

Performance Footwear and Apparel for Women's Outdoor Basketball Athletes Investigating  
Court Surface and Durability

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## **Project Inspiration**

Emily Guerra is a designer from Long Island, New York who uses her experiences as a multi-sport athlete to innovate products for the next female athlete. Vast experience in sport and rehabilitation have allowed her to witness first-hand the inequalities in men's and women's sports all the way up to the college level not only in opportunity, but also in product.

Emily grew up playing soccer, basketball, and lacrosse where she was a part of year-round training, travel teams, and school teams. Having been a part of a variety of teams has allowed her to take on many different roles in order to put the success of the team first. Emily played on the Pratt Institute Women's Basketball team while earning her Bachelor of Industrial Design. During her four years of playing college basketball, Emily went through two injuries that took her off the court for periods of time. One injury was caused by a lack of fit and cushioning in her shoes and the gym flooring her team practiced and played games on. Her inspiration for this project came from this injury because with the proper footwear this injury can be prevented, allowing female athletes to continue playing the sport they love while staying healthy.

Women in sports are lacking product designed for their bodies and their game. They are currently wearing products that require them to accommodate for the lack of fit, cushioning, and stability, putting them at a higher risk of injury.

After taking the Clifton Strength Finder test, her top five strengths are achiever, discipline, learner, focus, and maximizer. Being a female athlete has taught Emily a lot about teamwork and how to push oneself both physically and mentally to challenge the status quo or what is initially believed to be the "limit" or norm. As Emily moves into her design career, her passion as a sports product innovator is to design solutions studying the ecosystem of the female athlete to maximize her performance and her game for the future of footwear and apparel.

## **Project Overview**

Streetball began as a game where players were "doing more with less". The game's raw talent and showmanship gained the attention of those across the world. While the game has been heavily dominated by male athletes, women have also been playing this sport throughout its history in the 1900s and today. Because of the spontaneity of streetball, documentation of the women's game has been very little to none, further displaying the inequalities seen in men's and women's sports. In the 1980s, 3x3 basketball took inspiration from the most popular urban sport in the world and brought it into an organized and professional setting.

While streetball has gained even more popularity and attention due to the development of 3x3 basketball, there has been no innovation in the products female athletes are using for this specific game and environment. Female athletes are using products that have been designed and tested for male athletes and then manufactured in women's sizes, following the industry's

standard of “shrink it and pink it”. According to the NCAA 2018-19 Summary of Athletics Participation Survey, across the US there are 415,576 female basketball athletes (NCAA, n.d.). While female basketball players make up approximately 45% of high school and college level basketball players, only 1% of basketball footwear is designed for women (Luther, *Why the Gaps Between Men's and Women's Sports are so Frustrating*, 2017). Majority of female basketball players are wearing shoes marketed to male athletes and do not take into consideration female biomechanics and surface the game is played on. This inherently means they are also lacking proper fit, durability, and cushioning leading to many female players adjusting their biomechanics on the outdoor surface or developing injuries that could end their careers.

Outdoor court surfaces are typically asphalt, concrete, or polypropylene tiles. “Indoor wood courts offer the most shock absorption and are considered the safest courts, while outdoor courts of asphalt are more dangerous” (American Podiatric Medical Association, n.d.). As stated in Tarkett Sports’ ASTM F2772 Sports Flooring Standard, “High deformation can affect the safety of the athlete, causing instability of the foot, while low deformation may cause injuries as a result of immediate impact force” (Tarkett Sports, 2015). Surface materials such as asphalt and concrete have a low deformation due to less shock absorption leading to a high peak force when the athlete lands from a jump.

This research will be looking at how we can create innovative performance outdoor basketball footwear and apparel for female athletes investigating court surface and durability. The footwear and apparel will be investigating the connection between playing surface, foot landing, and risk of injury looking through the lens of the style of play seen in 3x3 outdoor women’s basketball.

### **Aesthetic/Functional Inspiration**

The Monarch Collection will not only be designed and tested through athlete insights and feedback but will utilize inspiration from the Monarch Butterfly. The wing venation system of the Monarch Butterfly is designed to be structural, but flexible, allowing them to change direction while flying quickly and withstand different factors of the environment. The Monarch Collection will design a new material application method to create a durable and flexible textile that fits the female foot using the Monarch Butterfly as inspiration.

### **Women’s Basketball History**

The game of basketball was created in 1891 by physical education teacher, James Naismith, at Springfield College in Massachusetts. Basketball was invented to be “playable indoors or on any kind of ground [...]. It should provide plenty of exercise, yet without the roughness of football, soccer, or rugby since those would threaten bruises and broken bones if played in a confined space” (The Birthplace of Basketball, n.d.). In 1892, another physical education teacher by the name of Senda Berenson Abbott taught the game to young women at Smith College (Suzuki, n.d.). She is known as “the mother of women’s basketball” and introduced the game to women in hopes it would be the forefront of women in athletics.

It was not common for women to participate in athletic activities in the nineteenth century nor play on team sports. Abbott introduced the game to women because she believed it would benefit females but modified the rules of the game to fit the expectations for women in the Victorian Era. During this time, it was believed that physical activity would damage women's reproductive organs (Wei-Haas & Mansky, 2016). Due to these beliefs, Abbott created rules which emphasized preserving "womanliness" and the image of femininity. Abbott's rules called for six players on each team to be on the court. The court was divided into three sections where players had to remain for the duration of the game to prevent any contact between players. This rule also allowed the game to not be dominated by the most skilled. Players were only allowed to dribble three times before passing or shooting the ball and were not allowed to take the ball from each other to prevent any contact with another player as stated prior (WYSK, 2016). In 1893, women were seen playing outdoors especially if the school also had a men's basketball team. This was because, at this time, men were not allowed to see women exercising, forcing women to have to practice, train, and play many games outdoors (Stanford University, n.d.).



*Figure 1: Stanford players playing outdoors (Stanford University, n.d.).*

In 1896, Stanford and University of California at Berkeley played the first women's intercollegiate game. Women blocked doorways and windows of the gym because men were excluded from the game. Soon after, Stanford and UC Berkeley both ruled that women were no longer allowed to compete at the intercollegiate level, so the women's team competed as an intramural team. In 1902, Phoebe Apperson Hearst provided the University of California at Berkeley with an outdoor basketball court while the men's team used the indoor court for their games since women were only allowed to play in front of spectators of their own sex (Athletic, Intercollegiate, 2009). In 1908, the Amateur Athletic Union (AAU) stated that women should not participate in basketball in public but later switched their position and hosted the first national tournament for women's basketball in 1926. The game did not move to the five player, full court game we see today until 1971 because it was believed that physical activity was not healthy for women.

In 1972, Title IX was passed into action. This legislation prohibited sex-based discrimination in schools and education programs (Pruitt, 2021). This allowed women to have equal opportunities in sports as well as other academic experiences. During the late 1900s, there were only 300,000 women and girls playing college and high school level sports in the United

States. In 2012, that number increased tremendously to more than 3 million (Pruitt, 2021) and has since grown today.

While the number of female basketball players grew during the late 1900s, there was a lack of athletic opportunity at the professional level. In 1996, the Women's National Basketball Association (WNBA) was established which provided female athletes the opportunity to play professionally in the United States.

### **Streetball History**

During the 1900s, the urban outdoor game of basketball, known as "streetball" was quickly growing in popularity. These outdoor courts did not consist of much more than a hoop and gravel surface where players were "doing more with less" and playing the game with a combination of grit, raw talent, and spontaneity not seen in traditional indoor basketball. Many players got their start in the professional leagues from playing streetball (Williams, 2015). The outdoor game was dominated by those in the colored communities of Washington D.C. and New York City. Amateur Leagues such as the Washington Interscholastic Athletic Association, Black Basketball League, and the Colored Intercollegiate Athletic Association began to draw in fans. In 1950, Holcomb Rucker established a basketball tournament in Harlem which became the place every streetball player wanted to play (Streetball History, n.d.). The iconic courts of New York and California such as Rucker Park, West 4<sup>th</sup>, "The Cage", Mosswood Park, and Venice Beach did not provide the same seating capacity as indoor gyms resulting in people lining the sidelines, climbing fences or trees, and watching from the upper stories of buildings to get a glimpse of these athletes playing.

While basketball first developed on the east coast of the United States, the west coast proved to be important in the development and push for the women's game and streetball culture. Today, there are women's streetball leagues all over the world with New York City being the "mecca" of streetball.

### **3x3 Basketball**

Originating in the late 1980s, 3x3 basketball has taken great inspiration from the most popular urban sport in the world, "the last three points in particular show how 3x3 mirrors the way streetball is played across the world" (Merrill, Tokyo Olympics: What is 3x3 Basketball All About?, 2021). In 2007, the International Basketball Federation (FIBA) established a universal set of rules for the format of the game based on rules set in streetball. Along with the rules being inspired by streetball, 3x3 tallies the men's and women's games together, creating equal representation in world rankings (Merrill, Tokyo Olympics: What is 3x3 Basketball All About?, 2021). 3x3 has taken the game from a neighborhood past time all the way to the Olympic stage where the USA women's team won gold at the Tokyo 2021 games showing the world how women's streetball is not a force to be reckoned with.

### **Streetball Rules**

Women's streetball rules differ from traditional indoor women's basketball due to its less organized nature. Players typically refer to streetball games as "pick up" games. People may play by asking participants to join their game or by organizing a team ahead of time to play a game. Players pick their teams which can create a different mix of people for each game.

In streetball, there are also unspoken rules, particularly when it comes to fouls. Players cannot call travelling if it doesn't affect the play, call touch fouls or soft fouls, and if there is an argument then players must "shoot for it" to see which team resumes the game with the basketball. Players must have respect for themselves and their teammates and are not allowed to foul on purpose but can attempt to distract an opposing player by lightly pushing them or talking to them. Nobody wants to get hurt as it is outdoor basketball, not the NBA Championship. Many players also have a signature move that may help them get picked up by other teams. An unspoken rule of streetball is that it isn't all about the plays in the game, but it is also about a player's style. Players aim to "dress to win" and wear modern apparel showing their sense of style and fashion.

Developed streetball leagues typically have an MC, a commentator with a microphone who is on the court, commentating the game for the audience. The job of this individual is to get the crowd involved and bring the energy of the game up. This is a part of the game which brings in a sense of community and excitement to streetball that has been a part of its history and culture.

FIBA established their set of rules for 3x3 basketball based on the most common form of streetball, three-on-three with a 1's and 2's scoring system. The game is half-court with a single hoop. The games are 10-minute durations or the first team to 21 points. Each time the ball switches possession, the team must get the ball behind the arc to declare themselves on offense. At this time, the 12 second shot clock will reset, and play continues. Only team fouls are tallied with each foul awarding the opposing team with one free throw. Once a team tallies seven fouls, the opposing team is awarded two free throws. Play is continuous and after each made basket, the opposing team in-bounds the ball to restart the game. The size of the basketball used in 3x3 is 72.39cm in diameter. The smaller size basketball allows players to handle and move the ball better to follow the faster pace of the game (Nag, 2021). This game differs from traditional basketball because there is no zone defense, and every player is expected to be versatile in scoring and defending (Clare, 2018).

### **Sport Success**

Games can play up to 7, 11, 13, 15, or 21 points and can have a scoring system of:

- 1's - one point for each basket
- 2's - two points for each basket
- 1's and 2's - one point for baskets made inside the arc and two points for baskets made outside the arc
- 2's and 3's - two points for baskets made inside the arc and three points for baskets made outside the arc



The 2's and 3's scoring system is most similar to traditional indoor women's basketball. In each scoring system, players call their own fouls, following an honor system and respect seen in streetball. If a player is fouled and awarded a foul shot, the made basket is one point. Games can be played from a one-on-one up to a five-on-five. Three-on-three half court is the most common streetball game and is what 3x3 basketball is based off of. Streetball and 3x3 play half court games and require teams to start the ball behind the arc. The game starts by each team shooting a basket and the team who makes their shot, starts on offense with the ball behind the arc. Players "check" the ball to the defender to be sure everyone on the court is ready to begin. When a defender gets the ball by stealing it from the opposing team or from a rebound, they must take the ball behind the arc to declare themselves on offense. If a player on offense makes a basket, they return behind the arc with the ball and stay on offense. Games are often played until a team "wins by one" or "wins by two" which is similar to the scoring system seen in tennis. Besides the common "pick up" game, there are also other streetball games such as H-O-R-S-E, Around the World, or 21. Streetball games can be played by one player on each team up to five players on each team and the team with the highest number of points wins.

### **Environment**

Streetball is played on an outdoor basketball court typically made up of asphalt or polypropylene tiles with a double-rim hoop. The court surface may also be littered with rocks, sand, and other debris players must attempt to avoid (Lafone, 2021). Asphalt tarmacadam is a stone mixture with tar and a stone subfloor. Once poured, leveled, and dried, this surface provides great slip resistance when wet. Asphalt can last up to 15 years before needing to be replaced. Many newer courts found around New York City are painted to help preserve the asphalt but create a surface that has less traction. This paint can wear away, exposing the asphalt.

### **Product Classification**

Footwear and apparel, women's outdoor basketball played on asphalt.

### **Product History**

Women's streetball has been a sport very unrepresented in media, support, and product. Currently, there are few women's outdoor specific footwear or apparel options on the market. Female athletes are wearing footwear and apparel designed for male biomechanics and style of game. The footwear industry has long been building lasts based on male foot morphology and altering the volume to fit the female foot rather than studying female biomechanics, morphology, and building lasts based truly on research (Krauss, Valiant, Horstmann, & Grau, 2010).

Women's basketball gained a lot of attention when the 1996 Olympic Women's Basketball team won gold with players such as Sheryl Swoopes, Lisa Leslie, and Dawn Staley followed by the first WNBA game in 1997 (Click, 2013). Sheryl Swoopes, nicknamed the "female Michael Jordan", opened the doors for female athletes with her signature shoe the Air Swoopes which were developed by Nike in 1995. She went onto develop seven more models with Nike. Since the Air Swoopes, a handful of WNBA players have had player exclusives, but

none truly looking at the shoe through the lens of biomechanics and women's game, let alone outdoor game.

The outdoor basketball shoe market consists of little to no options, and none specifically designed for women. In 1992, Nike took on the job of creating an outdoor basketball shoe, "that X was about strapping up to go into battle, because you're going to get knocked around the frickin' cage and you need to strap yourself in", as stated by Tinker Hatfield (Nike Air Raid, 2012). Based on New York City streetball, Nike designed the Nike Air Raid. It was a men's basketball shoe designed with a flat sole to ensure the shoe had total contact with the ground. The goal was to make this shoe resilient to the environment but keep it lightweight. Inspired by how athletes tape their ankle, Hatfield implemented straps crossing over the foot for extra lockdown. While the design process was similar to traditional basketball shoes, the focus was on outdoor play.

In 2020, Under Armour launched the first women's performance basketball shoe, the UA HOVR BREAKTHRU. This shoe was based on female foot morphology and biomechanics (PressBox, 2020). Women's basketball makes up just 1% of the basketball market, meanwhile female basketball players make up 45% of men's and women's players at the high school and college level (Luther, Why the Gaps Between Men's and Women's Sports are so Frustrating, 2017) making this a market that has yet to be tapped into.

### **Product Rules**

While there are no overbearing rules regarding a player's footwear in basketball, players must follow the unspoken rule that the products they wear cannot be made up of materials or have loose parts that could injure another player. Sports Illustrated states the NBA has a rule that a player's shoes must be "appropriate and designed primarily for basketball" (Newcomb, 2015). At the Under Armour 3x3 tournament, players are not allowed to wear shoes that have been worn off court because players could drag debris such as rocks and dirt onto the court surface, creating a hazardous environment. This means the footwear and apparel used must be clean before stepping onto the courts (Protective Footwear Requirements, 2020).

The footwear and apparel designed for this project will be performance-based products and must follow the American Society for Testing and Materials (ASTM) standards. To help validate and complete research on the court surfaces, this project will be referencing ASTM 2772. This standard is "the only material testing method recognized in the United States for indoor flooring" as stated by ASTM (ASTM 2772: The American Sports Flooring Safety Standard). This testing will measure court surface shock absorption, vertical deformation, ball bounce, and sliding effect. While it states the standard is for "indoor flooring", ASTM does list asphalt in the standard and findings of indoor flooring can help compare and contrast findings of asphalt throughout testing. The findings from ASTM 2772 will assist in the design of the footwear and apparel for these athletes. The American Podiatric Medical Association states that, "Indoor wood courts offer the most shock absorption and are considered the safest courts, while outdoor courts of asphalt are more dangerous" (ASTM 2772: The American Sports Flooring Safety Standard).

