be analyzed at the researcher's home. Tests C and D will take place at SBG's Portland location as well and the results will be analyzed at the researcher's home.

Timing: Test A should take 45-60 minutes, test B should should take 45-60 minutes, test C should take 45-60 minutes, and test D should take 45-60 minutes. The timing is dependent on how long switching out foams takes, how long the subject takes to change into and out of different gloves, how long the scan takes and whether it takes multiple tries, how long the subject's exercise takes to complete, and how long the subject takes to answer survey questions. Each subject should only have to come to the study 1x (unless there is an issue with the data collected, then they would be asked if they wanted to come back to re-collect data). There is also a potential that we would like to follow-up with the subject learn more about glove/footwear preferences.

Test A

| **Phase of Study** | **Procedure** | **Data Collected** | **Timing** |
|---|---|---|---|
| Material Gathering | Research team purchases/requests material samples of different foams used in baseline products. Enclosed box for testing environment. | NONE | NA |
| Camera/measurement setup | Prepare slow motion camera from side view. | NONE | 5 minutes |

| | | | |
|---|---|---|---|
| Foam Set up | Prepare first foam/foam combination underneath drop zone. | NONE | 2 minutes |
| Data Collection | Turn on camera | NONE | <1 minute |
| | Drop 1" steel sphere onto foam or lattice. | Height of bounce after drop. | 2 Minutes |
| | Repeat steps from foam set up to clean up for all sets of foam | | 30 minutes for 6 foam and lattice combinations |
| Data Compilation (Researcher at Home) | View videos in slow motion analyzing both the height of the ball bouncing. | Different height measurements. | 3 Hours. |

Test B

| **Phase of Study** | **Procedure** | **Data Collected** | **Timing** |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Subject Recruitment | Researcher solicits for subjects via emails, texts, at SBG MMA gym, and through shared survey on social media | NONE | NA |
| Subject Sign-Up | Subject agrees to get hand scanned both inside of and out of glove | NONE | <1 minute |
| Material Gathering | Training glove, 3d scanner (nucleus lab), blue masking tape, ruler, 10 print outs of palmar and dorsal sides of fist. | NONE | |
| Data Collection (Subject is at SBG MMA gym) | Subject marks predetermined distance on wrist for reference in 3d (from the bottom of where the glove ends and measurement from wrist spot to end of glove is taken on palmar side) on palmar, dorsal, medial, and lateral wrist | Measurement of hand is written down for subject-by-subject number | 5 minutes |

| | | | |
|---|---|---|---|
| | Subject removes glove, makes fist and is scanned with bare hand | 360-degree scan of hand is taken | 5 minutes |
| | Subject puts on training glove, makes a fist, and is scanned | 360-degree scan of hand is taken | 5 minutes |
| Data Collection | Repeat Data Collection steps for all subjects | | Approximately 1 hour |
| Data Compilation | 3D scans are scaled in 3d program | Scans are taken into CAD program and scaled based off markings on wrist | 30 minutes |
| | x-ray images/cross sections are taken showing how the natural fist compares to glove | Sizing images are created | 30 minutes |
| | Measurements are taken to show discrepancies in hand position from each phalange. | 3D scan measurements are recorded. | 30 minutes |

Test C

| **Phase of Study** | **Procedure** | **Data Collected** | **Timing** |
|---|---|---|---|
| Subject Recruitment | Research team solicits for subjects via emails, at SBG MMA gym, and through shared survey on social media | NONE | NA |
| Subject Sign-Up | Subject agrees to study | | <1 minute |
| Data Collection (Subject is at SBG MMA gym) | Researcher places pegboard test in front of subject and explains how the peg board test works | NONE | 3 minutes |
| | Subject explains test back to ensure understanding | Subject understands how test works | 3 minutes |

| | | | |
|---|---|---|---|
| | Subject takes timed pegboard test for both right and left hand without glove on | Baseline timing for test without gloves on | 2 minutes |
| | Subject puts on MMA Training Gloves | NONE | 1 minute |
| | Subject takes timed pegboard test for both right and left hand with gloves on | Timing for test with gloves on | 2 minutes |
| Data Collection | Repeat Data Collection tests for all subjects | | 45-60 minutes |
| Data Compiling | Researcher gathers data on times/pegs completed | Finding similarities between different users | 30 minutes |

Test D

| **Phase of Study** | **Procedure** | **Data Collected** | **Timing** |
|---|---|---|---|
| Subject Recruitment | Research team solicits for subjects via emails, at SBG MMA gym, and through | NONE | NA |

| | | | |
|---|---|---|---|
| | shared survey on social media | | |
| Subject Sign-Up | Subject agrees to in depth study | | <1 minute |
| Data Collection (Subject is at SBG MMA gym) | Researcher explains workouts and purpose of filming | NONE | 5 minutes |
| | Researcher applies black colored tape to user's knee and ankle for motion tracking | | 1 minute |
| | Researcher sets up camera for full body view and for foot view | NONE | 2 minutes |
| | Subject performs exercises without shoes on | 5 front lunges with arms above head, 5 side lunges with arms above head | 2 minutes |
| | Subject puts on regular training shoes | NONE | 2 minutes |

| | | | |
|---|---|---|---|
| | Subject performs exercises with training shoes on | 5 front lunges with arms above head, 5 side lunges with arms above head | 2 minutes |
| | Subject puts on benchmark shoes on | NONE | 2 Minutes |
| | Subject performs exercises with benchmark shoes on | 5 front lunges with arms above head, 5 side lunges with arms above head | 2 minutes |
| | Subject marks areas of comfort/discomfort on foot printouts. | Red for tight, blue for loose, room for notes | 5 minutes |
| Repeat data collection tests for all subjects | | | 60 minutes |
| Closing | Thank subjects for their time and ask about any additional comments or questions | | 1 minute |
| Data Compilation | Videos are analyzed for knee wobble and any foot slippage | | 90 minutes |

Test E

| **Phase of Study** | **Procedure** | **Data Collected** | **Timing** |
|---|---|---|---|
| Material acquisition | 3D print padding, and cut open and retrieve padding from inside of glove on benchmark product. | NONE | NA |
| Data Collection | Researcher sets up padding above plastic cups | NONE | 5 minutes |
| | Researcher uses water vaporizer to create pourable water vapor | | 1 minute |
| | Researcher sets up camera for view of padding | NONE | 2 minutes |
| | Researcher pours water vapor over benchmark padding | Observes if any vapor passes through | 2 minutes |
| | Researcher pours water vapor over 3D padding structure | Observes if any vapor passes through | 2 minutes |
| | Researcher retrieves video for analysis | NONE | 2 minutes |

| | | | |
|---|---|---|---|
| Observe vapor difference in water vapor pass through | Researcher analyses video | Observational difference between padding structures. | 10 minutes |

**MATERIALS REQUIRED**

Benchmark products (Hayabusa T3 Boxing gloves, Hayabusa T3 Hybrid MMA sparring glove, Whitin Men's Cross Trainers).

**QUALITATIVE USER RESEARCH-**

**In depth interview**

**Hayabusa T3 Boxing Gloves-**

User will wear gloves and work through three, five-minute rounds on the heavy bag.

1. Was your wrist supported comfortably in this glove? Did you feel issues in any direction?

2. Did you have any issues with your thumb in terms of making a fist?

3. Did you impact with your thumb at any time?

4. How was the spacing and flexibility of the knuckle? Did you have any trouble making a fist?

5. How fatigued are your forearms? Did you feel the need to work to make a fist?

How hard was making a fist 1 being no glove, 10 being exhausting.

6. How did these gloves feel in terms of impact protection? Were there any specific areas on the knuckle that were less protected?

7. Did you have any problems strapping on the glove? Would this potentially get in the way of the fluidity of a workout?

8. Was there any rubbing or discomfort in terms of friction? Where?

9. How was the space for your fingers? Were there any areas that felt cramped? Any areas that felt excessively loose?

10. Were you comfortable using these gloves without hand wraps?

**Whitin Men's Cross Trainers-**

User will wear shoes through a dynamic lower body workout.

1. How was the security of the shoe on the heel? Did your heel feel supported?

2. How was the fit around the toe box? Were your toes squished or was there a low of room?

3. Did the shoe feel "locked in" on the midfoot or did it feel like the lacing only applied tension to the top of the shoe?

4. Did you feel stable when lifting?

5. Would it be preferable to slip these shoes on?

6. How was the traction? Did it feel slick? Did it change on different surfaces?

7. Would you consider wearing these without socks? Why or why not?

8. Did you feel stable while performing these exercises? If no, would you attribute that to sensation on the ground or to instability in the upper?