The interaction of the foot, shoe, and court surface will be a large scope of the testing of the footwear. ASTM F2333 is the testing method used to determine the traction between the shoe outsole and sport surface (ASTM, n.d.). Due to the court being made of asphalt and environment having many uncontrollable factors such as water, temperature, rocks, debris, etc., there will need to be research and testing done to determine what effect hazards such as rocks, sand, moisture, and sun due to the traction of the court surface and shoe outsole (ASTM, n.d.).

ASTM 1976-13 is the standard testing method for impact attenuation of athletic shoe cushioning systems and materials. This standard will be important in determining if the footwear and apparel designed in this project will reduce risk of injury and decrease loading impact from vertical ground reaction forces while jumping (Standard Test Method for Impact Attenuation of Athletic Shoe Cushioning Systems and Materials, n.d.).

The fit of the footwear and apparel for female basketball athletes will be very important in ensuring the athletes' safety and comfort level. ASTM F539 must be used to ensure the fit of the footwear will not cause disfiguration to the bone structure or other parts of the foot, as well as not diminish the athletes' performance (Standard Practice for Fitting Athletic Footwear, n.d.). Shoe forms can come in different shapes and sizes based on the materials and manufacturing used, the last shape the shoe was built around, and activity the footwear is designed for.

### **Initial Line Plan**

The Monarch product line will consist of one footwear option, one in-game top, one in-game bottom, two leg sleeves, and one arm sleeve. The products will utilize a black and teal colorway, logo, and graphics and take much inspiration from the Monarch Butterfly. The footwear option will consist of a mid top height shoe and focus on fit, flexibility, and durability.

The Monarch apparel top and bottom will be designed for the female anatomy and anthropometry during outdoor play. The apparel will consist of a short sleeve top and shorts bottom. Women's outdoor and 3x3 basketball consists of players driving to the basket rather than taking outside shots due to its high-intensity play in a confined space. The apparel products will focus on mobility, breathability, and durability. The sleeves will focus on added abrasion protection.

### **User/Athlete**

The target users of this footwear and apparel are 18-24-year-old female basketball athletes. Outdoor courts are easily accessible for many high school and college level players living in urban environments, making street ball an important part of offseason training and a large part of their early training. These athletes are either looking to get recruited and play in college or are already recruited and currently playing college level basketball.

The high school and college level female basketball player is a very underserved consumer. Only 1% of the basketball footwear market is for women, meanwhile 45% of high school and college level basketball players are female (Luther, Why the Gaps Between Men's and Women's Sports Are So Frustrating, 2017). At the professional level, only 20.9% of

basketball players are women (Professional Basketball Player Demographics and Statistics in the US, 2021). Due to the lack of opportunity, pay, and product, female athletes tend to end their careers after high school or college but is continuing to grow with additional support and attention being drawn to women's sports.

### **Athlete Role**

The half-court game of streetball allows more space for these athletes to move. The game is faster-paced requiring athletes to not follow the traditional guard, post, and forward positions seen in traditional indoor basketball. Each player on the court is moving and shooting from anywhere on the half-court playing area, requiring players to have knowledge of each position in traditional basketball and be versatile on the court.

In women's basketball, the game is played with more speed, precision, and power compared to the men's aggressive game. Athletes are proactive, staying on their toes, and working to get themselves and their teammates open. The women's game is more about teamwork and less about one athlete being the star player. This style of play, anatomical differences, and biomechanical differences are why these athletes need their own products designed for them.

### **Jobs to be Done**

Women's basketball players are lacking adequate product designed for them and their biomechanics. Despite the women's game and men's differing in style of play, female basketball players are wearing men's shoes which are designed for male athletes who are much taller, heavier, and stronger than them. The women's game is about finesse, being proactive, and constantly moving. There is a greater sense of togetherness and a sisterhood culture helping ignite the teamwork mentality. While the game consists of less contact than the men's game, these athletes are still leaving everything on the court and playing an aggressive, gritty game.

Female streetball athletes need footwear and apparel options that fit and move with their body, allowing them to play their style of game. Current footwear worn by female streetball players are designed for male foot morphology and biomechanics resulting in footwear options that are very overbuilt, stiff, and heavy for female basketball athletes. Apparel is also important for female streetball athletes not only for function, but for style as well. These athletes need apparel that can protect them from the elements in the extreme and unpredictable environment and from risk of injury on the outdoor court surface. Focusing on fit, durability, and cushioning will ensure these athletes have the best footwear and apparel products for their biomechanics and style of play on the outdoor court surface.

Fit- Female foot morphology has been long overlooked with the industry following "shrink it and pink it". The angle formed by the metatarsal heads and dimensions of the arch differ in male and female feet (Wunderlich & Cavanagh, 2001). Malleoli height and heel shape differences in male and female feet cause heel slippage and stability issues for women. At the same foot length, women's feet have a higher arch, shallower first toe, shorter ankle length, shorter length of the outside ball of the foot, and smaller instep circumference than the male foot

(Wunderlich & Cavanagh, 2001). Differences in foot shapes between female also differ across ethnicity, height, age, and other populations.

**Durability-** Female streetball athletes are currently wearing shoes designed for indoor play. The texture of the outdoor court wears down the traction on the shoe which results in athletes having to swap out shoes more frequently and continuously purchase new shoes and discard of the worn-out pair, adding to the waste that comes from the sport.

**Cushioning-** Asphalt court surfaces do not provide the same level of cushioning and give as hardwood indoor courts. Footwear and apparel products currently used by female streetballers are designed and tested on hardwood indoor courts. The lack of proper cushioning for these outdoor court surfaces lead to players adjusting their running form, foot landing and push off, as well how they fall. These changes in biomechanics can lead to the overworking of certain muscles or overuse injuries taking players out of commission for a period of time.

### Physiological Demands

The environment outdoor basketball is played in puts different physiological demands on female players than indoor basketball. Environmental factors found in the 'Environment' section of this paper will cause an increased core temperature and muscular strain for these athletes. Athletes tend to have a higher heart rate and lactate response due to short bursts of energy and game play. Compared to traditional indoor 5x5 basketball, outdoor basketball demands greater anaerobic capacity than aerobic capacity (Mancha-Triguero, García-Rubio, Antúnez, & Ibáñez, 2020). The women's game in general is much more about finesse and constant movement rather than about power seen in the men's game despite it still demanding greater energy in a shorter period of time. One reason for this difference in play style is because the female anatomical structure is built with approximately 7-23% more Type 1 fibers, benefitting more longer duration and aerobic exercise than male athletes (Ansdell, et al., 2020). Due to the unique structural make-up of the female body, techniques used in women's sports differ from men's sports.

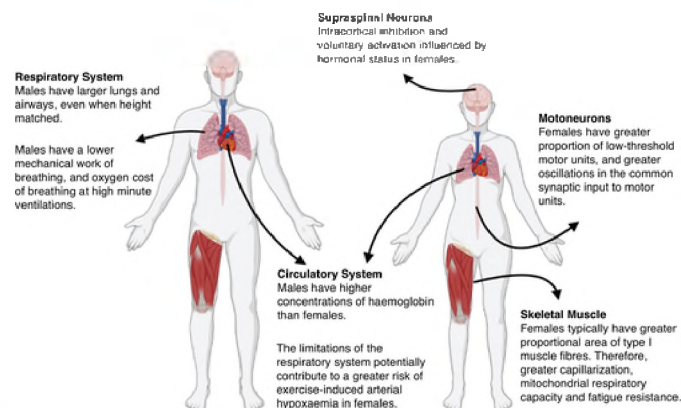


Figure 2: Summary of sex differences within the key physiological systems implicated in exercise performance (Ansdell, et al., 2020)

## Anatomy / Morphology

Female outdoor basketball athletes are typically between 5'8" and 6'1". Outdoor and 3x3 basketball is played with a two guard, one forward line up which is why taller players who can play both guard and forward positions are the ones seen on the court. These athletes are typically not as tall and muscular as male athletes simply because the anatomical make-up of males and females are quite different. Females have less muscle mass and bone density along with a wider pelvis, more oblique femurs, and larger ratio of leg to body weight (Blair, 2007). Females have approximately two-thirds the amount of strength of males with majority of their strength coming from their lower extremities (Alexander, 1997). "Wilmore found the female's absolute upper body strength to be 30-50% and their lower extremity strength to be 70% of the same size male" (Thein & Thein, 1996). Because females have a stronger lower body than upper body, female basketball athletes are taught to jump when they shoot, getting their power behind their shot from their legs and accuracy from their upper body. Females also have a lower center of gravity relative to their height because of their wider hips and narrower shoulders. Females have a greater Q angle which is why female athletes suffer more knee injuries than males. The Q angle is the line of force between the quadriceps muscles and patella tendon. It should be less than 22 degrees in females when the knee is in extension and less than nine degrees when the knee is flexed at 90 degrees ('Q' Angle, n.d.). Q angle plays an important role in the biomechanics and forces applied when changing direction vertically and horizontally.

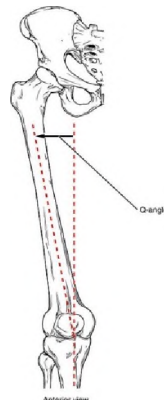


Figure 3: Female Q Angle ('Q' Angle, n.d.)

Female feet have been found to have a shorter heel-to-ball length, narrower heel and forefoot, higher and more sensitive arch, and lower mid-foot and malleoli height (Luo, et al., 2009). Due to the Q angle of female anatomy, weight distribution in static position and in gait analysis differs from males. Women's feet are not men's feet scaled down hence why the long-time practice of scaling down men's shoe lasts is not beneficial for creating women's footwear.

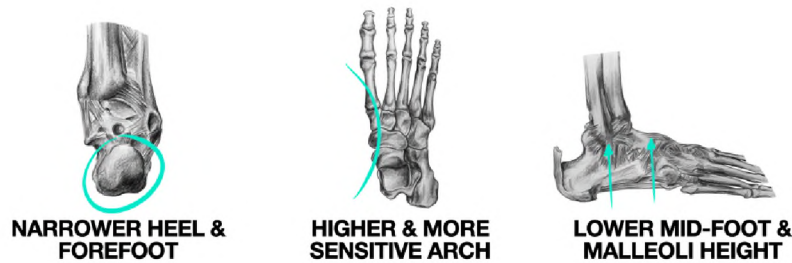


Figure 4: Female Foot Morphology Differences than Males (Guerra, 2021)

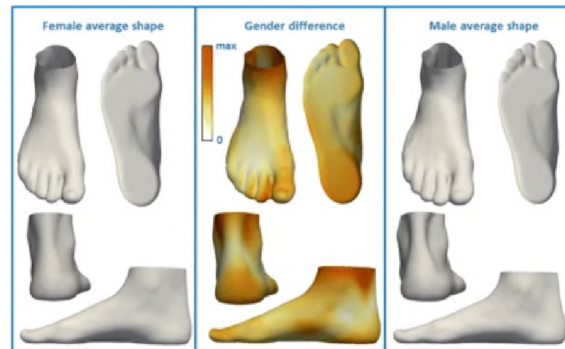


Figure 5: Visualization of the effect of sex and foot shape (Stanković, et al., 2015)

### Performance/Biomechanics

Women's sports play with greater speed, precision, and power than in the past, leading to an increase in sport-related injuries. Female athletes have been found to sustain injuries 1.6 times more than male athletes (A Comparison of Men's and Women's Professional Basketball Injuries, 1982). The lack of product designed specifically for the female athlete causes many of these athletes to become injured, either taking them out of their athletic careers for a period of time or end it altogether (Professional Basketball Player Demographics and Statistics in the US, 2021). At East Tennessee State University, a study by Emily Wills looked at the Epidemiology of High School Sports Injuries. Her research showed that the highest rate of injury was found in girls' basketball at 86.7%. This was taken from a survey Wills sent out to athletes at Appalachian High School (Wills, 2016).

Research completed by Marion J.L. Alexander of the University of Manitoba referenced J.M. Stevenson's 1988 study of biomechanical differences in male and female athletes. Alexander states, "The Kin Com back strength comparisons indicated that strength values for females were 60% of those attained by males. Analysis of the data suggested there were sex differences in lifting technique which accounted for the differences in performance [...]" (Alexander, 1997). Based on musculoskeletal differences, males and females simply have different biomechanics. Another study done by Komi and Karlsson in 1978 used male and female twins 15-24 years old to determine the biomechanical differences between the two sexes. Their research concluded that the performance in females was 61-84% of that of males; females have more slow-twitch fibers, differing skeletal characteristics, and metabolic profiles (Alexander, 1997).

Lay-up Take Off/Landing

Outdoor basketball demands a high number of low and mid-range deceleration movements. A lay-up utilizes changing direction and jumping. When athletes are changing direction and accelerating/decelerating there is a greater ground reaction force. During lay-up take-off, the athlete changes speed and direction, applying much more force on the opposite foot of the direction they are moving in. As the athlete approaches the lay-up, they have two steps where they lower their center of mass (COM) and generate much more force in their legs and feet. During the second step in lay-up take-off, there is a high peak force and peak pressure in the heel region of the “take-off foot” as the athlete is beginning to decelerate and change direction vertically; “In the layup the dribble towards the basket needs to have speed however, the two steps before the jump should be controlled and slower” (Knapman, 2014). During landing, there is a high peak force and peak pressure in the heel and forefoot regions of the opposite foot from the “take-off foot” (Chua, Quek, & Kong, 2016). It is hypothesized that more pressure is seen in the forefoot during landing because the athlete is preparing to change direction and get into defensive position again. This is very important in 3x3 because once a team scores, the ball is quickly brought behind the 3-point arc by the opposing team and play continues.

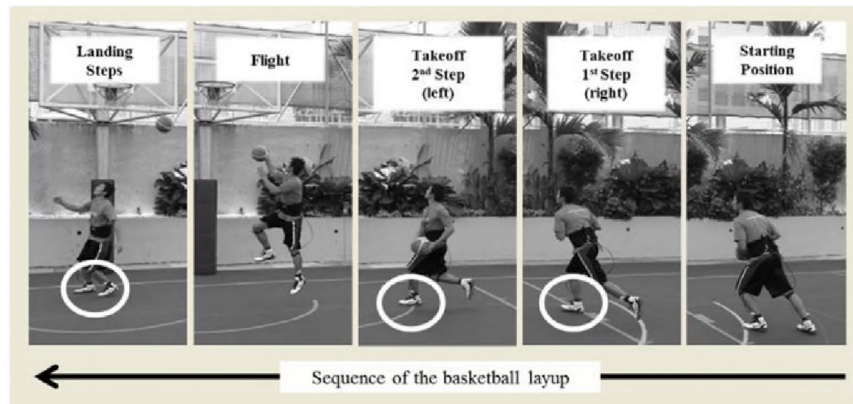


Figure 6: Sequence of Basketball Layup Approach from Right Side of Rim (Chua, Quek, & Kong, 2016)

Illustration	Step	Variable	Hallux	Lesser Toes	Medial Forefoot	Central Forefoot	Lateral Forefoot	Medial Arch	Lateral Arch	Heel
	Takeoff (right)	PF	82.6 (42.3)	187.0 (58.4)	178.2 (71.0)	290.4 (53.4)	121.9 (50.9)	67.0 (45.0)	104.0 (41.7)	323.2 (129.6)
		PP	241.7 (96.3)	268.9 (85.1)	331.2 (89.5)	303.2 (71.5)	134.4 (47.2)	75.8 (35.8)	91.3 (31.2)	196.8 (79.0)
		PTI	34.2 (14.0)	39.3 (12.4)	53.2 (14.4)	48.4 (11.6)	21.7 (8.3)	12.1 (12.8)	16.4 (11.1)	21.2 (11.3)
	Takeoff (left)	PF	96.1 (53.7)	293.9 (83.9)	157.2 (42.0)	347.6 (52.2)	284.8 (79.0)	90.8 (37.5)	216.8 (51.1)	694.1 (162.1)
		PP	296.5 (117.3)	338.5 (70.3)	246.2 (80.5)	271.0 (65.6)	235.8 (52.9)	115.4 (29.3)	182.0 (35.9)	410.3 (67.2)
		PTI	36.1 (16.6)	46.3 (9.6)	32.7 (11.8)	37.4 (9.3)	38.6 (9.2)	13.3 (5.1)	26.8 (7.2)	35.8 (8.9)
	Landing (right)	PF	70.6 (32.4)	199.0 (49.7)	146.4 (48.9)	278.0 (72.5)	188.6 (64.9)	142.0 (85.4)	203.7 (84.4)	424.7 (219.1)
		PP	210.4 (86.9)	272.9 (97.4)	291.9 (94.5)	283.0 (92.8)	194.6 (58.6)	160.4 (60.1)	185.2 (55.6)	258.4 (128.5)
		PTI	62.1 (34.4)	82.1 (36.6)	79.1 (44.5)	86.9 (46.8)	58.3 (27.5)	21.5 (18.6)	27.2 (17.9)	30.9 (23.0)
	Landing (left)	PF	103.2 (39.4)	162.3 (60.1)	181.6 (53.0)	258.3 (40.8)	163.6 (53.8)	98.8 (78.6)	144.5 (75.0)	197.8 (166.8)
		PP	264.0 (86.4)	221.8 (74.3)	261.4 (70.8)	234.0 (38.2)	193.9 (69.1)	101.7 (65.0)	140.2 (60.4)	124.9 (84.1)
		PTI	38.6 (18.9)	33.8 (19.6)	36.0 (17.3)	30.4 (13.1)	20.5 (11.6)	5.8 (6.1)	9.0 (7.3)	8.35 (9.7)

PF = peak force (N), PP = peak pressure (kPa), PTI = pressure time integral (kPa s)

Figure 7: Ten-Trial Mean of Peak Force (N), Peak Pressure (kPa), and Pressure-Time Integral (kPa s) Obtained During the Basketball Lay-up (Chua & Quek, 2016)



Mobility in the upper body is also important to an efficient lay-up. As the lower body is taking more impact forces, the arm with the basketball which is opposite the “take-off foot” is the part of the body requiring greater extension, using the shoulders (scapula, supraspinatus, infraspinatus, deltoids, and teres) and back muscles. Having extension of the hip and plantarflexion in the ankle joint during the take-off and flight phases are also important. Athletes want to have as much extension of the body during the lay-up to “hang” in the air for a longer period of time; “When someone would normally be about to fall back down towards the ground under the influence of gravity, players rapidly extend their legs downwards, to conserve momentum, their upper body moves upwards” (Blazevich, 2017). Anthropometric measurements will need to be taken into account during this research due to measurements differing from one athlete to another based on height, leg length, and arm length (Chakraborty & Mondal, 2019). The kinetic chain pattern used during a lay-up is a push-like movement pattern. While in this position, athletes are more susceptible to getting injured by impact or from momentum stopped by limited extension. Ensuring efficient mobility and protection from impact will be important for athletes as they are driving to the basket for a lay-up.

Little research has been conducted on slow motion analysis of a female basketball lay-up form and biomechanics. The following figure demonstrates a basketball lay-up for a male athlete. Slow-motion analysis of the female basketball lay-up will be done for research and testing purposes during this project.



*Figure 8: Male Basketball Lay-up Frame-by-Frame Analysis (Knapman, 2014)*

## **Jumping**

Inadequate footwear has resulted in many female basketball players not being able to have a smooth heel to toe transition when jumping while shooting resulting in these athletes using more energy to shoot the basketball. A crucial part of the game is jumping and landing during the lay-up phases and getting back into defensive position quickly. Current products are causing these athletes to become tired quicker, adjust their biomechanics, and put themselves at a higher risk of injury.



Figure 9: USA v. Japan 3x3 Basketball Tokyo Olympics Jumping (WBAL TV11, 2021)

Increasing the jumping movement activation level is suggested to improve explosive power and coordination of the lower limbs (Tai, et al., 2019). Impulsive impact forces are caused by foot-ground contact when landing from a jump. The risk of lower limb injuries can be affected by vertical ground reaction force (vGRF), loading rate, tibial acceleration, and impact attenuation (Bruce, Firminger, Wannop, Stefanyshyn, & Edwards, 2019). When landing from a vertical jump, athletes may adopt one of two landing techniques, according to Dr. Harry Prapavessis and Dr. Peter J. McNair. Athletes may land on the forefoot where the ankle is in plantarflexion while others may land more flatfooted. By studying how soon the heel made contact with the floor surface, the study was able to determine that athletes landing flatfooted typically had a higher ground reaction force due to the decreased amount of time they had to slow down the velocity of the heel after foot-strike. This can also be seen in the peak forces and peak pressure of central forefoot landing in Figure 7. Female athletes are losing flex in their forefoot which would help decrease the amount of time it takes for their heel to land.

Different studies have either concluded that midsole cushioning either decreased or did not change the loading impact of a jump landing. It is believed that across these various studies, there were different landing techniques used as well as a range of midsole densities worn. Female athletes have been found to be more sensitive to shoe hardness than ground surface compliance. It has also been found that there is a certain threshold in which the human body will not notice or react to impact force.

Another belief is that midsole densities alone may not affect overall shoe cushioning. Other factors such as material viscoelasticity, midsole thickness, and shoe fit/structure should be included in future studies. By using different fitted and cushioned shoe models, the shoe as a whole could lead to a more conclusive study of loading impact (Kinetics and Perception of Basketball Landing in Various Heights and Footwear Cushioning, 2018). Investigating the relationship between perceived surface and jumping/landing biomechanics will be important in innovating outdoor basketball footwear and apparel for female athletes.

### **Change of Direction**

Changing direction and accelerating efficiently are important parts of performance in basketball. A study published by the International Journal of Foot and Ankle, found that when athletes pushed off their hallux and medial forefoot when sprinting less than on wood flooring

(Kong, Nin, Quek, & Chua, 2018). Footwear plays a role in the forces and friction created during sprint acceleration. Shoe-surface interaction may affect vertical impact loading as well as shearing forces which act in a direction parallel to a surface. Frictional properties between shoe cushioning and midsole hardness will help provide a better understanding of the interaction between footwear and court surface.



*Figure 10: USA v. Japan 3x3 Basketball Tokyo Olympics Lay-Up (Swift, 2021)*

## **Injuries**

Approximately 90% of athletes have suffered some form of sports-related injury during their career with 54% saying they have played while injured (Robert H. Shmerling, 2020). The most common injuries seen in female athletes are ankle sprains, shoulder injuries, knee injuries, stress fractures, and plantar fasciitis, according to an article published by the Harvard Health Blog (Robert H. Shmerling, 2020). They also experience hormonal differences which affect ligaments, causing a greater number of injuries (Alexander, 1997). Many injuries can be avoided with the proper footwear, apparel, and equipment built for the morphology and biomechanics of the female athlete.

## **Athlete Psychology**

Athletes need to not only train physically, but mentally as well. Athletes must have good team dynamics, concentration, emotional control, motivation, and confidence not only for themselves but for their teammates as well. With the UA 3x3 environment, there will be non-controllables such as temperature, sun, wind, and humidity. Venice Beach is a public beach where there may be other distractions as well. A tournament setting where there are multiple games happening at once will create an environment with a lot of noise and movement.

Colors used in the tournament may have the biggest effect on athlete psychology. Having strong color contrast between players, spectators, court surface, and lines on the court will help athletes have good court vision and be able to differentiate objects in a short amount of time. The colors listed in the Graphics, Logos, and Color section of this paper will be used to create patterns with high contrast. The black and violet colors in the Monarch colorway emit a feeling of strength and power, white emits cleanliness and peace and teal emits harmony and balance (Brenner, 2016). Black, white, and teal will be used as the dominate colors and violet as the

subdominant colors to create strong contrast and allow players to easily see their teammates on the court. Having this contrast will allow the players to point out opponents and placement on the court easily.

Fit and comfort of the products worn by athletes is important to their performance. How a product feels against the skin is enough to distract an athlete from the task at hand. Ensuring the product is fit for their biomechanics, anatomy, and environment will allow them to focus on the game. How an athlete feels in a product can also bring a sense of poise and make the athlete feel motivated and confident. A large part of outdoor basketball culture is the style you bring to the court through what you wear. Many athletes may also wear compression garments under or over their apparel or footwear, adding a level of complication for fit and comfort of the products.



*Figure 11: Compression garments seen worn by female 3x3 basketball players (Merrill, Tokyo Olympics: What is 3x3 Basketball All About?, 2021)*

Landing techniques and proprioception when on an outdoor court surface can have an impact on how high the risk of injury is. When it comes to the psychology of the athlete, it is hypothesized that athletes change their landing techniques based on the perception and appearance of the court surface.

### **Competitor Analysis**

Footwear and apparel products in the sports product industry are separated into categories titled men's, women's, and kids. From there, the categories break down further into sport specific focuses. Further breaking down the basketball category, shoes can be divided into high top, mid top, and low top. The different heights of shoes are marketed towards the different positions (point guard, shooting guard, post, and forward) seen in traditional indoor basketball. Basketball shoes on the market today have been designed and tested for indoor courts made of hardwood. This can cause them to have a lack of performance and durability when used on an outdoor court. Studying men's and women's shoes used by outdoor and indoor female basketball players, can help determine the pros and cons for each.

While it may seem as if there is a substantial amount of women's basketball shoes found on websites, these shoes are in fact designed with a men's or unisex last and available in "female" colorways. Additionally, women's basketball shoes seen on brand websites show both

men's and women's sizes. This is because the shoes were designed for men, using a men's last, and then adjusted to fit onto the unisex last. More women know their size conversion to men's because they have been dealing with the lack of product for them for so long.

Select Size	Size Guide
M 3.5 / W 5	M 4 / W 5.5
M 4.5 / W 6	M 5 / W 6.5
M 5.5 / W 7	M 6 / W 7.5
M 6.5 / W 8	M 7 / W 8.5
M 7.5 / W 9	M 8 / W 9.5
M 8.5 / W 10	M 9 / W 10.5
M 9.5 / W 11	M 10 / W 11.5
M 10.5 / W 12	M 11 / W 12.5
M 11.5 / W 13	M 12 / W 13.5
M 12.5 / W 14	M 13 / W 14.5
M 13.5 / W 15	M 14 / W 15.5
M 15 / W 16.5	M 16 / W 17.5
M 17 / W 18.5	M 18 / W 19.5

Figure 12: Men's to Women's Shoe Size Conversion Table found on Women's Basketball Footwear Tab (Kyrie 7, n.d.)

**Women's Basketball Shoes**



- Under Armour Women's HOVR Breakthru / \$110*
- Breathable mesh upper with support films, designed for the anatomy of the female hoopster
  - Bootie construction with molded collar for comfortable fit & anatomically correct support
  - 3D molded sockliner for underfoot cushioning & support
  - Responsive UA HOVR™ cushioning reduces impact, returns energy, and propels you forward
  - Internal shank for extra midfoot stability
  - Rubber outsole uses herringbone traction pattern to provide maximum floor control & grip
- (Women's UA HOVR Breakthru Basketball Shoes, n.d.)



- Under Armour Women's Flow Breakthru / \$120*
- Breathable engineered mesh upper with supportive films for enhanced comfort and flex
  - Women's-specific build with bootie construction and molded collar for incredible fit
  - External TPU wing for heel lockdown and lateral containment
  - Proprietary, 3D-molded TPE-blend sockliner with low compression set for energy return
  - UA Flow cushioning technology for lightweight feel and insane grip on court
  - Integrated Pebax shank for midfoot stability
  - Durable UA Flow outsole provides better court feel
- (Women's UA Flow Breakthru 2 Basketball Shoes, n.d.)



*Adidas Women's Exhibit A Candace Parker Shoes / \$110*  
-Unisex fit  
-Lace closure for secure fit  
-Textile upper with durable and supportive overlays  
-Structured clip for heel stability  
-Rubber outsole for traction  
(Exhibit A Candace Parker Shoes, n.d.)

## **Men's Basketball Shoes**

*The following men's basketball shoe options can also be found in women's basketball section of Nike.com*



*Nike Men's Air Zoom G.T. Run / \$175*  
-React foam sockliner and Zoom Air unit to provide cushioning underfoot  
-2-layer upper made with lightweight, breathable mesh for break-in feel  
-Haptic print design on upper for abrasion resistance  
-Rubber outsole with curvy ridges that bend and flex to provide traction in multiple directions  
-Nike React foam midsole for cushioning  
-Padded, mid-high collar for comfort and support around the ankle  
(Nike Air Zoom G.T. Run, n.d.)



*Nike Men's Cosmic Unity / \$150*  
-Made of at least 25% recycled material by weight  
-Full-length Air Zoom Strobel to provide energy return  
-Light, durable, made with partially recycled material in the upper, midsole, and lace system  
-Thin, durable outsole made with partially recycled materials for on-court traction  
(Nike Cosmic Unity "Green Glow", n.d.)



*Nike Men's Kyrie 7 / \$130*  
-Mesh details wrap around foot for close, comfortable fit for quickness  
-Forefoot Air Zoom Turbo unit curved to bend in multiple directions  
-Air Zoom for energy return  
-360-degree, computer-generated traction pattern for hard cuts  
-Padded collar around ankle for support  
(Kyrie 7, n.d.)

Under Armour developed the first, and only, women's specific basketball shoe in September 2020 with the introduction of the HOVR Breakthru. This shoe was designed in partnership with Dick's Sporting Goods. The design of this shoe started with looking at female foot morphology and gathering female athlete insights. These shoes were retailing at \$110.00, came in five colorways, and were mid-height shoes. During the research phase of designing the HOVR Breakthru, UA conducted extensive secondary and primary research, speaking with collegiate female basketball players, WNBA players, as well as a Chinese national women's 3x3

team (Santiago, 2020). The HOVR Breakthru features a women's specific arch shape, narrower ankle collar and heel, double-layer cushioned heel and sockliner for extra durability and support, and tongue webbing for easy entry (Santiago, 2020).

In October 2021, Under Armour released the second iteration of the Breakthru line, the UA Flow Breakthru 2 which is retailed at \$120.00. This shoe introduces Under Armour's Flow foam instead of the HOVR midsole seen in the HOVR Breakthru. Under Armour is not only the only company to have a women's specific basketball shoe, but now two shoes. Jessie Benjamin, the lead footwear designer for the Breakthru line stated, "Making products for her sends her the signal that she matters, that we're taking her into consideration when we build our products from the last on outward" (Verry, 2021). Amongst the women's basketball community, there is a strong appreciation for Under Armour taking the step to create women's basketball shoes designed starting with the female athlete in mind, but the shoes are only available in limited colorways and shoe heights.

Due to the women's specific basketball shoe market consisting of only one option, many female basketball players have been wearing men's shoes. One shoe worn by many female players is the Nike Air Zoom G.T. Run Men's Basketball shoe. This shoe retails for \$175 and is designed for indoor play. While its breathability and flexibility are very good, the shoe is designed around a men's last making fit an issue for women wearing the shoe. The last used for this shoe is inflated, making this shoe not comfortable for individuals with wide, flat feet. The outsole pattern provides great traction on indoor court surfaces but due to the shallower suction cup pattern, the outsole wears away quickly on outdoor court surfaces (Foot Doctor Zach, 2021).

The Nike Cosmic Unity has been a popular shoe used this past 2020-21 NCAA women's basketball season. This shoe is retailed at \$150 and is made using sustainable materials, despite it not having the appearance of being sustainable. While the Cosmic Unity is designed for male basketball players and indoor courts, reviews from players who have worn them outdoors state that the traction is overall pretty good but does wear away overtime. The shoe provides good court feel, stability, and ease of movement since the foot sits quite low in the shoe. Nike implemented an Air Zoom bag in the forefoot for impact protection as well. The exaggerated midsole tooling causes some stiffness, requiring break in time, and may affect fit for those with wider feet. The upper does not provide as much airflow and breathability as the Nike Air Zoom G.T. Run but perforations in the tongue help provide a bit of airflow in the upper (WearTesters, 2021).

## **Running Footwear**

While most players use their old, worn-out indoor shoes to play basketball outdoors, many players also wear running shoes. Running shoes lack lateral stability but are durable to the materials used for outdoor courts. They are also designed to handle the impact forces from running on asphalt or concrete, making them more cushioned than basketball shoes when used on outdoor court surfaces (Playing Basketball In Running Shoes: Is It A Good Idea?, 2019).



*Brooks Women's Glycerin 19 / \$150*

- Soft cushioning underfoot that react to your specific stride
  - DNA LOFT cushioning for ultimate softness
  - Road running
  - Mesh upper for breathability
- (Glycerin 19, n.d.)