9. Do you have any other comments regarding fit or comfort?

## QUANTITATIVE RESEARCH-

This research questionnaire was conducted through google forms. The following are key questions asked to gain insights into user preferences for each product category.

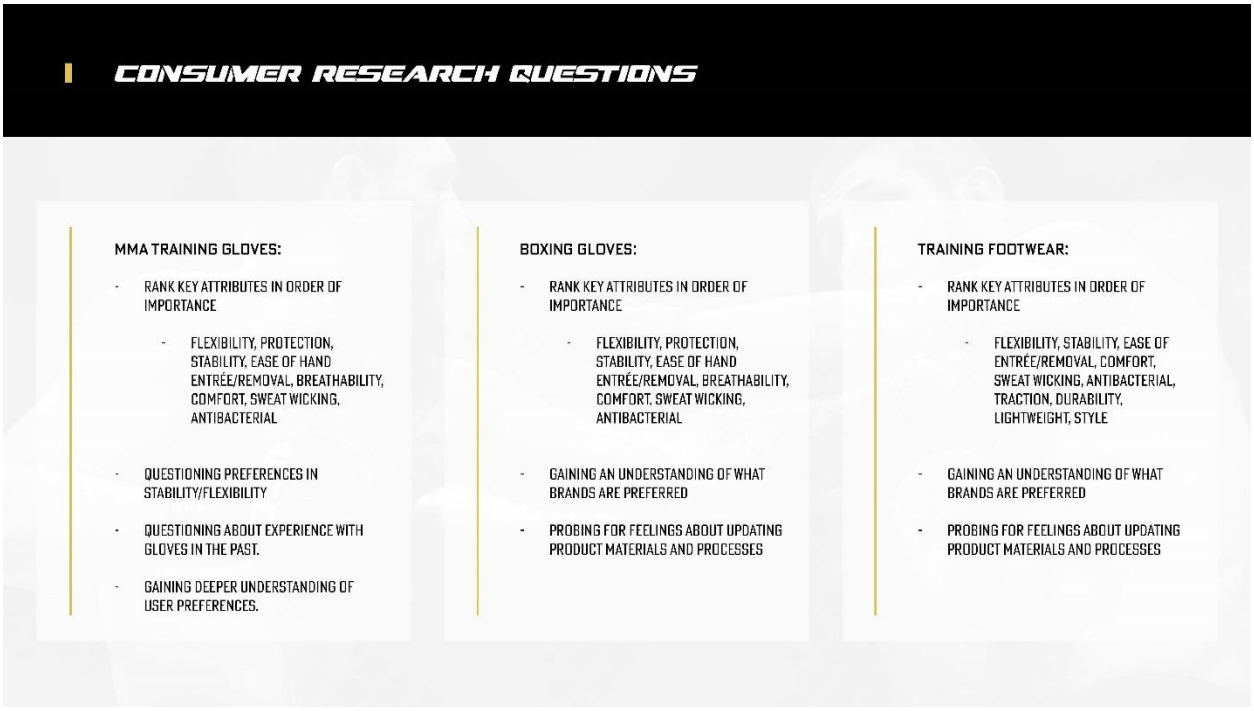



*Figure 35. Key questions asked to gain insights into user preferences for each product category.*

### Fieldwork Execution

The following image depicts the location and key athlete involved in the testing protocol.

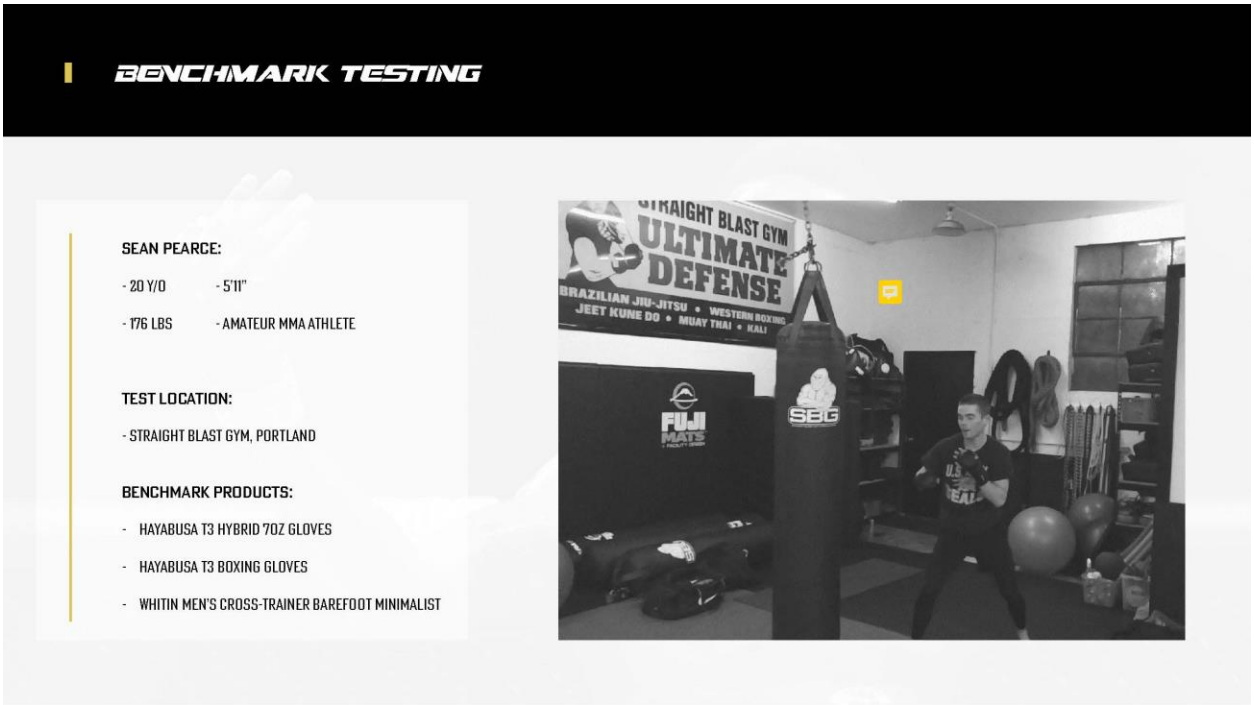



*Figure 36. Location and key athlete involved in the testing protocol.*

The following are images depicting the testing process, from left to right, top down the first image depicts the qualitative strike test, the second image depicts the ball drop impact test, the third image depicts the dexterity test, the fourth image depicts the 3D fit test, and the fifth image depicts the lateral stability and deformation testing.

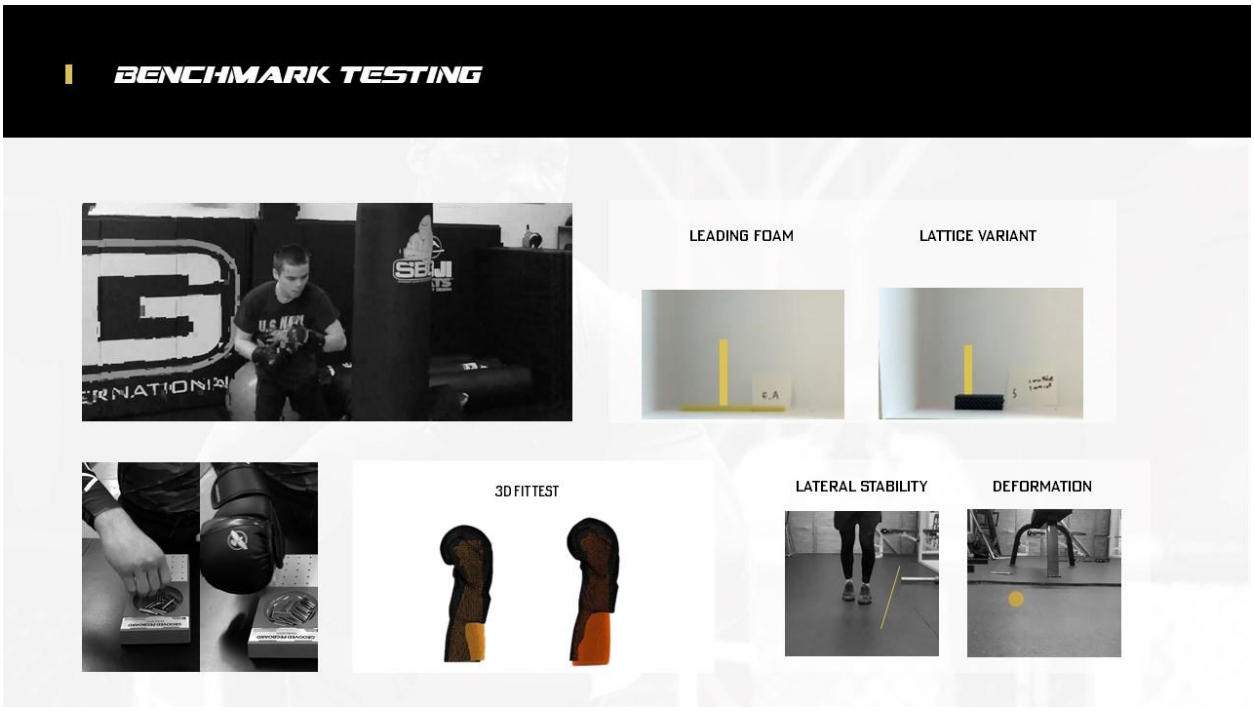



*Figure 37. from left to right, top down, qualitative strike test, ball drop impact test, dexterity test, 3D fit test, lateral stability and deformation testing.*

The following image depicts the results of each test from left to right, top to bottom the results of the qualitative strike test, the results of the ball drop impact test showing that the varying lattice structures performed generally better than the baseline impact foam in terms of impact attenuation, the results of the dexterity test which showed a 33% loss in dexterity in the peg board test, the results of the 3D scan fit test which showed up to a 1” difference in finger position with the glove on vs a natural fist, and the stability and deformation tests in which the barefoot trainer performed slightly worse that the generic training footwear and barefoot tests in both stability and deformation.

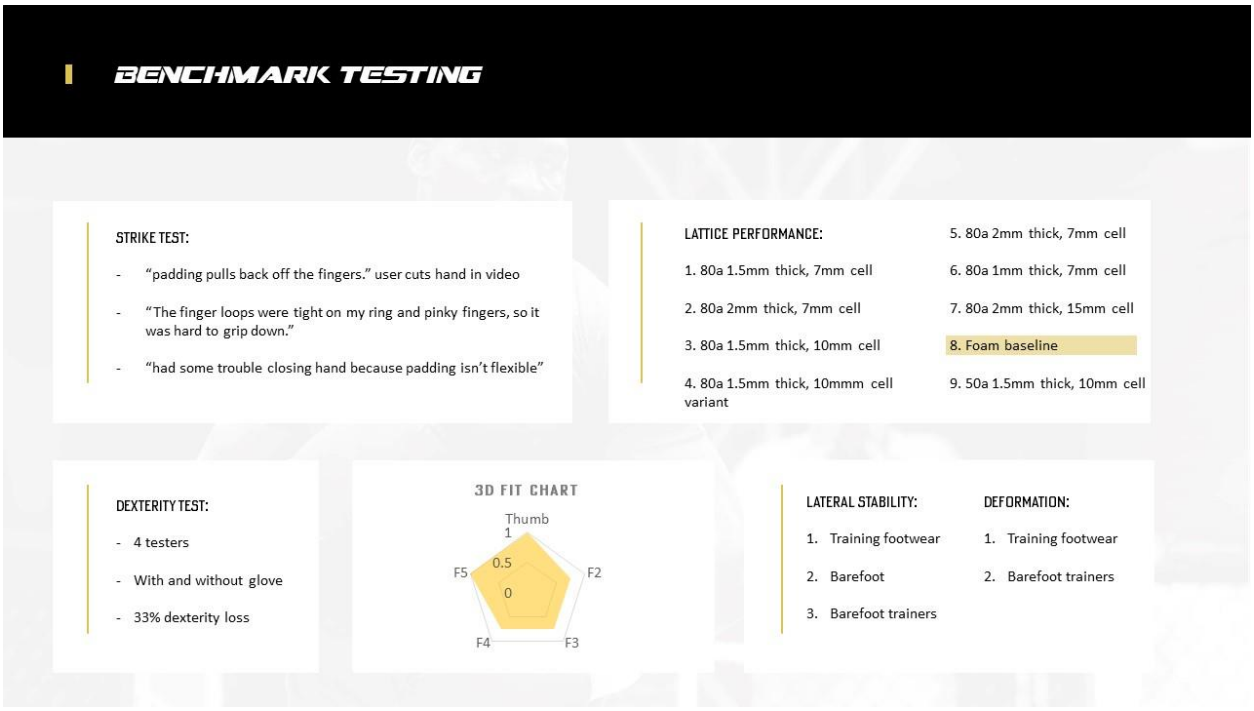



*Figure 38. from left to right, top down, qualitative strike test, ball drop impact test, dexterity test, 3D fit test, lateral stability and deformation testing.*

*Figure 39. Key depicting zones that require improvement based on qualitative research questions, key insights about Hayabusa T3 Boxing Glove, and key insights about the Whitin Men's Cross Trainers*