*Nike Women's ZoomX Invincible Run Flyknit / \$180*

- Higher foam height for softer feel
  - Wide, exaggerated forefoot for stability
  - ZoomX foam is responsive and lightweight
  - Flyknit upper places zones of breathability and stability
- (Nike ZoomX Invincible Run Flyknit, n.d.)



*New Balance Women's Fresh Foam 1080v11 / \$149.99*

- Fresh Foam midsole for ultra-cushioned, lightweight ride
  - Bootie upper construction for snug, supportive fit
  - Ortholite sockliner for comfort
  - Ultra-heel design hugs back of the foot for snug, supportive fit
- (Fresh Foam 1080v11, n.d.)

## **Apparel**

Performance tops and bottoms worn by outdoor female basketball players come in many different styles. Historically, streetball consisted of players wearing t-shirts and shorts, with no matching uniform. Today, in 3x3 basketball and tournament play, athletes are wearing matching uniforms made up of sleeveless tops and shorts. These tops and bottoms are designed to keep the athlete cool when performing this high-intensity sport.



*Under Armour Women's Muscle Tank / \$25*

- 60% cotton / 40% polyester
  - Soft, cotton-blend fabric providing all-day comfort
  - Generous dropped armholes
  - Racerback construction for full range of motion
- (Women's UA Muscle Tank, n.d.)





*Under Armour Women's Locker T-shirt / \$25*

- 100% polyester
  - UA Tech fabric is quick-drying and ultra-soft with a more natural feel
  - Material wicks sweat
  - Anti-odor technology prevents growth of odor-causing microbes
- (Women's UA Locker T-Shirt, n.d.)



*Nike Fly Women's Crossover Basketball Shorts / \$60*

- 100% polyester
  - Nike Dri-Fit Technology moves sweat away from your skin to keep you dry
  - Lightweight, double-knit fabric feels soft, breathable, and stretchy
  - Loose fit with elastic waistband for roomy, secure fit
- (Nike Fly Women's Crossover Basketball Shorts, n.d.)



*Figure 13: Nike Women's Basketball 2020 Catalog (Nike Digital Pinnacle Premier Jersey CQ4307)*

Team uniforms may be selected by the coaches or team organization and ordered from a catalog. Uniforms seen worn by female basketball athletes in 2020 consist of a sleeveless top and short. The Nike Women's Basketball 2020 catalog consists of uniform options mainly made of 100% polyester or 91% polyester/9% spandex (Women's Basketball 2020, 2020). Teams may also have additional warm up and recovery jackets and joggers, sports bras, leggings, socks, and bags with colors and graphics matching their uniforms.

## Product Anatomy



Figure 14: Basketball Footwear Anatomy of the Nike Hyperdunk (Guerra, 2021)

Basketball shoes consist of many hard and soft good pieces to allow the shoe to be supportive, flexible, cushioned, and breathable. The current market consists of low, mid, and high-top shoes all providing a variety of levels of support and flexibility. Traditional indoor basketball shoes tend to target specific positions players may be such as guards or forwards (How to Buy Basketball Shoes, n.d.). Outdoor basketball does not have players in specific positions but because of the height and weight of different players, they may prefer a certain type of shoe. Due to the fast-paced play of outdoor basketball, players may find they want a flexible, lightweight, and breathable shoe that they can move easily and organically in.

Current state-of-the-art basketball footwear consists of three main components: the upper, midsole, and outsole. The upper is made up of mainly textiles along with films and occasionally hardware. The midsole is composed of foam and a shank while the outsole is made up a molded rubber with a pattern for traction on the court.

The upper's main job is to protect the foot. It must fit securely and provide cushion to keep the foot comfortable. The upper may also have an inner upper either encasing the entire foot like a sock or is focused mainly around the midfoot where it can attach to the lacing system for adjustability for varying foot sizes. The toe area has cushion as well as a film for abrasion resistance. The medial and lateral sides of the upper are made up of meshes and perforations to promote breathability. The medial side is kept soft because the female foot has a sensitive arch. The foot sits on a sockliner or insole. The sockliner is the first layer of foam which the foot sits directly onto. The lacing system either has aluminum eyelets or yarns formed into loops. This locks down the midfoot area. Many shoes may have a strap on the exterior of the upper for additional lockdown and stability. The heel area of the shoe is composed of fabrics, foams, and heel counter. The heel counter is designed to support the shape of the shoe as well as provide heel stability to prevent any lateral or medial slippage. Additional lateral and medial sidewalls may also be added as seen in the image above. Above the heel counter, sits the ankle collar. Depending on the height of the shoe, the ankle collar may sit above or below the malleoli. The

ankle collar has additional cushioning to keep the heel locked down and provide enough comfort to prevent rubbing. The upper is attached to the midsole through a strobel. This gives the upper its shape so it can be glued onto the midsole.

The midsole of the basketball shoe is meant to provide cushion, stability from torque, and flexibility. A lot of innovation has been done to midsole materials as seen with the Under Armour Curry 8 and UA Flow Breakthru 2 which uses UA's Flow technology (Under Armour Unveils Second Iteration of Women's Only UA Flow Breakthru 2 Basketball Shoe, 2021). The midsole has a half-length, ¾ length, or full-length shank. The shank prevents torque and rollover. It can be engineered to allow flexibility in one direction and be rigid in another. It can either be placed at the top of the midsole or sit below the midsole (Importance of Shank Plates, 2020).

The outsole is a very important part of the shoe when it comes to traction. This is the part of the shoe that needs the most durability since it is the part of the shoe constantly on the court surface. Outsoles are typically one piece with a traction pattern molded into the material. Traction patterns can come in different designs depending on the type of movement it is promoting. The most common pattern is the herringbone pattern. The herringbone promotes multi-directional movement which is very important for basketball. Court surface types will influence traction patterns as well as pattern ridge height (Inside Access: The Science of Traction, 2015).

Materials

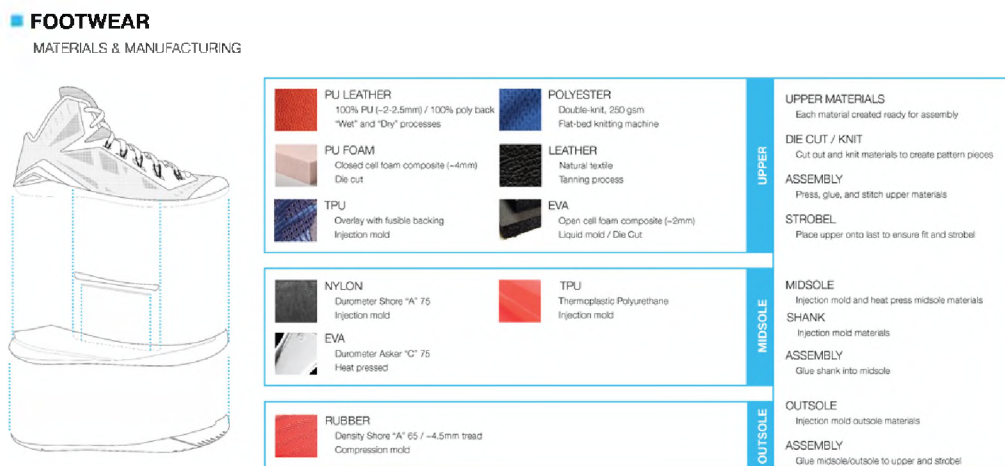


Figure 15: Footwear Materials and Manufacturing (Guerra, 2021)

Originally made up of natural leathers and cotton canvas, basketball footwear has moved to using synthetic materials for performance benefits. Materials such as PU (polyurethane) leather, polyester, and PU foam are commonly seen in footwear because of their durability, breathability, and lightweight qualities. TPU (thermo-plastic polyurethane) films and overlays can add to abrasion resistance and durability. Knits made of polyester and nylon can be engineered to have specific characteristics and are excellent for zoning shoe uppers. Nike Flyknit is great innovation for performance footwear uppers proving to be lighter weight, breathable, and provide better fit than traditional cut and sew methods. Nike worked to “micro-engineer static

properties into pliable materials” (Nike Engineers Knit for Performance, 2012) to create a knit upper that replicates a sock-like fit. After its debut in 2012, more innovation has been made to incorporate it into more performance footwear, outside of running. Nike Knitposite was debuted in basketball footwear with the LeBron 17 in 2020. It uses Nike Flyknit with heat-molded yarns to add structure and support the upper (New Nike's LeBron XVII Introduces Knitposite, 2019). Sockliners, or insoles, are made of EVA or PU foams. Overlays and films used for abrasion resistance are typically TPU and are applied using heat and pressure.

Midsole materials have seen a lot of improvements in cushioning through foam or implementing other technology into the midsole. The most common material used in basketball footwear is a variation of EVA foam. Many companies have proprietary names on these variations. Nike's React foam and UA's HOVR and Flow foams have been three highly anticipated innovations in basketball footwear. Nike's React foam is incredibly responsive and cushioned (Nike React, n.d.). While it is most commonly used in running shoes, the Nike Air Zoom G.T. Run basketball shoe is an example where it is used in basketball footwear. Under Armour's HOVR footwear cushioning technology was debuted in 2018. It is an 'Energy Web' that has mesh fabric wrapped around a foam cushioned core (Hodge, 2018). Its mission is to provide responsiveness and energy return for runners. In 2020, Under Armour used HOVR in the UA HOVR Breakthru women's basketball shoe. Nike's Air Zoom units are additional cushioning technologies that are added into the midsole to provide more cushion and energy return. The Curry 8 men's basketball shoe debuted UA's new cushioning technology, Flow, in 2020. Flow provides both cushion and traction. This technology does not need an additional rubber outsole (Going With a New Flow, 2020). UA Flow differs from traditional midsole and outsole materials because it is more flexible while also providing traction. Without the rubber outsole, it allows the user to have better court feel. The shank is also added to the midsole to prevent torque. Shanks can be made of nylon, TPU, or carbon fiber. They typically sit under the midfoot area and can be half,  $\frac{3}{4}$ , or full-length of the midsole depending on the degree of flex and torque the shoe is working to prevent (Importance of Shank Plates, 2020).

The outsole of a basketball shoe is typically made up of rubber. Rubber is durable and provides enough grip with the added traction pattern to allow the user to make hard cuts and change direction quickly. Indoor basketball shoes typically use a softer rubber while outdoor shoes use a hard rubber for added durability. The height and width of the tread is also important because tread for indoor courts will be thinner, lower heights, and made of a softer rubber, causing it to tear and wear down quicker when used on an outdoor court.

■ APPAREL - TOPS

MATERIALS & MANUFACTURING

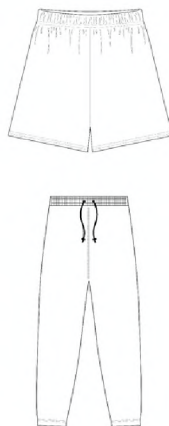


<p><b>COTTON</b> Knit "Wet" Process / Cut and Sew</p> <p><b>POLYESTER</b> Knit mesh Flat-bed knitting machine</p>	<p><b>NYLON</b> Knit mesh Flat-bed knitting machine</p>	<p><b>T-SHIRT</b></p>	<p><b>CREATE PATTERNS</b> Drape or measure out patterns</p>
			<p><b>CREATE MATERIALS</b> Knit yarns to create fabric</p>
			<p><b>CUT PATTERNS</b></p>
			<p><b>ASSEMBLY</b> Single-needle and four-thread stitch</p>
<p><b>COTTON</b> Knit "Wet" Process / Cut and Sew</p> <p><b>POLYESTER</b> Knit mesh Flat-bed knitting machine</p>	<p><b>ELASTANE</b> Polyurethane / Knit Dry spun fibers</p>	<p><b>SLEEVELESS TOP</b></p>	<p><b>CREATE PATTERNS</b> Drape or measure out patterns</p>
			<p><b>CREATE MATERIALS</b> Knit yarns to create fabric</p>
			<p><b>CUT PATTERNS</b></p>
			<p><b>DIE CUT VENTS</b> Create vents on out pattern piece</p>
			<p><b>ASSEMBLY</b> Single-needle and four-thread stitch</p>

Figure 16: Materials and Manufacturing- Tops (Guerra, 2021)

■ APPAREL - BOTTOMS

MATERIALS & MANUFACTURING



<p><b>COTTON</b> Knit "Wet" Process / Cut and Sew</p> <p><b>POLYESTER</b> Knit mesh Flat-bed knitting machine</p>	<p><b>NYLON</b> Knit mesh Flat-bed knitting machine</p>	<p><b>SHORT</b></p>	<p><b>CREATE PATTERNS</b> Drape or measure out patterns</p>
			<p><b>CREATE MATERIALS</b> Knit yarns to create fabric</p>
			<p><b>CUT PATTERNS</b></p>
			<p><b>ASSEMBLY</b> Single-needle and four-thread stitch</p>
<p><b>COTTON</b> Knit "Wet" Process / Cut and Sew</p> <p><b>POLYESTER</b> Knit mesh Flat-bed knitting machine</p>	<p><b>ELASTANE</b> Polyurethane / Knit Dry spun fibers</p> <p><b>NYLON</b> Knit mesh Flat-bed knitting machine</p>	<p><b>JOGGERS</b></p>	<p><b>CREATE PATTERNS</b> Drape or measure out patterns</p>
			<p><b>CREATE MATERIALS</b> Knit yarns to create fabric</p>
			<p><b>CUT PATTERNS</b></p>
			<p><b>DIE CUT VENTS</b> Create vents on out pattern piece</p>
			<p><b>ASSEMBLY</b> Single-needle and four-thread stitch</p>

Figure 17: Apparel Materials and Manufacturing- Bottoms (Guerra, 2021)

Basketball and athletic apparel use synthetic materials such as polyester, nylon, elastane (spandex), or natural material like cotton. By constructing a garment with both synthetic and natural materials, the garment can have characteristics of both. Polyester is durable, lightweight, wrinkle resistant, and dries quickly. These properties are highly considered for athletic apparel (Vanoer, 2019). Elastane, or Spandex, is used to help provide stretch in a garment for a wider range of movement and to create compression gear which would help keep the garment from getting caught on other objects.

**Manufacturing**

The manufacturing of footwear uppers starts with die-cutting patterns from the materials or using CNC or flat-bed knitting machines to create an engineered mesh (How Does a Factory Make Shoes?, 2018). The components are then stitched, glued, and/or laminated together using heat and pressure to create the shell pattern. The mesh lining and upper shell are assembled

separately and then stitched together at the ankle collar. Once the two are connected, the shape of the upper will begin to form. The strobels are stitched onto the upper and fit around the last. This process is known as lasting.

The midsole is created through injection or compression molds. Compression molding uses a block of EVA, Polyurethane, or proprietary foam (which differs for each company) and compressing it inside a metal mold with the selected design etched into it (Solereview, 2016). The mold is designed to be half the size of the intended shape because the foam will rapidly expand once out of the mold. If there are additional technologies being integrated into the midsole, each part will be manufactured separately and glued to the midsole (Solereview, 2016). The outsole is made using an injection or compression mold and glued onto the midsole.

Lastly, basketball footwear uppers and midsoles are assembled using adhesives. With the upper fitted around the last, the midsole is glued to the strobels to ensure a perfect fit and shaping (How Rubber Shoe Soles are Made, 2017).

Basketball apparel is manufactured using cut and sew and knitting methods. Many materials used in performance wear use a blend of materials or use engineered knits for zoning purposes. Once the materials are determined, patterns are created using either draping methods or research related to zoning to the anatomy and biomechanics of the athlete. Engineering materials based on zoning is typically done prior to creating the materials. The materials for the apparel are then cut using die cutting methods or knitted using a CNC knit machine or flatbed knitting machine. Once created, the pattern pieces are assembled using a single-needle or two-needle-four-thread machine. Some garments may call for welding or fusing depending on the end use (School, 2019). During the pattern cutting process, additional features such as air vents or decals may be added.

### **Graphics, Logos, and Color**

Basketball footwear utilizes graphics, logos, and color to show performance features and expressive style of the shoe. Graphics may be applied to the upper, midsole, or outsole and typically have a performance value like textures used for abrasion resistance. Transparency, 3D textures, ombré, and “phygital” graphics will be utilized for the Monarch footwear and apparel options. The environment will utilize layering and contrast of color to provide players a strong visual for when the game and players are in motion.