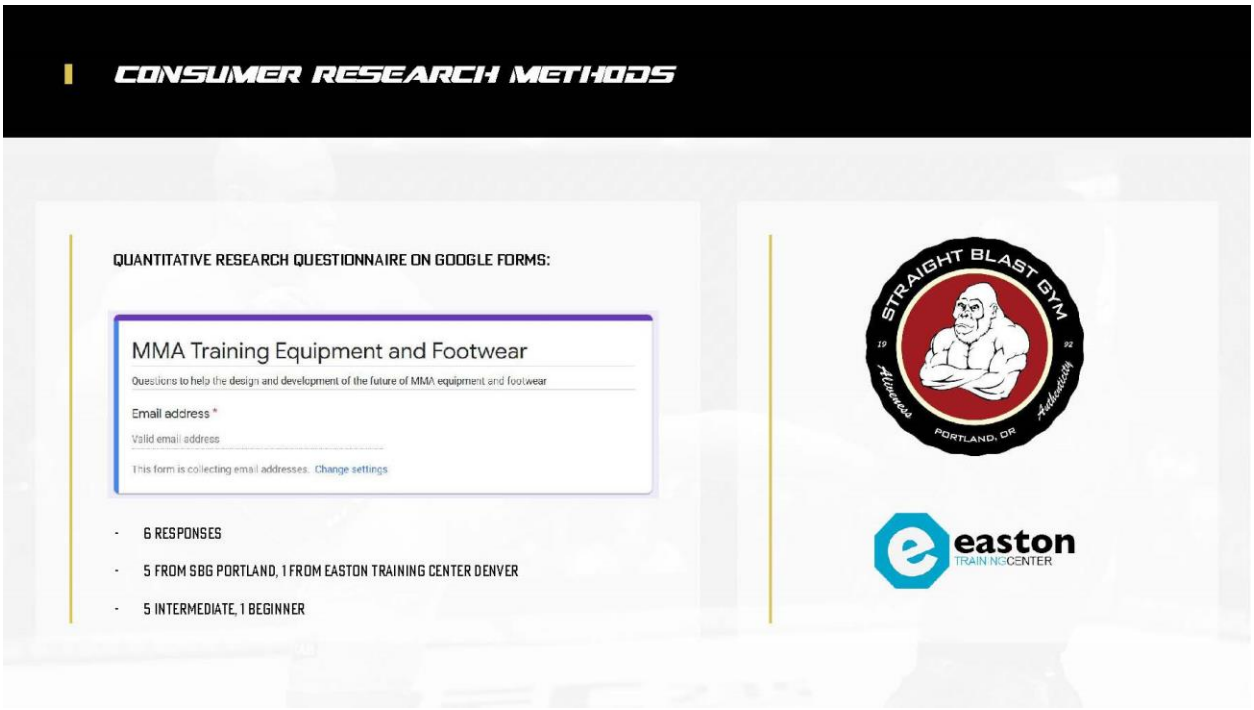



*Figure 40. Responses to qualitative questionnaire*

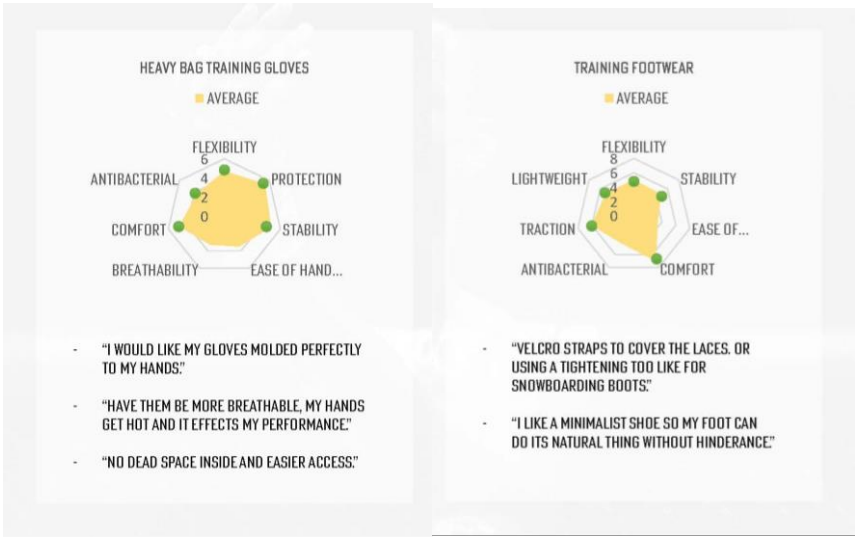
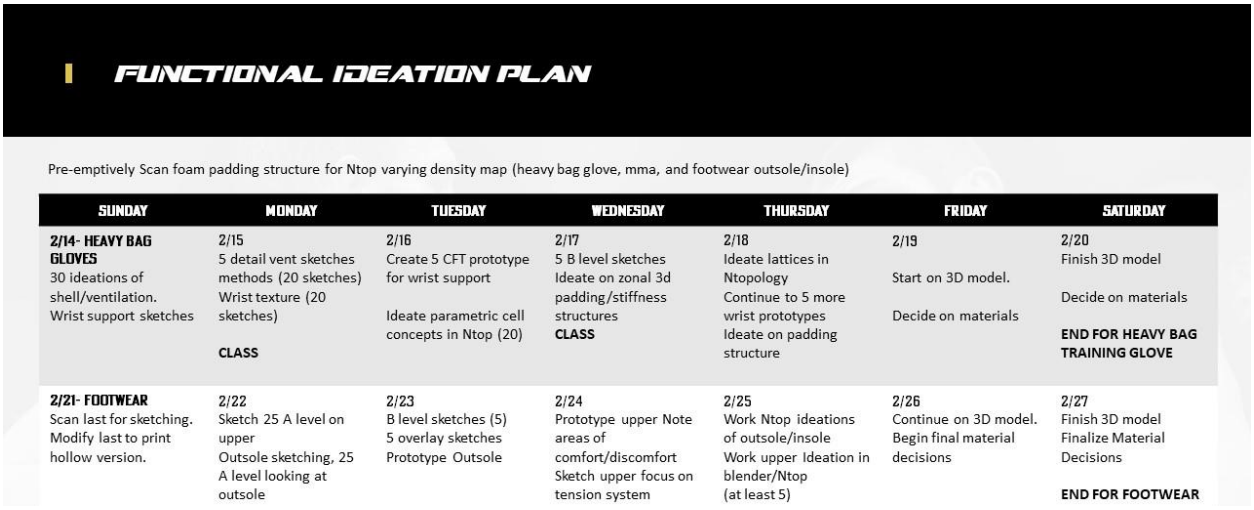



*Figure 41. Responses to qualitative questionnaire*

## Ideation Planning



FUNCTIONAL IDEATION PLAN

Pre-emptively Scan foam padding structure for Ntop varying density map (heavy bag glove, mma, and footwear outsole/insole)

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---|---|---|---|---|---|---|
| **2/14- HEAVY BAG GLOVES**<br>30 ideations of shell/ventilation.<br>Wrist support sketches | 2/15<br>5 detail vent sketches methods (20 sketches)<br>Wrist texture (20 sketches)<br><br>**CLASS** | 2/16<br>Create 5 CFT prototype for wrist support<br><br>Ideate parametric cell concepts in Ntop (20) | 2/17<br>5 B level sketches<br>Ideate on zonal 3d padding/stiffness structures<br>**CLASS** | 2/18<br>Ideate lattices in Ntopology<br>Continue to 5 more wrist prototypes<br>Ideate on padding structure | 2/19<br><br>Start on 3D model.<br><br>Decide on materials | 2/20<br>Finish 3D model<br><br>Decide on materials<br><br>**END FOR HEAVY BAG TRAINING GLOVE** |
| **2/21- FOOTWEAR**<br>Scan last for sketching.<br>Modify last to print hollow version. | 2/22<br>Sketch 25 A level on upper<br>Outsole sketching, 25 A level looking at outsole | 2/23<br>B level sketches (5)<br>5 overlay sketches<br>Prototype Outsole | 2/24<br>Prototype upper Note areas of comfort/discomfort<br>Sketch upper focus on tension system | 2/25<br>Work Ntop ideations of outsole/insole<br>Work upper Ideation in blender/Ntop<br>(at least 5) | 2/26<br>Continue on 3D model.<br>Begin final material decisions | 2/27<br>Finish 3D model<br>Finalize Material Decisions<br><br>**END FOR FOOTWEAR** |

*Figure 42. Functional Ideation Planning*

## Ideation and Prototyping

The sketching for the heavy bag gloves focused on a wrist support concept that both maintains a straight wrist for stability and alignment upon impact, as well as an interior system that uses the tension provided by the straps to pull the hand into a tighter position. The prototype is a very basic representation of what that would look like, and this concept will be applied using high strength, high tension wires that weave through the internal padding structure. The ventilation will rely on the internal, open cell lattice structure for improved airflow.

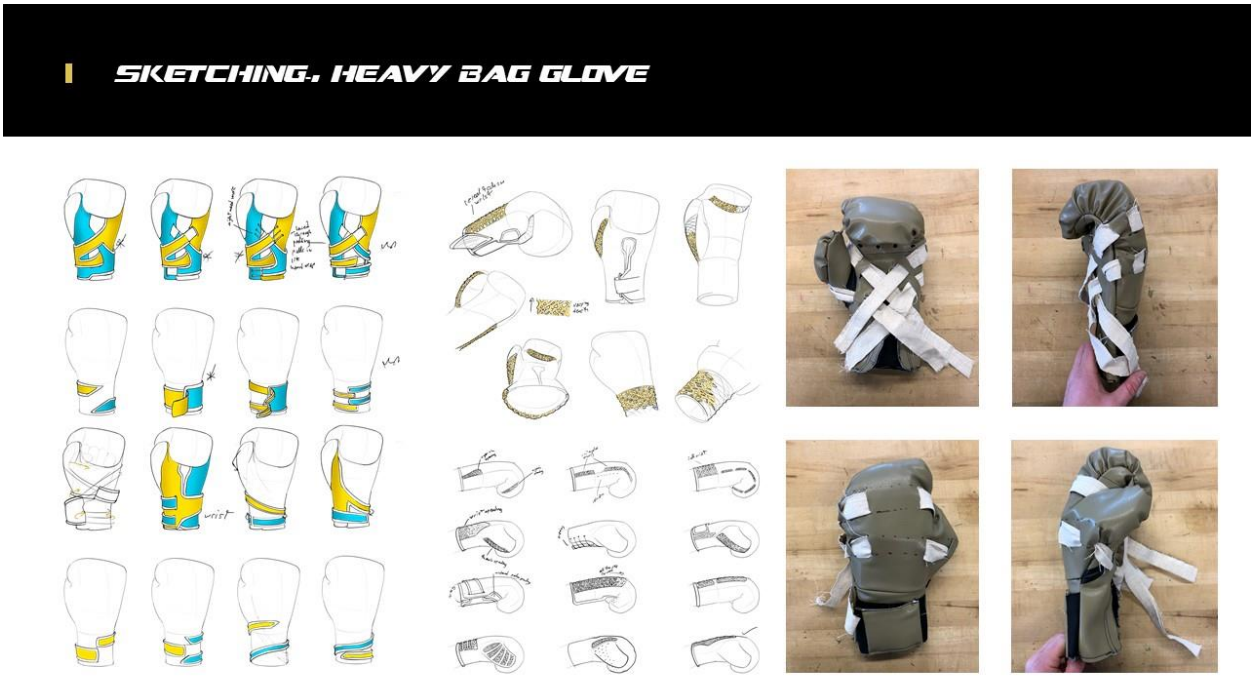



*Figure 43. Sketching and Prototyping for heavy bag glove*

The internal padding will use a varied lattice structure based on an impact test conducted by covering a heavy bag in chalk and striking the bag with both heavy bag gloves, and MMA training gloves to find key impact zones.