The Monarch Collection will be utilizing the Worth Global Style Network's (WGSN) projected Spring/Summer 2023 trend of “Phygital”. This is a blur between the virtual and physical worlds with digital purples and transformative brights (Kostiak, 2021).



Figure 18: Monarch Collection Moodboard (Guerra, 2021)

Logos seen on basketball footwear can be found most commonly on the lateral side of the shoe, heel, and tongue. TPU overlays, reflective tapes, embossments, and screen-printed logos and graphics may inform the technology used in the footwear or line the shoe is a part of. Many professional players who have signature shoe lines will include their logos on the outsole and tongue while the brand the line is a part of is on the lateral side of the shoe.



Figure 19: Market Logos (Guerra, 2021)

Footwear is typically sold in baseline colors such as black, white, grey, and color variation. Today, many basketball players are choosing brighter colors that express personality or team they're a part of. Players may wear footwear a part of signature lines like the LeBron or Kyrie. The limited options of women's footwear have long followed the industry standard of "shrink it and pink it". Bridget Brennan states, "In 2016, marketing to women is all about being inclusive. That doesn't mean excluding men; it means excluding stereotypes" (Contrera, 2016). Women have found there are not the same amount of color variations, let alone footwear styles, for them. Marketing product to women does not mean forcing them to pick a pink shoe but provide them a variety of colors they can freely choose from (Contrera, 2016). Female basketball

athletes want many of the same colorways as seen in men's footwear which provides both neutrals and colorful options.

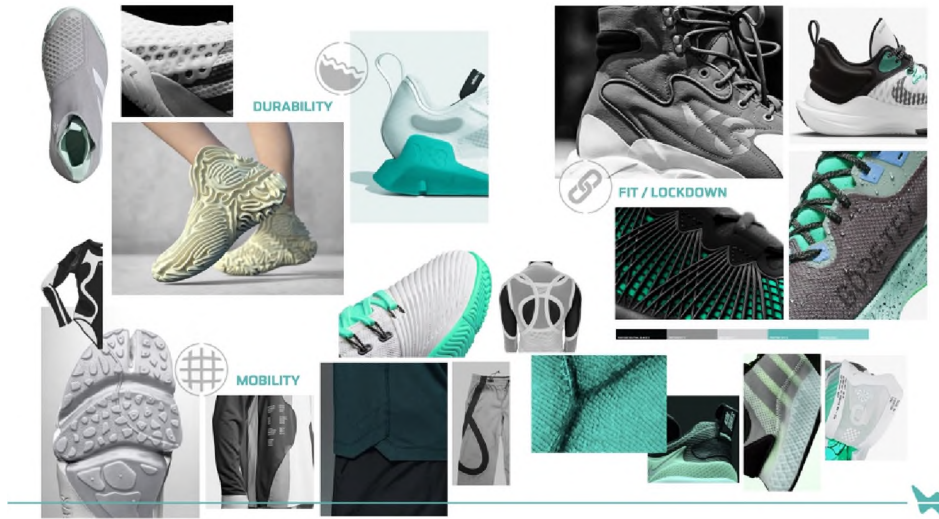


Figure 20: Monarch Colorway and Functional Direction (Guerra, 2021)

The colors utilized in the Monarch Collection will be Pantone Neutral Black C, Pantone 877 C, Pantone 427 C, Pantone 7472 C, and Pantone 3245 C. These colors represent both digital glitch and the natural environment. Colors, graphics, and logos will be incorporated into player apparel, accessories, footwear, and court surfaces. Showing color through transparency, patterned textures, and 3D textures will provide athletes a sense of protection and comfort many are seeking post pandemic (Saldana, 2021). Outdoor women's basketball has grown much attention with the help of FIBA and success of the USA 3x3 women's team in the Tokyo Olympics. Many people watched this sport for the first time through a digital screen. The return to in-person events and athletics with a digital twist will familiarize and invite athletes to what the next step in outdoor basketball is with the introduction of more outdoor leagues and tournaments.

## Intellectual Property

Relevant patents within the footwear and apparel spaces include patents on fit, lockdown systems, cushioning, and zoning. For additional information, refer to Appendix A.

### *Footwear:*

- Article of Footwear with Adaptive Fit and Method of Manufacturing (Taiwan Patent No. 722322B, 2021)
- Strap Systems for Articles of Footwear and Other Foot-Receiving Devices (US Patent No. 10299541B2, 2019)
- Article of Footwear Having Shock-Absorbing Elements in the Sole (US Patent No. 9044067B2, 2015)
- Articles of Footwear with Bootie Components Having Fixed Connections and Non-Fixed Regions (US Patent No. 20210153604A1, 2021)



*Apparel:*

- Asymmetric Athletic Apparel and Methods of Use Therefor (US Patent No. 20190166797A1, 2019)
- Garment with Stretchable Section and Related Methods (US Patent No. 7941871B1, 2011)
- Article of Sports Clothing (South Korea Patent No. 101895096B1, 2018)
- Impact Protection Systems (US Patent No. 20200154797A1, 2019)
- Aerographics and Denier Differential Zoned Garments (US Patent No. 20180055093A1, 2018)

**Research Plan**

Athlete insights and additional primary research will be conducted through questionnaires, interviews, and frame-by-frame analysis of female basketball athletes. The questionnaires will be sent to athletes in a randomized order to ensure an adequate number of insights are gathered for footwear and apparel sections of this project. Each questionnaire will begin with introduction regarding the project followed by a section of general questions and either the footwear or apparel questions. For additional information, refer to Appendix B. Questions and insights will be aimed at answering “How can we create innovative performance outdoor basketball footwear and apparel for female athletes investigating court surface and durability?”.

Travel will also be a method used to conduct athlete research. A brief schedule of the dates, locations, and goals can be found below.

December 2021 – NYC – Footwear Innovation Summit 2021 / Metropolitan Museum of Art/ Retail Visits / Athlete Interviews / Pratt Institute Women's Basketball team

March 2022 – NYC – Meet with Athlete to show prototypes, get measurements, and any additional feedback she may have.

May 2022 – NYC – Final photography and videography

**Baseline Testing Plan**

Baseline product testing will be completed using female basketball athletes with high school and college level experience playing indoors and outdoors. Testing will take place in December 2021-January 2022 in Brooklyn, NY and Portland, OR . Metrics to be beat for baseline footwear and apparel products tested will be fit, comfort, durability, mobility, and overall performance during a lay-up. Methods used will be questionnaires, photography, and 2D motion capture (video). Based on the geographical location of testing during the winter months of December and January, three tests will be completed. The first test will focus on footwear,

second on apparel, and third on both footwear and apparel. Participants will be asked to bring their own apparel and footwear to test as well. See Appendix D for more information.

### **Final**

The Monarch Collection is a women's outdoor basketball footwear and apparel collection designed to provide durable and flexible protection to help the athlete play her best game. Outdoor courts are a lot different than indoor courts due to environmental factors, varying surfaces, and uneven surfaces. Current footwear and apparel products worn by athletes do not adequately address these factors. The main goals of the Monarch Collection was to provide better fit, mobility, and durability throughout the footwear and apparel. Appendix G contains the final spring 2022 midterm presentations posters containing information and ideation leading up to the final presentation. Appendix H contains the final presentation consisting of research, athlete insights, competitor products, focus areas, design process, wear testing, tech packs, final product photography and renders, and expert validation. Final photography was taken in the environment Monarch used much inspiration from, New York City.

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Figures



Figure 21: *Starford players playing outdoors (Starford University, n.d.).*

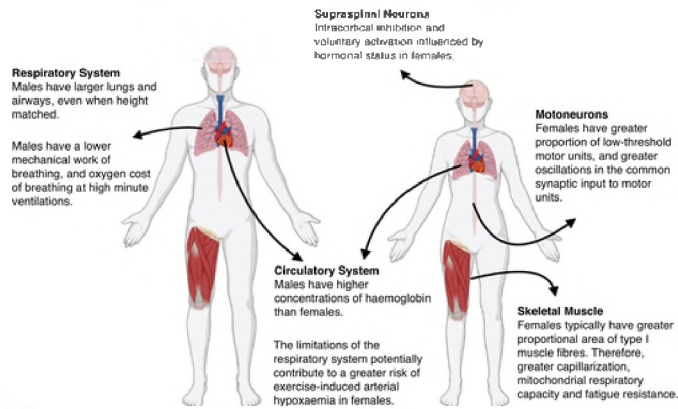


Figure 2: Summary of sex differences within the key physiological systems implicated in exercise performance (Ansdell, et al., 2020)

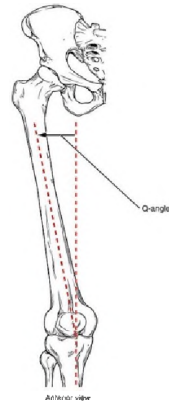


Figure 3: Female Q Angle ('Q' Angle, n.d.)

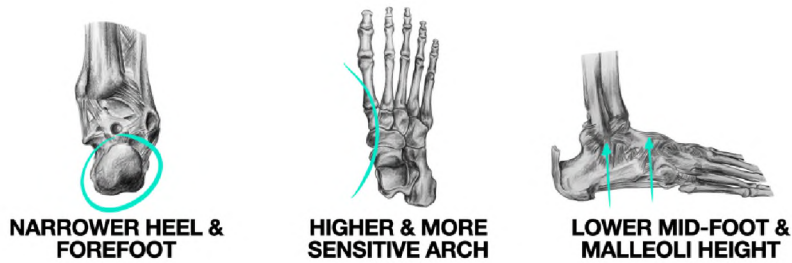


Figure 4: Female Foot Morphology Differences than Males (Guerra, 2021)

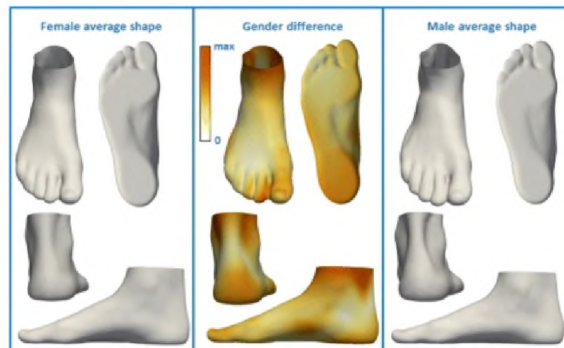


Figure 5: Visualization of the effect of sex and foot shape (Stanković, et al., 2018)

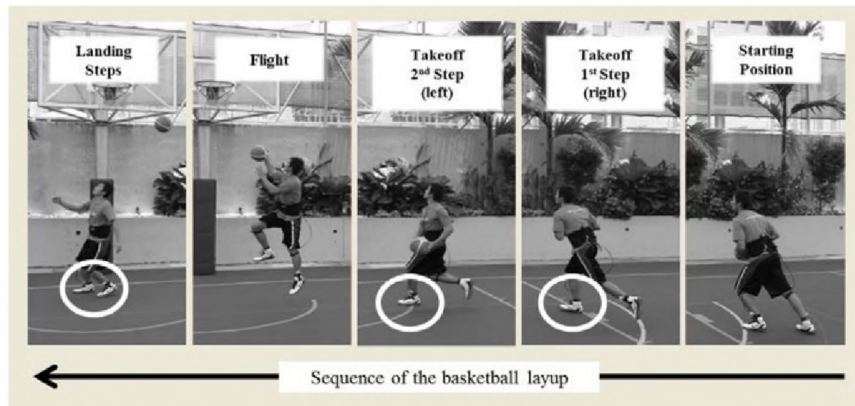


Figure 6: Sequence of Basketball Layup Approach from Right Side of Rim (Chua, Quek, & Kong, 2016)



Figure 7: Male Basketball Lay-up Frame-by-Frame Analysis (Knapman, 2014)

Illustration	Step	Variable	Hallux	Lesser Toes	Medial Forefoot	Central Forefoot	Lateral Forefoot	Medial Arch	Lateral Arch	Heel
	Takeoff (right)	PF	82.6 (42.3)	187.0 (58.4)	179.2 (71.0)	290.4 (51.4)	121.9 (50.9)	67.0 (45.0)	104.0 (41.7)	323.2 (139.6)
		PP	241.7 (96.3)	268.9 (85.1)	331.2 (89.5)	303.2 (71.5)	134.4 (47.2)	75.6 (35.8)	91.3 (31.2)	196.8 (79.0)
		PTI	34.2 (14.0)	39.3 (12.4)	53.2 (14.4)	48.4 (11.6)	21.7 (8.3)	12.1 (12.8)	16.4 (11.1)	21.2 (11.3)
	Takeoff (left)	PF	95.1 (53.7)	293.9 (83.9)	157.2 (42.0)	347.6 (52.2)	284.8 (79.0)	90.9 (37.5)	216.8 (51.1)	694.1 (162.1)
		PP	296.5 (117.3)	338.5 (70.3)	246.2 (80.5)	271.0 (65.6)	235.8 (52.9)	115.4 (29.3)	182.0 (35.9)	410.3 (67.2)
		PTI	36.1 (16.6)	45.3 (9.6)	32.7 (11.8)	37.4 (9.3)	38.6 (9.2)	13.3 (5.1)	26.8 (7.2)	35.8 (8.4)
	Landing (right)	PF	70.6 (32.4)	199.0 (49.7)	146.4 (48.9)	278.0 (72.5)	188.6 (64.9)	142.0 (35.4)	203.7 (84.4)	424.7 (219.1)
		PP	210.4 (86.9)	272.9 (91.4)	291.9 (94.5)	283.0 (92.8)	194.6 (38.6)	160.4 (60.1)	185.2 (55.6)	258.4 (128.5)
		PTI	62.1 (34.4)	82.1 (36.6)	79.1 (44.5)	86.9 (46.8)	58.3 (27.5)	21.5 (18.6)	27.2 (17.9)	30.9 (23.0)
	Landing (left)	PF	101.2 (39.4)	162.3 (60.1)	181.6 (53.0)	258.3 (40.8)	163.6 (53.8)	98.8 (78.6)	144.5 (75.0)	197.8 (166.8)
		PP	264.0 (86.4)	221.8 (74.3)	261.4 (70.8)	234.0 (38.2)	193.9 (69.1)	101.7 (65.0)	140.2 (60.4)	124.9 (84.1)
		PTI	38.6 (18.9)	33.8 (19.6)	36.0 (17.3)	30.4 (13.1)	20.5 (11.6)	5.8 (6.1)	9.0 (7.3)	8.35 (9.7)

PF – peak force (N), PP – peak pressure (kPa), PTI – pressure-time integral (kPa s)

Figure 8: Ten-Trial Mean of Peak Force (N), Peak Pressure (kPa), and Pressure-Time Integral (kPa s) Obtained During the Basketball Lay-up (Chua & Quek, 2016)



Figure 9: USA v. Japan 3x3 Basketball Tokyo Olympics Jumping (WBAL TV11, 2021)



Figure 10: USA v. Japan 3x3 Basketball Tokyo Olympics Lay-Up (Swift, 2021)



Figure 11: Compression garments seen worn by female 3x3 basketball players (Merrill, Tokyo Olympics: What is 3x3 Basketball All About?, 2021)

Select Size	Size Guide
M 3.5 / W 5	M 4 / W 5.5
M 4.5 / W 6	M 5 / W 6.5
M 5.5 / W 7	M 6 / W 7.5
M 6.5 / W 8	M 7 / W 8.5
M 7.5 / W 9	M 8 / W 9.5
M 8.5 / W 10	M 9 / W 10.5
M 9.5 / W 11	M 10 / W 11.5
M 10.5 / W 12	M 11 / W 12.5
M 11.5 / W 13	M 12 / W 13.5
M 12.5 / W 14	M 13 / W 14.5
M 13.5 / W 15	M 14 / W 15.5
M 15 / W 16.5	M 16 / W 17.5
M 17 / W 18.5	M 18 / W 19.5

Figure 12: Men's to Women's Shoe Size Conversion Table found on Women's Basketball Footwear Tab (Kyrie 7, n.d.)



Figure 13: Nike Women's Basketball 2020 Catalog (Nike Digital Pinnacle Premier Jersey CQ4307)

FOOTWEAR



NIKE HYPERDUNK

Figure 14: Basketball Footwear Anatomy of the Nike Hyperdunk (Guerra, 2021)

FOOTWEAR

MATERIALS & MANUFACTURING



Figure 15: Footwear Materials and Manufacturing (Guerra, 2021)



■ APPAREL - TOPS

MATERIALS & MANUFACTURING

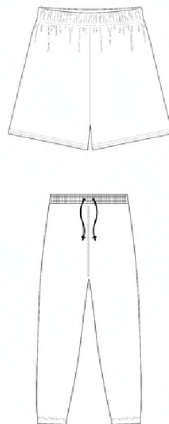


<p><b>COTTON</b> Knit "Wet" Process / Cut and Sew</p> <p><b>POLYESTER</b> Knit mesh Flat-bed knitting machine</p>	<p><b>NYLON</b> Knit mesh Flat-bed knitting machine</p>	<p><b>T-SHIRT</b></p>	<p><b>CREATE PATTERNS</b> Drape or measure out patterns</p>
			<p><b>CREATE MATERIALS</b> Knit yarns to create fabric</p>
			<p><b>CUT PATTERNS</b></p>
			<p><b>ASSEMBLY</b> Single-needle and four-thread stitch</p>
<p><b>COTTON</b> Knit "Wet" Process / Cut and Sew</p> <p><b>POLYESTER</b> Knit mesh Flat-bed knitting machine</p>	<p><b>ELASTANE</b> Polyurethane / Knit Dry spun fibers</p>	<p><b>SLEEVELESS TOP</b></p>	<p><b>CREATE PATTERNS</b> Drape or measure out patterns</p>
			<p><b>CREATE MATERIALS</b> Knit yarns to create fabric</p>
			<p><b>CUT PATTERNS</b></p>
			<p><b>DIE CUT VENTS</b> Create vents on out pattern piece</p>
			<p><b>ASSEMBLY</b> Single-needle and four-thread stitch</p>

Figure 16: Materials and Manufacturing- Tops (Guerra, 2021)

■ APPAREL - BOTTOMS

MATERIALS & MANUFACTURING



<p><b>COTTON</b> Knit "Wet" Process / Cut and Sew</p> <p><b>POLYESTER</b> Knit mesh Flat-bed knitting machine</p>	<p><b>NYLON</b> Knit mesh Flat-bed knitting machine</p>	<p><b>SHORT</b></p>	<p><b>CREATE PATTERNS</b> Drape or measure out patterns</p>
			<p><b>CREATE MATERIALS</b> Knit yarns to create fabric</p>
			<p><b>CUT PATTERNS</b></p>
			<p><b>ASSEMBLY</b> Single-needle and four-thread stitch</p>
<p><b>COTTON</b> Knit "Wet" Process / Cut and Sew</p> <p><b>POLYESTER</b> Knit mesh Flat-bed knitting machine</p>	<p><b>ELASTANE</b> Polyurethane / Knit Dry spun fibers</p> <p><b>NYLON</b> Knit mesh Flat-bed knitting machine</p>	<p><b>JOGGERS</b></p>	<p><b>CREATE PATTERNS</b> Drape or measure out patterns</p>
			<p><b>CREATE MATERIALS</b> Knit yarns to create fabric</p>
			<p><b>CUT PATTERNS</b></p>
			<p><b>DIE CUT VENTS</b> Create vents on out pattern piece</p>
			<p><b>ASSEMBLY</b> Single-needle and four-thread stitch</p>

Figure 17: Apparel Materials and Manufacturing- Bottoms (Guerra, 2021)



Figure 22: Monarch Collection Moodboard (Guerra, 2021)



Figure 19: Market Logos (Guerra, 2021)

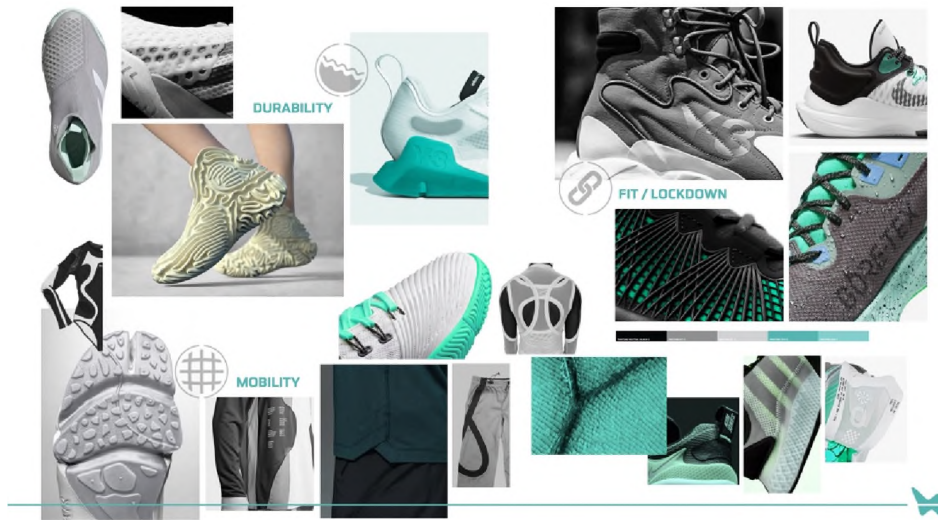


Figure 23: Monarch Colorway and Functional Direction (Guerra, 2021)

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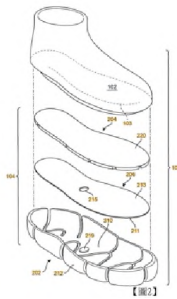
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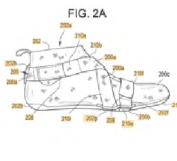
**Appendix A – Patent Landscape**

*Footwear:*



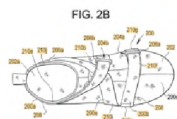
Article of Footwear with Adaptive Fit and Method of Manufacturing (Taiwan Patent No. 722322B, 2021)

- Upper attached to the peripheral surface region of the sole and bottom portion held in tension over the central surface region.
- Sole and heel units characterized by the constructive form with a part of the shoe being flexible, permitting articulation and torsion.

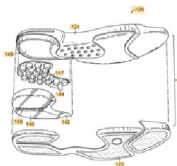


Strap Systems for Articles of Footwear and Other Foot-Receiving Devices (US Patent No. 10299541B2, 2019)

- One or more strap members forms or engaged together in a continuous path along an upper for an article of footwear or foot-receiving device.
- Strap systems can be arranged so the strap tightens during plantar flexion or dorsiflexion.



- Additional aspects of the invention relate to the bootie with supporting strap systems, upper members or bootie members including strap systems, and articles of footwear and other foot-receiving devices.



Article of Footwear Having Shock-Absorbing Elements in the Sole (US Patent No. 9044067B2, 2015)

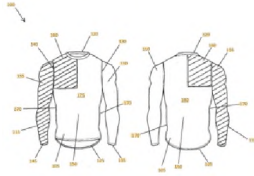
- Shoe with a sole providing shock absorption without reducing support and stability or a shoe that is lightweight.
- Sole may include an upper force-distribution plate portion, lower force-distribution plate portion spaced below the upper plate portion, lateral shell connecting the upper and lower force-distribution plate portions, and at least one resilient shock-absorber element in contact with and between the upper and lower plate portions.



Articles of Footwear with Bootie Components Having Fixed Connections and Non-Fixed Regions (US Patent No. 20210153604A1, 2021)

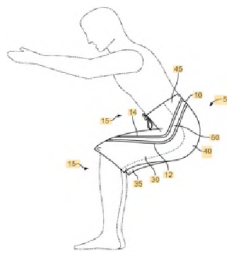
- Footwear or other foot-receiving devices include various conforming fit, stability, and/or “lockdown” feel features.
- Upper may include shell defining an interior chamber and includes plater support surface, sidewalls, and bootie component.
- Bootie component and/or foot wrapping bands may be secured to the upper shell on the inside of the plantar support surface or the upper shell. Sits beyond bight line and between sidewalls of the upper and support.

*Apparel:*



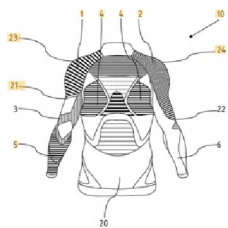
**Asymmetric Athletic Apparel and Methods of Use Therefor (US Patent No. 20190166797A1, 2019)**

- Invention relates to apparel and methods for supporting a movement of an athlete during an asymmetrical athletic motion.
- First material portion and second material portion are arranged asymmetrically with respect to a central vertical plain of the garment, and the second material being adapted to provide lesser resistance to at least one of stretching or twisting than the first to reduce resistance to a movement.



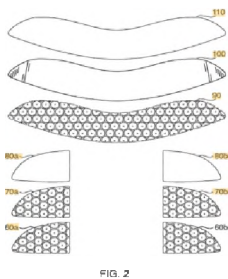
**Garment with Stretchable Section and Related Methods (US Patent No. 7941871B1, 2011)**

- Garment having a stretchable section preferably of neoprene, that provides for improved comfort and wearability while other panels may be constructed of less stretchable materials
- Stretchable portion is positioned in an "area of flex" of the garment so the stretchable portion can "stretch" when the wearer rotates limbs extending into the garment.



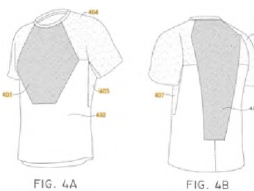
**Article of Sports Clothing (South Korea Patent No. 101895096B1, 2018)**

- Sports apparel product comprised of one basic textile area consisting of a resiliently stretchable textile fabric and at least one compression zone.
- Compression zone comprised of ridges on the side of the textile fabric facing the skin.
- Compression zones 1, 2, 4, 5, 6, and 11 are arranged in the zones provided with the body 20 and/or upper and/or lower limbs 21, 22, 23, and it is divided and arranged asymmetrically.



**Impact Protection Systems (US Patent No. 20200154797A1, 2019)**

- Comprised of at one plate element layer with an interconnected mesh plate element network.
- Further embodiments may comprise the combination of multiple body impact protection systems in a single protective garment or device.



**Aerographics and Denier Differential Zoned Garments (US Patent No. 20180055093A1, 2018)**

- Zoned moisture management apparel for wear during exertion.
- Fabric may include two layers, which may be woven or knit.
- Zoned garment capable of one-way moisture transport in selected areas without bulky and uncomfortable seams between panels.

Appendix B - SWOT Analysis

BASELINE COMPETITOR ANALYSIS

FOOTWEAR

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
 <p>UNDER ARMOUR FLOW BREAKTHRU 2</p>	<p><b>HEEL COUNTER:</b> Interdimensional lock down</p> <p><b>TEXTILE:</b> Breathability</p> <p><b>FIT:</b> A vertical contour built for female foot</p> <p><b>HEIGHT:</b> Mid toe provides cushion but needs extra flexibility</p>	<p><b>HEEL COUNTER:</b> Interdimensional lock down not provide enough cushion or it should be more of a midfoot</p> <p><b>TEXTILE:</b> Does not provide enough airflow resistance and flexibility, more so for additional support in upper</p> <p><b>FIT:</b> Some basic set and setting of upper creates basic level of fit</p> <p><b>HEIGHT:</b> Mid toe causes sliding against ankle</p>	<p><b>HEEL COUNTER:</b> Create internal and external lock down around forefoot</p> <p><b>TEXTILE:</b> Utilize lining and flow to increase durability</p> <p><b>FIT:</b> Can reduce ankle motion - making it improve fit around ankle</p> <p><b>HEIGHT:</b> Work around female set and increase flexibility forefoot and ankle</p>	<p><b>HEEL COUNTER:</b> Existing interdimensional internal counter design</p> <p><b>TEXTILE:</b> Breathable mesh and durable overlays</p> <p><b>FIT:</b> UA Women's female basketball forefoot</p> <p><b>HEIGHT:</b> Existing cushion, airflow and shock to use additional equipment for support</p>
 <p>NIKE AIR ZOOM G.T. RUN</p>	<p><b>FOAM:</b> Deep in heel with 3D molded foam</p> <p><b>TEXTILE:</b> Cooling and breathability</p>	<p><b>FOAM:</b> General mold based on basic shape of foot</p> <p><b>TEXTILE:</b> No additional innovation</p>	<p><b>FOAM:</b> Zone in heel foam for additional fit and cushioning, with air, actually to heat the foot</p> <p><b>TEXTILE:</b> Offer lightweight, innovative materials</p>	<p><b>FOAM:</b> Flexible insoles</p> <p><b>TEXTILE:</b> Breathable fabrics without basic</p>
 <p>ADIDAS EXPORT A CARDOCE RUNNER</p>	<p><b>FOAM:</b> Deep in heel with 3D molded foam</p> <p><b>SHANK:</b> Nylon midsole and forefoot shank to help prevent fatigue</p> <p><b>TRACTION PATTERN:</b> Organic and direction traction with 3-Dim scale</p>	<p><b>FOAM:</b> Shanks experience high abrasion and wear due to excessive foot motion</p> <p><b>SHANK:</b> Shank shape and mass increase adding weight and additional manufacturing cost</p> <p><b>TRACTION PATTERN:</b> Area of high wear reduce weight, leading to a loss of "grip"</p>	<p><b>FOAM:</b> Zone foam to increase flexibility</p> <p><b>SHANK:</b> Offer organically shaped shank to work with flexibility of midsole but continue to prevent fatigue</p> <p><b>TRACTION PATTERN:</b> Follow user patterns and offer different grades of traction in pattern</p>	<p><b>FOAM:</b> Existing foam innovation</p> <p><b>SHANK:</b> Carbon fiber, lightweight shank incorporated into existing forefoot</p>
	<p><b>RUBBER:</b> Traction forefoot, reduce punching "grip" when around trees and trail for additional durability "UA Flow does not require rubber outsole"</p>	<p><b>RUBBER:</b> Create natural grain to back, leaving it soft on the forefoot and adding the impact of the cushioning technology "UA Flow not adequate or durable user line"</p>	<p><b>RUBBER:</b> High rubber in forefoot for flexibility and durability, wrap up around it to reduce and support for additional support and durability</p>	<p><b>RUBBER:</b> Rubber forefoot which reduce weight and increase flexibility</p>

BASELINE COMPETITOR ANALYSIS

APPAREL

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
 <p>NIKE DRI-FIT LEGEND T-SHIRT</p>	<p><b>FRONT:</b> Looser fit feels less restricting in movement</p> <p><b>BACK:</b> Looser fit feels less restricting in movement</p> <p><b>SLEEVES:</b> Women's cut (shorter), sits above end of bicep</p> <p><b>SILHOUETTE:</b> Basic, universal t-shirt and shorts</p>	<p><b>FRONT:</b> Looser fit causes snagging and baggy feel, may be tight in chest/shoulder area for some user</p> <p><b>BACK:</b> Looser fit causes snagging and baggy feel</p> <p><b>SLEEVES:</b> Sleeve circumference tight when moving arms in front or overhead</p> <p><b>SILHOUETTE:</b> Overall looser fit not specifically designed for outdoor basketball movements</p>	<p><b>FRONT:</b> Zoning for mobility and breathability</p> <p><b>BACK:</b> Zoning for mobility and breathability</p> <p><b>SLEEVES:</b> Construct sleeves to fit length and circumference of female outdoor basketball athletes</p> <p><b>SILHOUETTE:</b> Create women's outdoor basketball specific silhouette</p>	<p><b>FRONT:</b> Engineered knitted garments</p> <p><b>BACK:</b> Engineered knitted garments</p> <p><b>SLEEVES:</b> Sleeveless and engineered knitted garments</p> <p><b>SILHOUETTE:</b> Offer multi-use garments, fitted garments, or men's apparel worn by female athletes</p>
 <p>NIKE TEMPO SHORTS</p>	<p><b>LENGTH:</b> Longer length to keep secure when tucked into shorts</p> <p><b>NECK:</b> Relaxed collar for secure fit around neck</p>	<p><b>LENGTH:</b> Longer length of shirts get caught around hip area on front and back during squatting movements when shirt is tucked or articulated, shorts become baggy in front and tight in back when in squatting position</p> <p><b>NECK:</b> Neck tight for some users, may cause irritation around neck/shoulder area on shoulder/neck</p>	<p><b>LENGTH:</b> Offer front and back lengths for mobility and comfort, adjust length of shorts to fit when in squatting/defensive position</p> <p><b>NECK:</b> Fit better with sports bra</p>	<p><b>LENGTH:</b> Garments with different cuts or lengths between front and back or sides</p> <p><b>NECK:</b> Different silhouettes and height of collars</p>
 <p>UA LOCKER T-SHIRT</p>	<p><b>NECK:</b> Simple 0.5" trim, same material as body</p> <p><b>BODY:</b> Fold over hem, not inward or outward rolling</p> <p><b>SLEEVES:</b> Fold over hem, not inward or outward rolling</p>	<p><b>NECK:</b> No additional innovation</p> <p><b>BODY:</b> No additional innovation</p> <p><b>SLEEVES:</b> No additional innovation</p>	<p><b>NECK:</b> Breathable and lightweight trims, is trim necessary the entire way around the neck?</p> <p><b>BODY:</b> Additional trim following innovative body and silhouette</p> <p><b>SLEEVES:</b> Additional trim following innovative body and silhouette</p>	<p><b>NECK:</b> Garments with differing heights/lengths of trim with additional breathability or cooling abilities</p> <p><b>BODY:</b> Garments with differing heights/lengths of trim with additional breathability or cooling abilities</p> <p><b>SLEEVES:</b> Garments with differing heights/lengths of trim with additional breathability or cooling abilities</p>
 <p>UA PLAYUP SHORTS 3.0</p>	<p><b>SHORTS:</b> Nike - fold over with elastic, UA - additional leg with elastic to secure fit, UA - short material on inside sitting against body for comfort</p> <p><b>ADJUSTABILITY:</b> Nike - tie on inside of shorts waistband, UA - tie on outside of shorts waistband</p>	<p><b>SHORTS:</b> Material can become irritating with sweat build up, length of shorts cause rolling of the waistband</p> <p><b>ADJUSTABILITY:</b> No additional innovation</p>	<p><b>SHORTS:</b> Lightweight, soft, and trim option to reduce rolling, sweat buildup, or feeling of additional weight from layers of material</p> <p><b>ADJUSTABILITY:</b> Proper sizing and fitting may eliminate additional tie</p>	<p><b>SHORTS:</b> Garments with differing heights/lengths of waistbands that give the athlete the feeling or cooling or less material through proportionation</p> <p><b>ADJUSTABILITY:</b> Internal/external ties and other mechanical adjustability options</p>

Basketball Footwear SWOT

SWOT Analysis comparing top basketball shoes used by female basketball players at the high school and college levels in both indoor and outdoor.