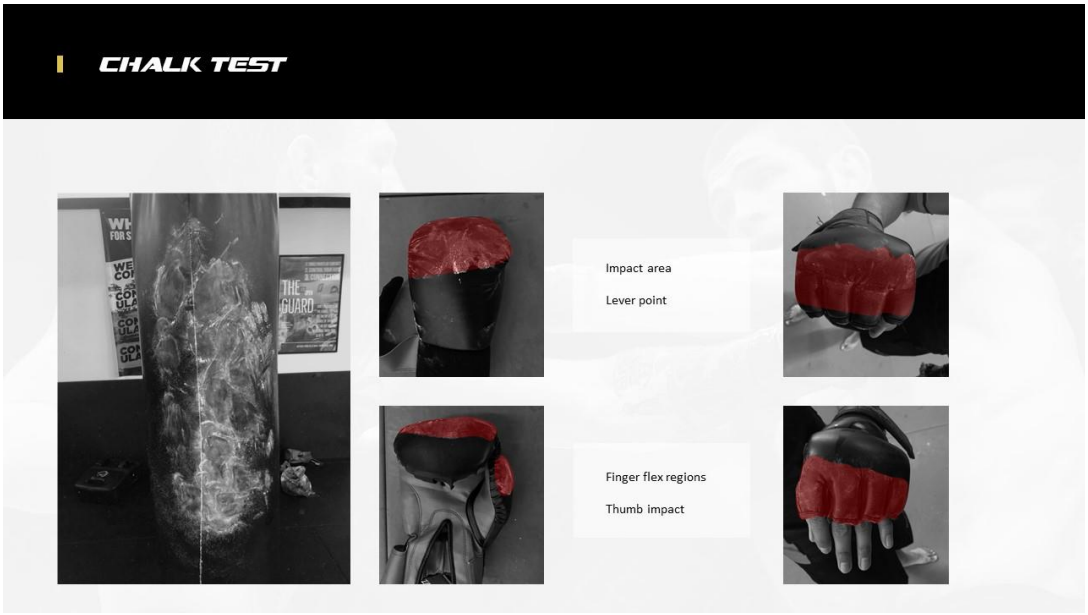



*Figure 44. Chalk test informing Impact Mapping.*

Those impact zones were then applied using a varying lattice structure with densities based on the lattices used in the impact test against the baseline foam. The variation in density was applied based on both the foams used in the baseline glove's layering system, and the chalk impact test. There are lower density zones in the outer padding area and higher density zones closer to the hand to slowly dampen the impact, lower density zones above the knuckle line and toward the fingertips to allow for more flexibility, and higher density zones on the wrist and in the impact zones for stability and protection.


*Figure 45. Ntopology and blender Ideation on heavy bag glove*

The footwear sketching focused on integrating a tension system into the outsole that also simplifies the entry into and removal of the shoe, the style and mapping of the outsole traction, and the flexible regions and opening for the upper based on the foot tissue density map from figure 23. The varying flex zones for the upper were then mapped in the Ntopology program to be laser cut as the mid layer for the upper.

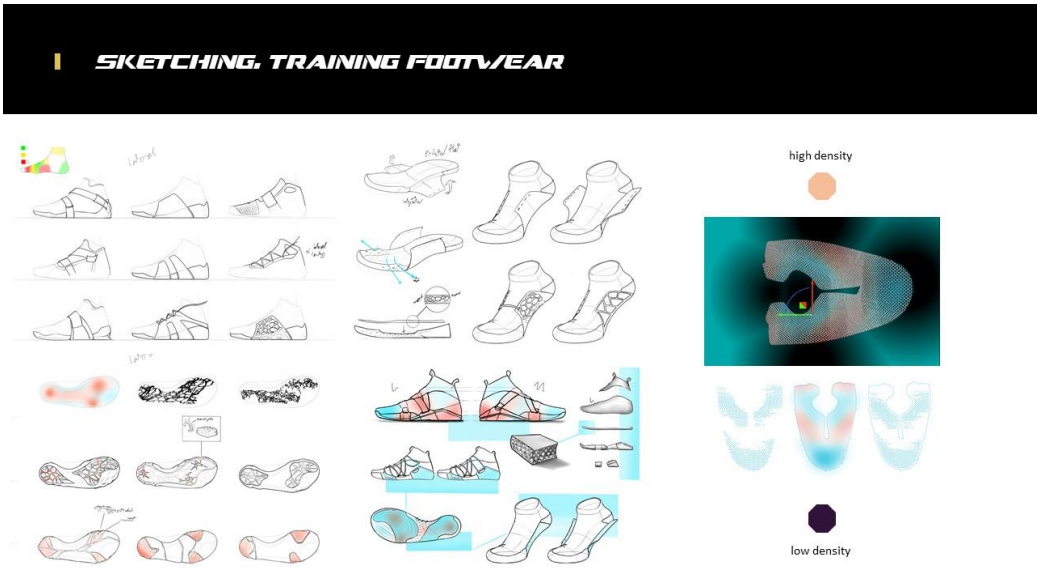



*Figure 46. Sketch and upper Ideation for training footwear*

The next step in the footwear ideation was creating a 3D insole based on a custom, zero drop last with a widened toe box that I created in blender and then applying a density map based on a foot impact map. I then prototyped the upper using the laser cut density map, which was created in Ntopology, and prototyping the tension system.


*Figure 47. Insole mapping, last customization, upper ideation, tension system ideation, 3D ideation*


*Figure 48. Exploded View and material breakdown for Heavy Bag Training Glove*

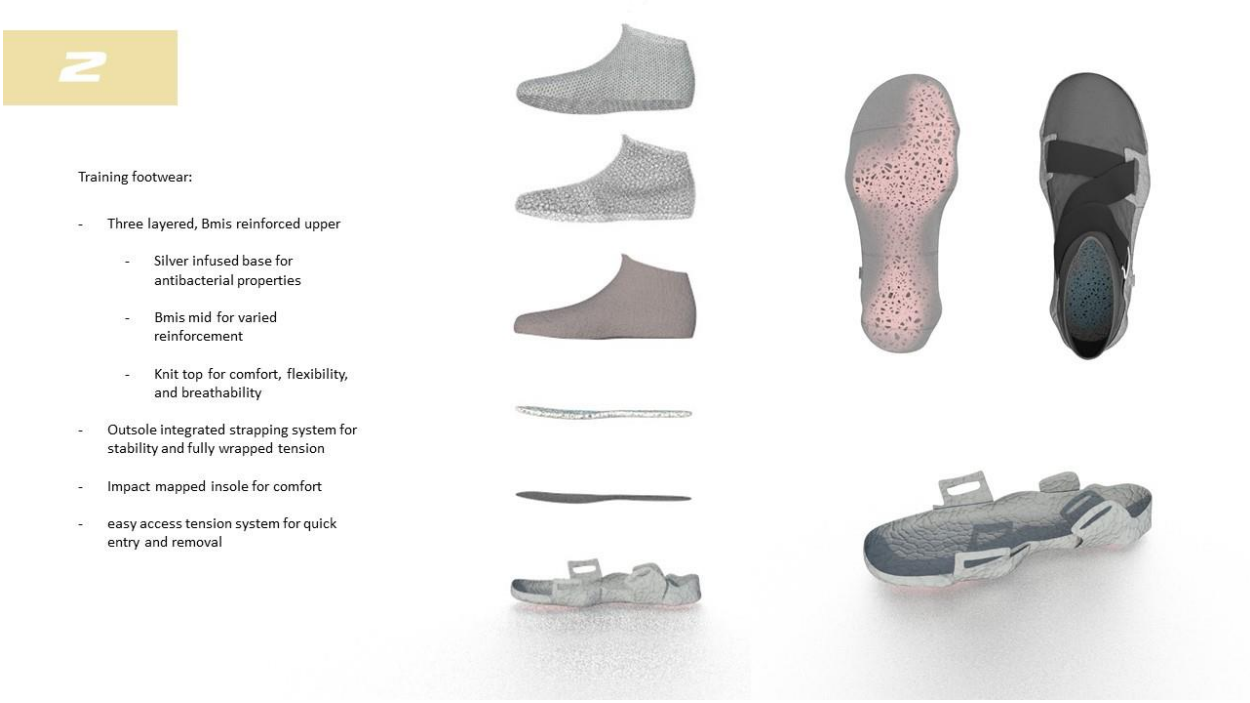



*Figure 49. Exploded View and material breakdown for Training Footwear.*

## Updated and Personalized Graphics

For the final products next term, the graphics were updated and personalized for Sean Pearce (see figure 39), the primary product tester and fit model for this project. The graphic and image ideas were taken directly from an interview with Sean regarding his interests and fighting style.


*Figure 50.Mood Board 1*

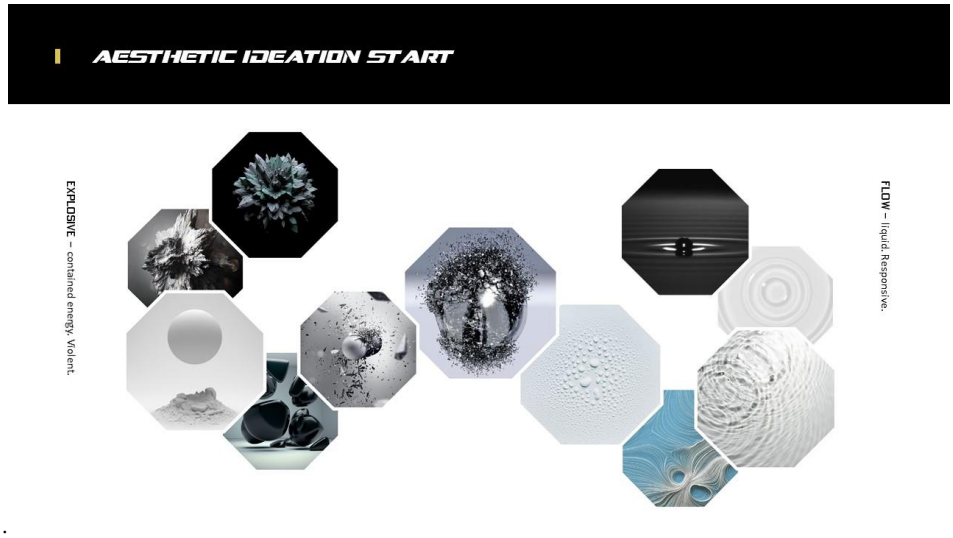



*Figure 51. Mood Board 2*

## Validation Planning

In the next term I will begin prototyping each product and testing for the same performance goals laid out for the benchmark products.

The testing plan and performance goals for the training footwear are as follows:

1. Improved comfort through dynamic lunge and workout test and qualitative questionnaire
2. Perceived arch activation through user workout test and qualitative questionnaire.

The testing plan and performance goals for the heavy bag training glove are as follows:

1. Improved comfort through side-by-side user testing against the benchmark product.
2. Improved Impact Protection through ball bearing impact test.
3. Improved Breathability through water vapor pour test.