**UA HOVR BREAKTHRU**  
\$110.00 / 10.5 oz.

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
UPPER	<ul style="list-style-type: none"> <li>Heel stability</li> <li>Mesh upper for breathability</li> <li>Anatomical correct build to the female foot.</li> </ul>	<ul style="list-style-type: none"> <li>Mid top difficulties</li> <li>Ankle pain due to top-eyed.</li> </ul>	<ul style="list-style-type: none"> <li>First women's specific shoe and the only option on the market at the time of its release.</li> </ul>	<ul style="list-style-type: none"> <li>Limited market</li> <li>UA not known for women's products.</li> </ul>
INSOLE	<ul style="list-style-type: none"> <li>Thicker foam for comfort</li> <li>3D molded</li> </ul>	<ul style="list-style-type: none"> <li>General mold based on static test.</li> </ul>	<ul style="list-style-type: none"> <li>Can explore female-specific molded insole for additional fit and comfort</li> </ul>	<ul style="list-style-type: none"> <li>Removable insoles replaced with molded, customized options</li> </ul>
MIDSOLE	<ul style="list-style-type: none"> <li>Utilizes HOVR technology</li> <li>Integral nylon shank</li> </ul>	<ul style="list-style-type: none"> <li>Lack of cushioning due to construction.</li> </ul>	<ul style="list-style-type: none"> <li>Use materials providing more flexibility</li> </ul>	<ul style="list-style-type: none"> <li>Lightweight engineered foams and 3D printed midsoles</li> </ul>
OUTSOLE	<ul style="list-style-type: none"> <li>Utilizes durable rubber and traction pattern.</li> </ul>	<ul style="list-style-type: none"> <li>Adds weight and stiffness to the midsole.</li> </ul>	<ul style="list-style-type: none"> <li>Create a female-specific traction pattern- may not require as much rubber</li> </ul>	<ul style="list-style-type: none"> <li>Lightweight construction of UA Flow.</li> </ul>



**UA FLOW BREAKTHRU 2**  
\$120.00 / 10.25 oz.

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
UPPER	<ul style="list-style-type: none"> <li>Breathable mesh</li> <li>Heel stability</li> <li>Ankle support</li> </ul>	<ul style="list-style-type: none"> <li>Limited height of shoe.</li> </ul>	<ul style="list-style-type: none"> <li>Second iteration of shoe based on female test</li> </ul>	<ul style="list-style-type: none"> <li>Limited market</li> <li>Lack of success with first iteration, reducing number of possible consumers.</li> </ul>
INSOLE	<ul style="list-style-type: none"> <li>3D molded foam</li> </ul>	<ul style="list-style-type: none"> <li>General mold based on static test.</li> </ul>	<ul style="list-style-type: none"> <li>Molded to dynamic nature of foot and sport</li> </ul>	<ul style="list-style-type: none"> <li>Removable insoles replaced with molded, customized options</li> </ul>
MIDSOLE	<ul style="list-style-type: none"> <li>Utilizes UA Flow technology</li> <li>Does not need break-in time.</li> </ul>	<ul style="list-style-type: none"> <li>Must be altered with a shank to avoid torque</li> </ul>	<ul style="list-style-type: none"> <li>Create dynamic foam based on female foot biomechanics and expansion during high forces</li> </ul>	<ul style="list-style-type: none"> <li>Durable foams with rubber outsoles</li> </ul>
OUTSOLE	<ul style="list-style-type: none"> <li>Utilizes UA Flow technology</li> <li>Good court feel</li> </ul>	<ul style="list-style-type: none"> <li>Not durable for outdoor courts.</li> </ul>	<ul style="list-style-type: none"> <li>Create outdoor material with same level of court feel.</li> </ul>	<ul style="list-style-type: none"> <li>Durability for outdoor surfaces.</li> </ul>



**NIKE AIR ZOOM G.T. RUN**  
\$175.00 / 13.23 oz.

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
UPPER	<ul style="list-style-type: none"> <li>Abrasion texture</li> <li>Breathable mesh</li> <li>Heel stability</li> </ul>	<ul style="list-style-type: none"> <li>Feel lace through tongue</li> <li>Relatively stiff at first</li> <li>Designed for male foot</li> </ul>	<ul style="list-style-type: none"> <li>Use material features and innovations on a female last.</li> </ul>	<ul style="list-style-type: none"> <li>Many players may want more support built into the upper.</li> </ul>
INSOLE	<ul style="list-style-type: none"> <li>Air Zoom stripe for cushioning</li> <li>3D molded removable insole.</li> </ul>	<ul style="list-style-type: none"> <li>Generic molded shape, limiting many options.</li> <li>Not removable</li> </ul>	<ul style="list-style-type: none"> <li>Incorporate removable air zoom units so athletes can replace with customized insoles if needed.</li> </ul>	<ul style="list-style-type: none"> <li>Drop-in midsoles and removable insoles</li> </ul>
MIDSOLE	<ul style="list-style-type: none"> <li>React foam has good cushioning under heel and forefoot</li> <li>Fairly flexible - not much break-in needed.</li> </ul>	<ul style="list-style-type: none"> <li>Not good fit for flat feet or low arches</li> <li>No rigid shank, so not the best "push-off"</li> </ul>	<ul style="list-style-type: none"> <li>Create better fit for various foot shapes</li> </ul>	<ul style="list-style-type: none"> <li>Other responsive, cushioned midsole technologies</li> </ul>
OUTSOLE	<ul style="list-style-type: none"> <li>Burton cup traction pattern.</li> </ul>	<ul style="list-style-type: none"> <li>Shallow traction pattern, not durable for outdoor courts.</li> </ul>	<ul style="list-style-type: none"> <li>Create taller and more durable traction pattern in areas of high wear</li> </ul>	<ul style="list-style-type: none"> <li>Outsole-free shoes</li> <li>Directional traction patterns</li> </ul>

## Running Footwear SWOT

SWOT Analysis comparing top running shoes used by female basketball players at the high school and college levels during outdoor play.



**BROOKS GLYCERIN 19**  
\$150.00 / 9.0 oz.

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
UPPER	<ul style="list-style-type: none"> <li>- Stretchable for roomy fit to various shapes.</li> <li>- Soft interior for cushion directly against foot.</li> <li>- Good air flow and breathability.</li> </ul>	<ul style="list-style-type: none"> <li>- Mesh is not waterproof.</li> <li>- Not ideal for wider feet.</li> <li>- Heel comes up to a point causing irritation.</li> </ul>	<ul style="list-style-type: none"> <li>- Create better fit during high force movements.</li> <li>- Add more abrasion resistance.</li> </ul>	<ul style="list-style-type: none"> <li>- Basketball footwear with great lateral stability.</li> <li>- Brooks does not design basketball footwear.</li> </ul>
INSOLE	<ul style="list-style-type: none"> <li>- 3D molded removable insole.</li> <li>- Insole helps provide great cushioning.</li> </ul>	<ul style="list-style-type: none"> <li>- Takes up space in upper of the shoe causing discomfort in the ankle.</li> </ul>	<ul style="list-style-type: none"> <li>- Moulded insole based on female foot biomechanics.</li> </ul>	<ul style="list-style-type: none"> <li>- Insole-free or drop-in insoles.</li> </ul>
MIDSOLE	<ul style="list-style-type: none"> <li>- Soft cushion utilizing DNA LOFT technology.</li> </ul>	<ul style="list-style-type: none"> <li>- Not good for wide feet.</li> <li>- Toe drop is too low.</li> <li>- Does not include lateral flare for multi-directional stability.</li> </ul>	<ul style="list-style-type: none"> <li>- Add lateral stability.</li> </ul>	<ul style="list-style-type: none"> <li>- Stiffer foam providing more stability.</li> </ul>
OUTSOLE	<ul style="list-style-type: none"> <li>- Durable traction for outdoor surfaces.</li> </ul>	<ul style="list-style-type: none"> <li>- Additional rubber adds weight.</li> </ul>	<ul style="list-style-type: none"> <li>- Add directional traction based on female basketball athlete movements.</li> </ul>	<ul style="list-style-type: none"> <li>- Current basketball footwear traction and outsole market.</li> </ul>



**NIKE ZOOMX INVINCIBLE RUN FLYKNIT**  
\$180.00 / 8.92 oz.

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
UPPER	<ul style="list-style-type: none"> <li>- Utilizes Flyknit technology.</li> <li>- Zoned mesh with breathability and durability.</li> </ul>	<ul style="list-style-type: none"> <li>- Less stability for overpronation.</li> <li>- Expensive.</li> </ul>	<ul style="list-style-type: none"> <li>- Create more lateral and heel stability.</li> <li>- Add more abrasion resistance.</li> </ul>	<ul style="list-style-type: none"> <li>- Basketball footwear with Flyknit and great lateral stability.</li> </ul>
INSOLE	<ul style="list-style-type: none"> <li>- 3D molded removable insole.</li> </ul>	<ul style="list-style-type: none"> <li>- Poor arch support.</li> </ul>	<ul style="list-style-type: none"> <li>- Moulded insole based on female foot biomechanics.</li> </ul>	<ul style="list-style-type: none"> <li>- Insole-free or drop-in insoles.</li> </ul>
MIDSOLE	<ul style="list-style-type: none"> <li>- Utilizes React foam for extra cushion.</li> <li>- Responsive and lightweight.</li> </ul>	<ul style="list-style-type: none"> <li>- Bulkier overall design.</li> <li>- Does not include lateral flare for multi-directional stability.</li> </ul>	<ul style="list-style-type: none"> <li>- Add lateral stability with lateral flare.</li> </ul>	<ul style="list-style-type: none"> <li>- Stiffer foam providing more stability.</li> </ul>
OUTSOLE	<ul style="list-style-type: none"> <li>- Traction created using sithene silica.</li> <li>- Curved outsole for better heel to toe transition.</li> </ul>	<ul style="list-style-type: none"> <li>- Poor ground feel and flexibility.</li> <li>- Noisy outsole for different types of flooring.</li> </ul>	<ul style="list-style-type: none"> <li>- Add directional traction based on female basketball athlete movements.</li> </ul>	<ul style="list-style-type: none"> <li>- Current basketball footwear traction patterns and outsole market.</li> </ul>



**NEW BALANCE FRESH FOAM 1080v11**  
\$149.99 / 8.1 oz.

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
UPPER	<ul style="list-style-type: none"> <li>- Ultra Heel design hugs back of foot for snug, supportive fit.</li> <li>- Boosted heel upper construction for snug, breathable fit.</li> </ul>	<ul style="list-style-type: none"> <li>- Narrow toe box.</li> <li>- Laces are not secure.</li> <li>- Not stable on declines.</li> <li>- Ankle discomfort when laces tightened.</li> </ul>	<ul style="list-style-type: none"> <li>- Create more lateral and heel stability.</li> <li>- Add more abrasion resistance.</li> </ul>	<ul style="list-style-type: none"> <li>- Basketball footwear with great lateral stability.</li> <li>- NB basketball footwear is not commonly used by female athletes.</li> </ul>
INSOLE	<ul style="list-style-type: none"> <li>- OrthoLite molded insole for comfort.</li> </ul>	<ul style="list-style-type: none"> <li>- Not as much innovation done on molding insole to female foot.</li> </ul>	<ul style="list-style-type: none"> <li>- Moulded insole based on female foot biomechanics.</li> </ul>	<ul style="list-style-type: none"> <li>- Insole-free or drop-in insoles.</li> </ul>
MIDSOLE	<ul style="list-style-type: none"> <li>- Utilizes NB Fresh Foam technology.</li> <li>- Soft, responsive cushioning.</li> <li>- Lightweight.</li> </ul>	<ul style="list-style-type: none"> <li>- Does not include lateral flare for multi-directional stability.</li> </ul>	<ul style="list-style-type: none"> <li>- Add lateral stability.</li> </ul>	<ul style="list-style-type: none"> <li>- Stiffer foam providing more stability.</li> </ul>
OUTSOLE	<ul style="list-style-type: none"> <li>- Good grip and traction.</li> </ul>	<ul style="list-style-type: none"> <li>- Noisy outsole.</li> </ul>	<ul style="list-style-type: none"> <li>- Add directional traction based on female basketball athlete movements.</li> </ul>	<ul style="list-style-type: none"> <li>- Current basketball footwear traction and outsole market.</li> </ul>



**Basketball Apparel SWOT**

SWOT Analysis comparing top apparel tops and bottoms used by female basketball players at the high school and college levels during outdoor play.