*Figure 52. Performance Goals for final products.*


*Figure 53. Final presentation opening slide*


*Figure 54. Project Goals*

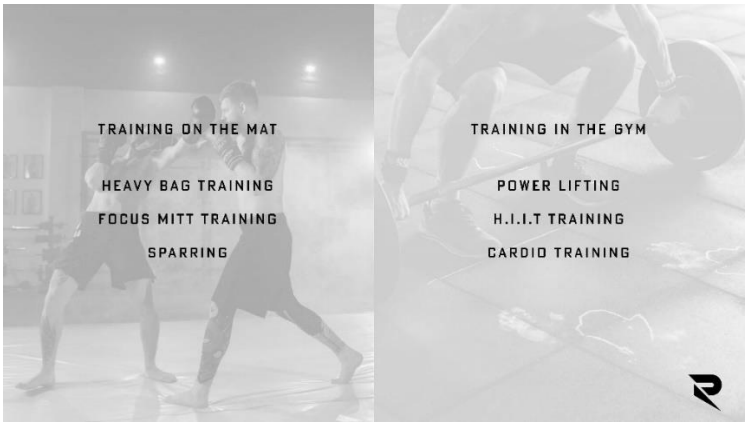



*Figure 55. Training Locations*

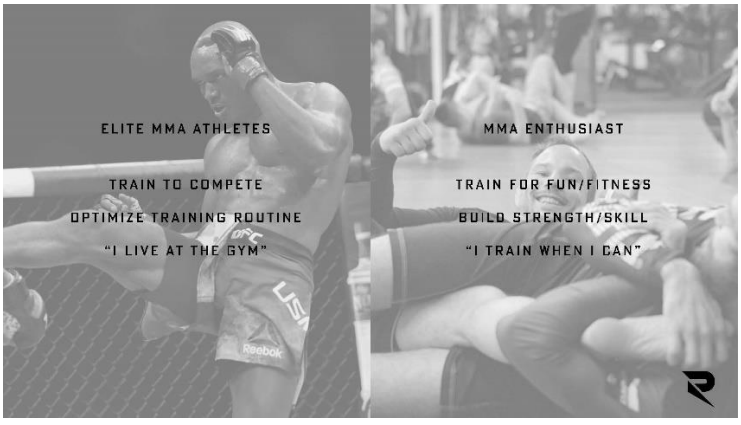



*Figure 56. User Focus*

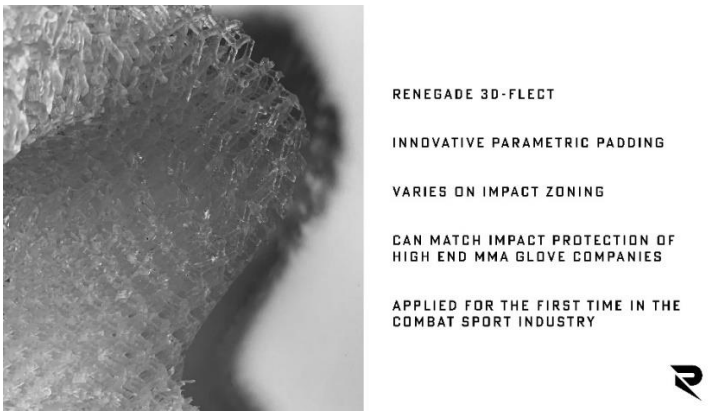



*Figure 57. 3D-Flect Technology Explanation*


*Figure 58. R1 Training Glove*


*Figure 59. Glove Areas of Improvement*

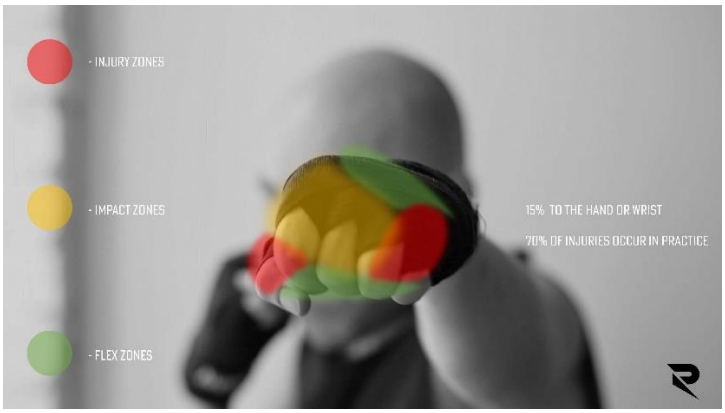



*Figure 60. Impact Zoning*

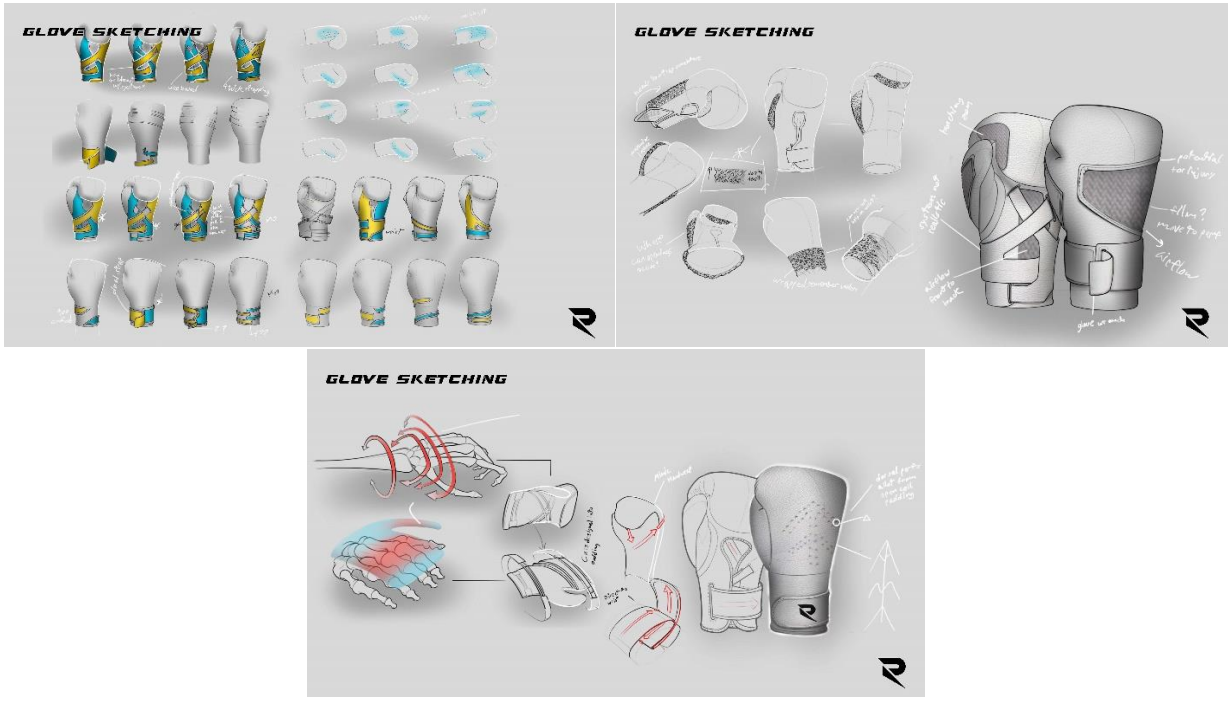



*Figure 61. Glove Sketching*

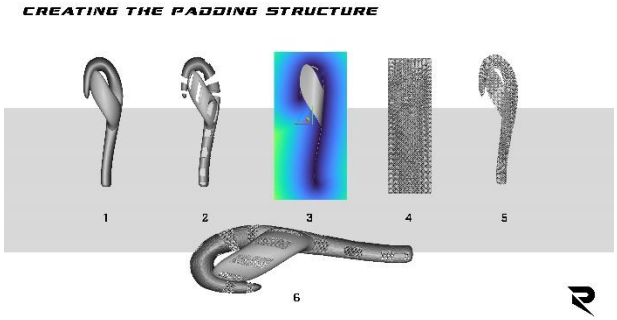



*Figure 62. 3D Padding Structure*

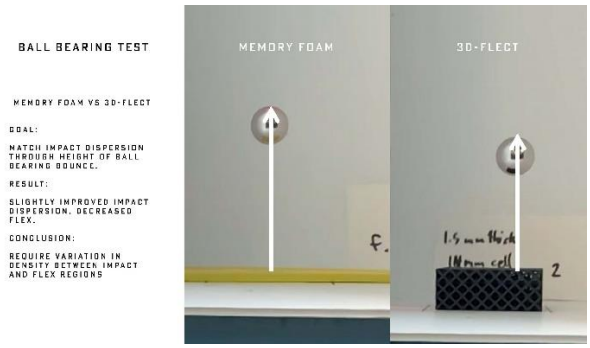



*Figure 63. Ball Bearing Test*

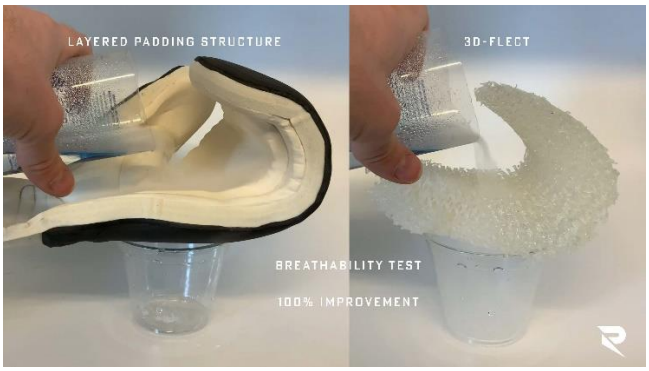



*Figure 63. Breathability Test*

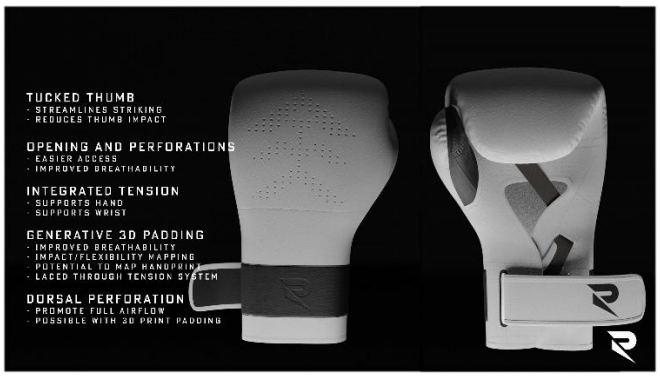



*Figure 63. Features and Benefits*

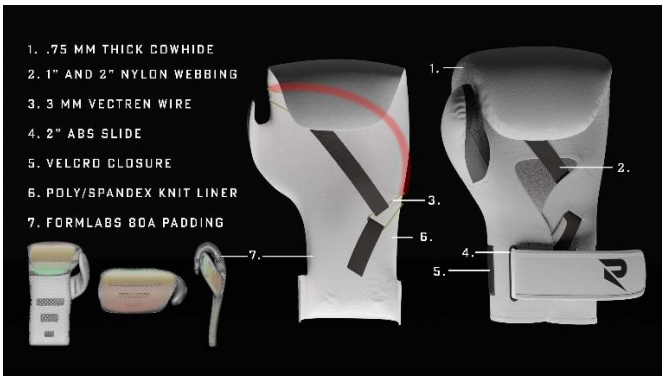



*Figure 63. Materials*

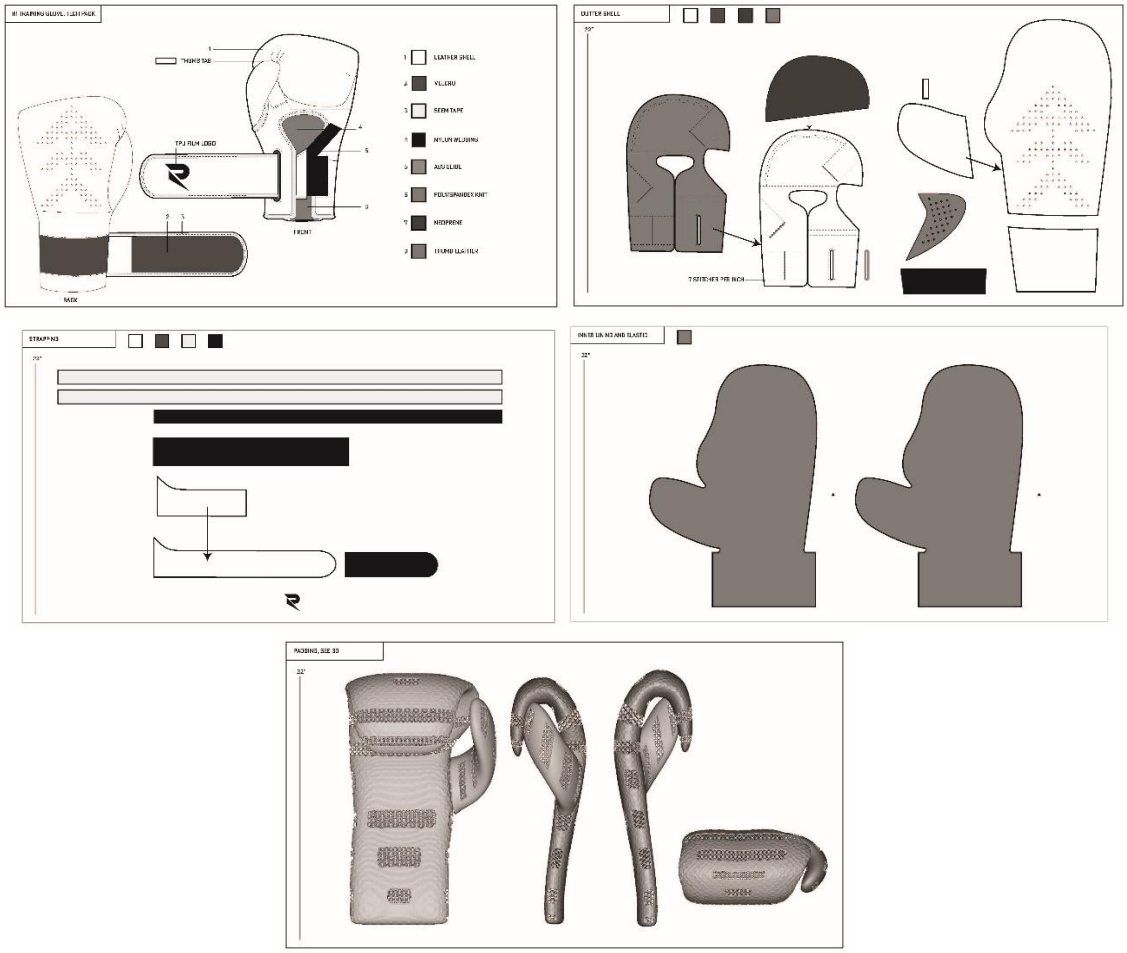



*Figure 64. Tech Pack*


*Figure 65. User Feedback*

*Figure 66. Final Images*


*Figure 66. R1 Training Footwear*


*Figure 67. R1 Training Footwear Areas of Improvement*

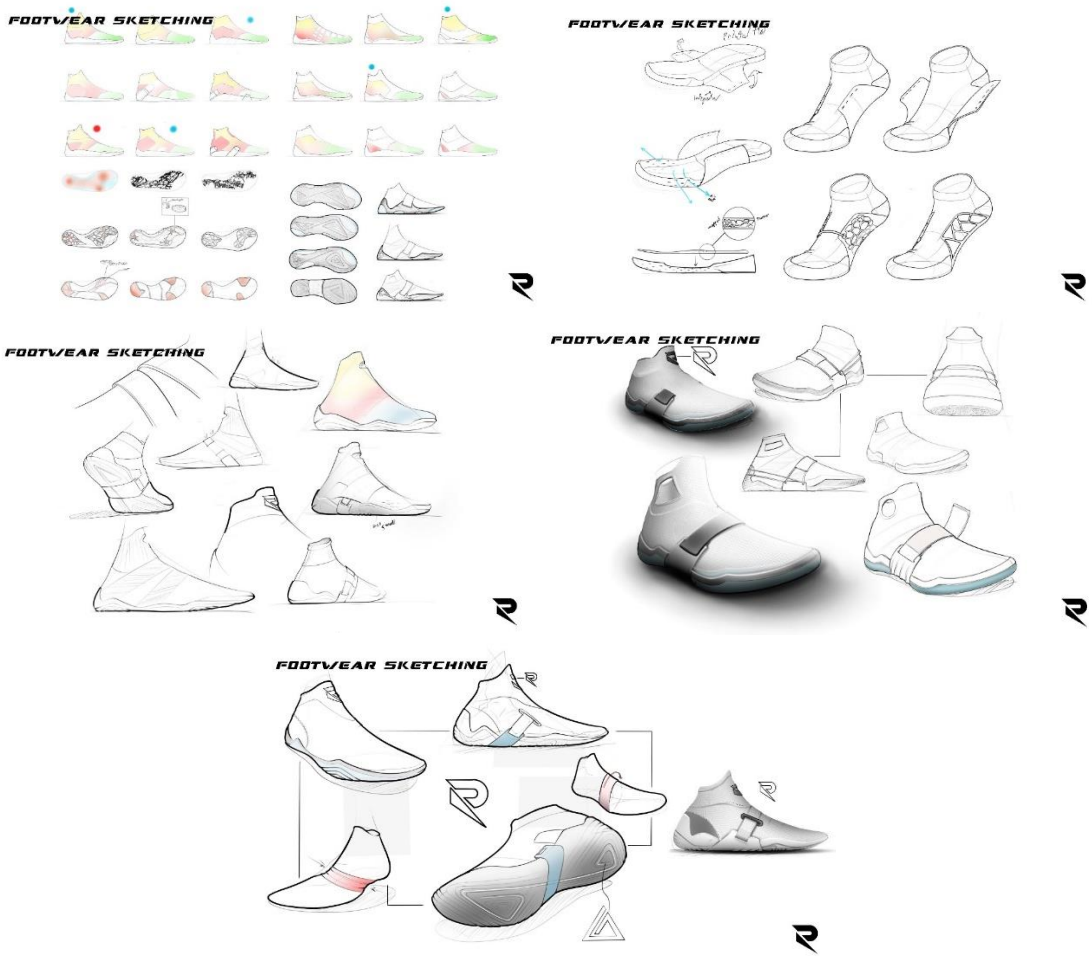



*Figure 67. R1 Training FootwearSketching*

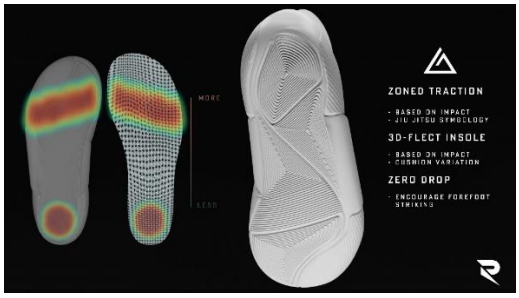



*Figure 68. R1 Training Footwear Outsole and Insole*


*Figure 69. R1 Training Footwear Features and Benefits*

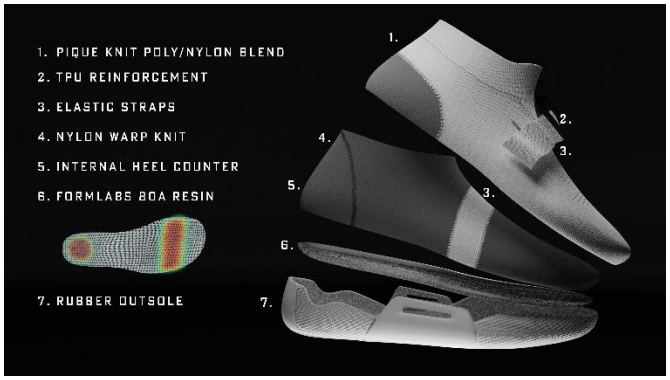



*Figure 70. R1 Training Footwear material callouts*


*Figure 71. R1 Training Footwear Testing Results*


*Figure 72. R1 Training Footwear Insights*

*Figure 73. R1 Training Footwear Images*

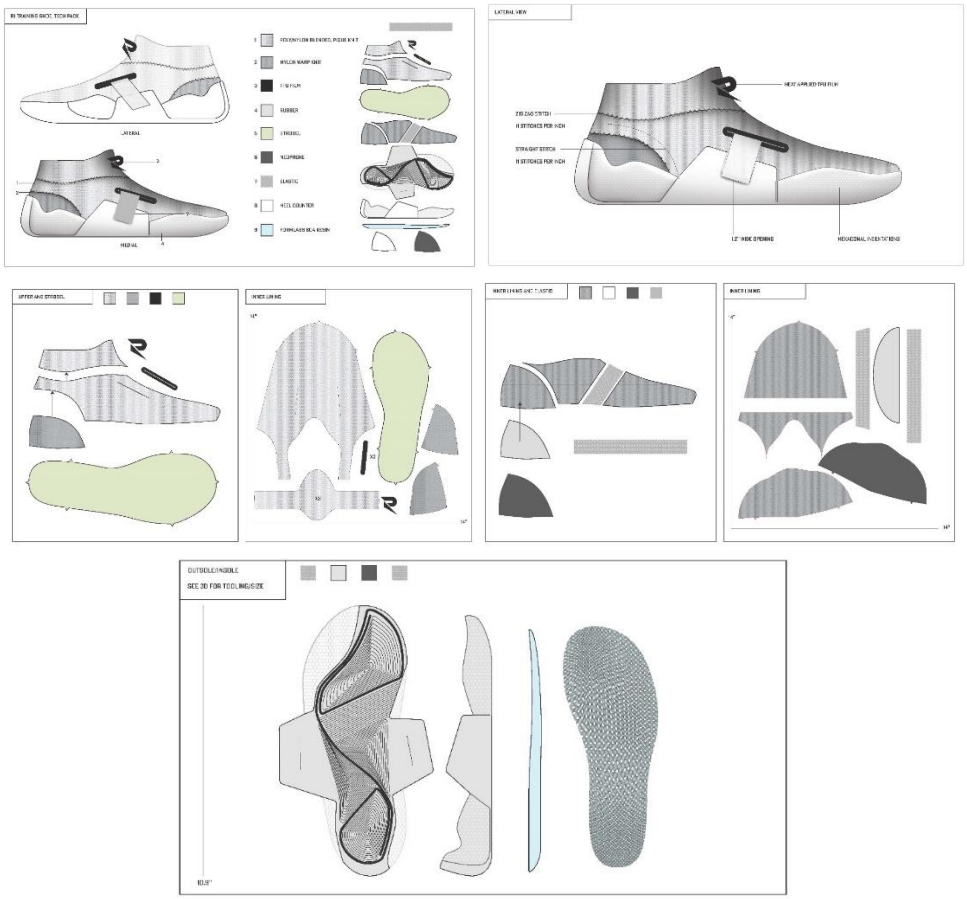


*Figure 74. R1 Training Footwear Tech Pack*


*Figure 75. R1 Project Conclusions*

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