**UA MUSCLE TANK**  
\$25.00

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
<b>BODY</b>	<ul style="list-style-type: none"> <li>- Looser fit for mobility.</li> <li>- Functional ventilation.</li> <li>- Does not stick to the body with sweat.</li> </ul>	<ul style="list-style-type: none"> <li>- Looser fit could get snagged or caught.</li> </ul>	<ul style="list-style-type: none"> <li>- Zoning for breathability, comfort, and fit.</li> <li>- Sleeveless tops are most commonly used in basketball.</li> </ul>	<ul style="list-style-type: none"> <li>- Simple construction and minimal design.</li> </ul>
<b>TRIM/CUFF LENGTH</b>	<ul style="list-style-type: none"> <li>- Lightweight</li> <li>- Comfortable, soft fabric.</li> </ul>	<ul style="list-style-type: none"> <li>- No additional performance benefits.</li> <li>- Limited color and style.</li> </ul>	<ul style="list-style-type: none"> <li>- Incorporating cuff/trim into garment if it already made of same material.</li> </ul>	<ul style="list-style-type: none"> <li>- Simple hem and trim for universal use.</li> </ul>
<b>CUT</b>	<ul style="list-style-type: none"> <li>- Good mobility.</li> <li>- Draped armhole</li> </ul>	<ul style="list-style-type: none"> <li>- Not as much protection against impact or abrasion.</li> </ul>	<ul style="list-style-type: none"> <li>- Length of garment designed for increased mobility.</li> </ul>	<ul style="list-style-type: none"> <li>- Accessible and easy to wear for many different uses.</li> </ul>



**UA LOCKER T-SHIRT**  
\$25.00

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
<b>BODY</b>	<ul style="list-style-type: none"> <li>- Looser fit for mobility.</li> <li>- Does not stick to the body with sweat.</li> </ul>	<ul style="list-style-type: none"> <li>- Looser fit could get snagged or caught.</li> </ul>	<ul style="list-style-type: none"> <li>- Fit garment for mobility.</li> </ul>	<ul style="list-style-type: none"> <li>- Simple t-shirts are accessible and easy to wear for many different uses.</li> </ul>
<b>TRIM/CUFF LENGTH</b>	<ul style="list-style-type: none"> <li>- Lightweight</li> <li>- Comfortable, soft fabric.</li> </ul>	<ul style="list-style-type: none"> <li>- No additional performance benefits.</li> <li>- Limited color and style.</li> </ul>	<ul style="list-style-type: none"> <li>- Adjust length of cuff/trim to reduce snagging.</li> </ul>	<ul style="list-style-type: none"> <li>- Simple hem and trim for universal use.</li> </ul>
<b>CUT</b>	<ul style="list-style-type: none"> <li>- Good protection against impact or abrasion</li> </ul>	<ul style="list-style-type: none"> <li>- Not as much mobility in shoulder region.</li> </ul>	<ul style="list-style-type: none"> <li>- Length of garment designed for increased mobility.</li> </ul>	<ul style="list-style-type: none"> <li>- Simple t-shirts are accessible and easy to wear for many different uses.</li> </ul>



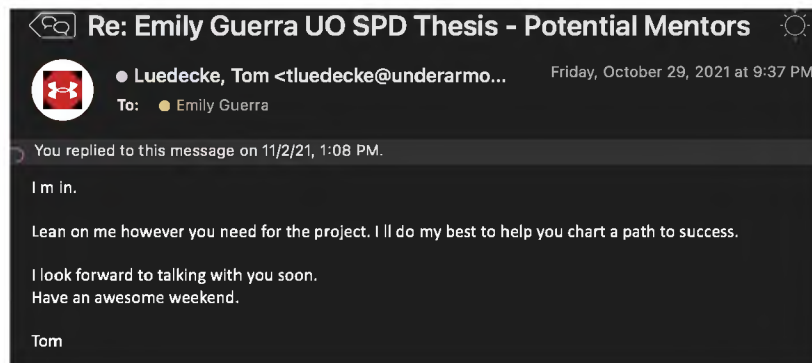
**NIKE FLY CROSSOVER BASKETBALL SHORTS**  
\$60.00

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
<b>BODY</b>	<ul style="list-style-type: none"> <li>- Looser fit for mobility.</li> <li>- Does not stick to the body with sweat.</li> </ul>	<ul style="list-style-type: none"> <li>- Looser fit could get snagged or caught with movement.</li> </ul>	<ul style="list-style-type: none"> <li>- Zone shape of garment for movements of 2nd women's basketball.</li> <li>- Shorts are most commonly used in basketball.</li> </ul>	<ul style="list-style-type: none"> <li>- Shorts are accessible and easy to wear for many different uses.</li> </ul>
<b>WAISTBAND</b>	<ul style="list-style-type: none"> <li>- Stretch for snug fit.</li> <li>- Comfortable, soft fabric.</li> </ul>	<ul style="list-style-type: none"> <li>- Thicker material causing sweat buildup.</li> <li>- Limited color and style.</li> </ul>	<ul style="list-style-type: none"> <li>- Trim/cuff material and length designed to reduce snagging and increase mobility.</li> </ul>	<ul style="list-style-type: none"> <li>- Simple hem and trim for universal use.</li> </ul>
<b>CUT</b>	<ul style="list-style-type: none"> <li>- Good mobility.</li> </ul>	<ul style="list-style-type: none"> <li>- Less protection against impact and abrasion.</li> </ul>	<ul style="list-style-type: none"> <li>- Design hem to fit anatomy when athletes in specific positions during a game.</li> </ul>	<ul style="list-style-type: none"> <li>- Shorts are accessible and easy to wear for many different uses.</li> </ul>

### Appendix C – Mentor Confirmation

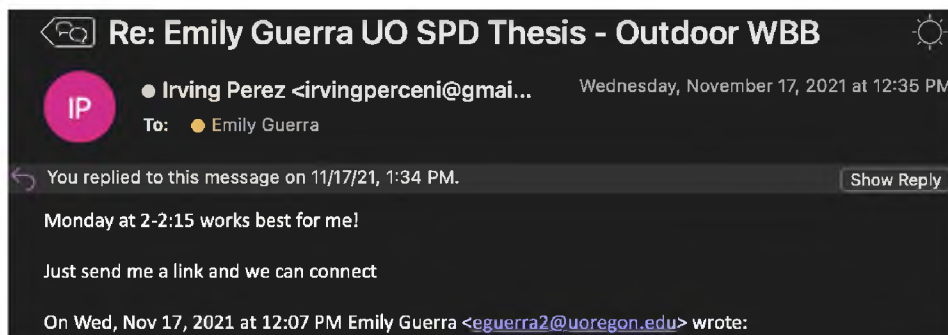
Tom Luedecke  
Design Director Footwear Innovation  
Under Armour

Meeting 1x every 1-2 weeks for 30-40 mins. Expertise storytelling, research, design process, industry knowledge.



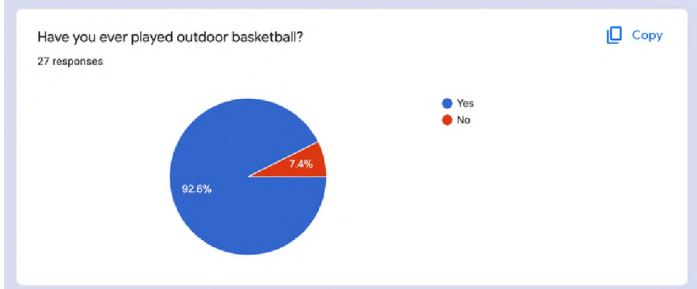
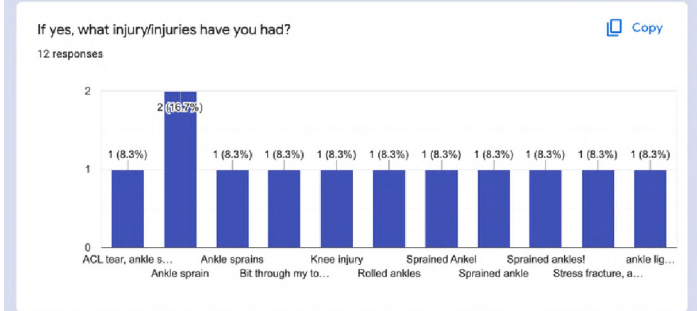
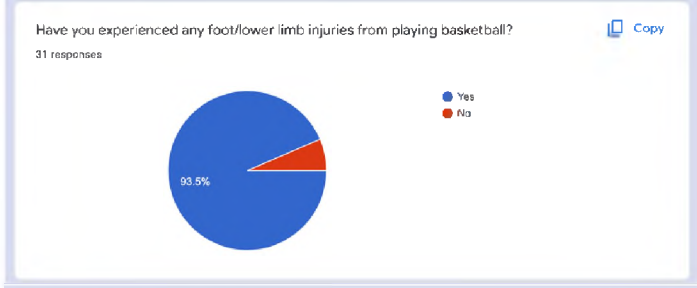
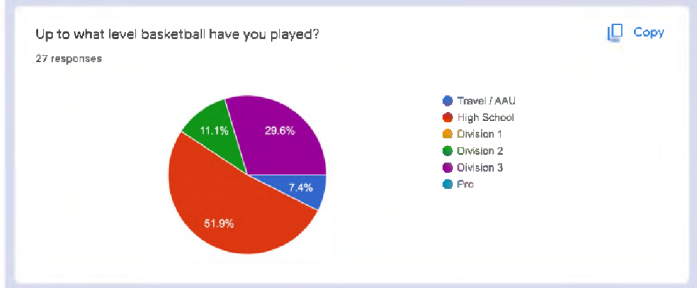
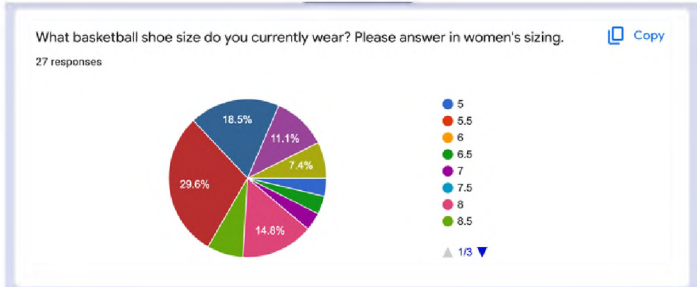
Irving Perez  
Apparel Designer – Basketball  
Adidas

Meeting 1x per month for 30 mins. UO SPD alum and expertise in basketball apparel knowledge, LA basketball culture knowledge.



Appendix D – Athlete Questionnaires





If yes, in your own words how do you think outdoor basketball is different from indoors?

11 responses

The surface is a lot different, there's much less traction. You play a little safer and definitely never dive for the ball

Traction on a normal court versus an outdoor court is very different. With that said, how fast you can make cuts or how hard you can change directions is different. Which changes what skills you would utilize. Also typically, outdoor basketball is less rules so more vulnerable to injury!

Different terrain, shoes grip differently

Harsher on the body and typically more physical

The courts are different, the energy is different, the space is different, the basketballs are different, everything feels different

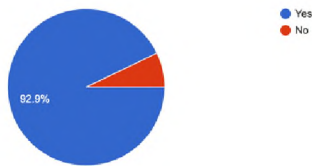
playing on harder surface, needs better support from shoes to absorb shock from jumping and running

The surface is a lot harder

Have you ever played 3x3 basketball?

 Copy

28 responses



If yes, in your own words how do you think 3x3 basketball is different from traditional indoor basketball?

10 responses

Much faster game pace, way more offensive touches

You have a lot more space on the court which makes it fun to take your defender 1:1. I think it highlights skill in different ways than what you see in a 5:5 game! For example, there is a lot more court awareness because if you are beat, the defenders need to cover more space to help!

More area to work with

Typically more physical and dirty

Less people on the court but more responsibility and more teamwork

faster pace

More space, and lets me do more 1v1 moves

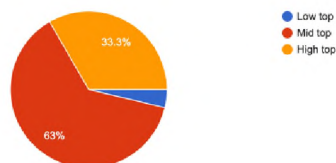
Faster paced. Every team member has to be at the top of their game all the time since there are less people on the court. You have to be good at everything, can't just be a post or a guard.

Footwear

What silhouette of basketball shoes do you wear?

 Copy

27 responses



Why do you like this type of silhouette?

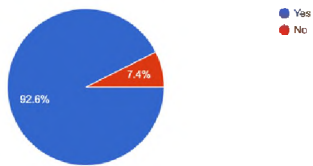
12 responses

- Ankle support
- ankle protection; however, my low top pair is the most stylish to me! :)
- Basketball shoes often are big and chunky and feel like I am wearing clown shoes, so although it is important to have ankle support because you are turning and stopping short, I like something that has a more sleek look to it
- Yes
- Support on ankles
- It feels better
- gives enough ankle support without being too heavy
- It protects my ankles

Do you have trouble finding women's-specific basketball shoes?

 Copy

27 responses



If yes, what sort of challenges do you face?

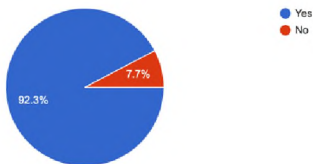
11 responses

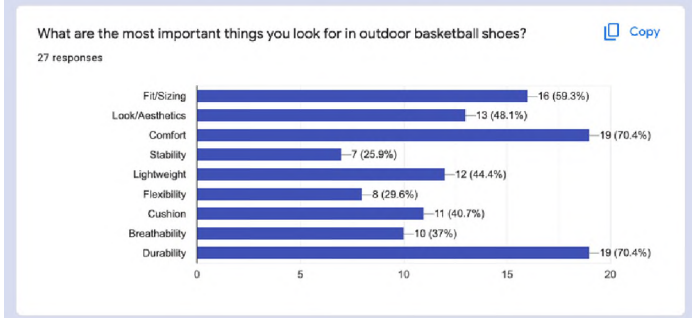
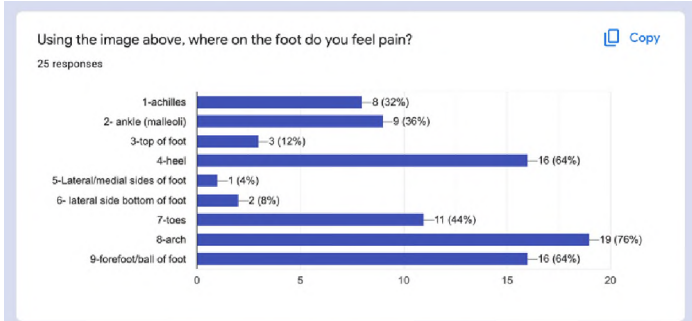
- They just don't exist! And if they do they are lesser quality than men's
- I wouldn't say I have trouble finding women's shoes but there are for sure less options available!
- I never like how they look because they always look big and bulky
- Too bulky (adds weight to sneaker), not narrow enough
- Not a huge selection of shoes
- Not really sure just never really seen women basketball shoes
- selection for womens shoes is limited or underdeveloped, more options in mens shoes
- They're all unisex now and never have my size
- There's only like 1 pair that exists.

After basketball practice/games do you ever have foot pain?

 Copy

26 responses





What BRAND is your favorite basketball shoe ever?

12 responses

- Nike
- NIKE
- Nike
- Really anything that's light
- don't have one
- nike

What STYLE is your favorite basketball shoe ever?

10 responses

- Nike Hyperdunk
- Not too high of an ankle, I would say a mid ankle
- Mid top
- Mids
- KD aunt pearl's
- PGs
- High top
- LeBron's
- It's been too long for specific style, but high top for sure

What do you like about these basketball shoes?

9 responses

- Comfortable & well-priced! However, they did not last very long!
- That they don't appear as bulky and big like clown shoes, but still support my anoes
- Not to much around the ankle but still gives support
- Fit well
- There cute and comfortable
- tight fit, light weight, supports ankle and cushions when jumping
- They are supportive to my ankle/foot
- I like that they were very plain for the most part
- Ankle support

Do you wear any additional braces or equipment when playing basketball to protect your feet/lower limbs? If so, what and why? (ex. ankle braces, second layer of socks, etc)

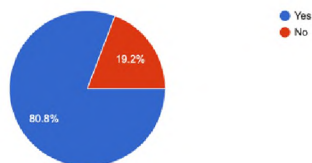
10 responses

- No
- Ankle braces or ankle tape because I've had many sprained ankles in the past!
- n/a
- Knee brace that I don't usually wear and in need of a mouth guard for my braces
- ankle brace
- 2 socks for extra tight feel and more sturdy feel
- Ankle braces because I wrecked one of my ankles and it will easily roll if I don't
- Ankle brace for my sprained ankle
- Ankle braces, knee peds.

Do you wear different basketball shoes for different court surfaces? If yes, explain why.

 Copy

26 responses



Why?

8 responses

- Nice shoes inside, older shoes outside
- I want to protect the traction on my indoor court shoes!
- Different grips on different grounds
- n/a
- outdoor shoes need to be more durable and more cushioned
- Never wear your indoor shoes outdoors because you will wreck the indoor floor
- My outdoor shoes have the soles worn off because of the difference in court material
- Don't wear my indoor shoes outside



If you answered no, do you think different basketball shoes are necessary for different court surfaces? Please explain why

4 responses

Yes because the bottoms would get worn out much quicker on a concrete or pavement surface than indoors, also for indoors they need to stick to the ground well and not be slippery

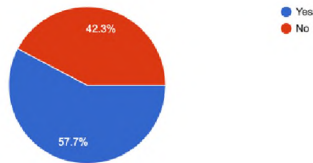
Yes for the different surfaces of the ground

Playing in doors the floors are slippery and usually don't have wax on them

Not really. I wear running sneakers if I'm outdoors so I don't ruin my pair of basketball sneakers

Do you wear different basketball shoes for playing different game styles (ex. 3x3, pick up games, etc)? If yes, explain why. [Copy](#)

26 responses



Why?

2 responses

n/a

I'm cheap and don't play at a high level. Plus it's still the same game.

If you answered no, do you think different basketball shoes for playing different game styles are necessary? Please explain why

8 responses

I think a lot of the movements are the same

I tried to have a practice shoe & a game shoe! It's important to be sure that game shoe feels comfortable but you prioritize the stick on the bottom of the shoe! Idk how to explain that best!

I don't think for the size of the game as much as the location and type of ground

Same game

No

I only change shoes for indoor and outdoor, rather than type of game. I think it's more about the surface than how the game is being played

No. They're usually built to handle each part of basketball no matter the play style

I'm actually not sure and I haven't thought about this question much

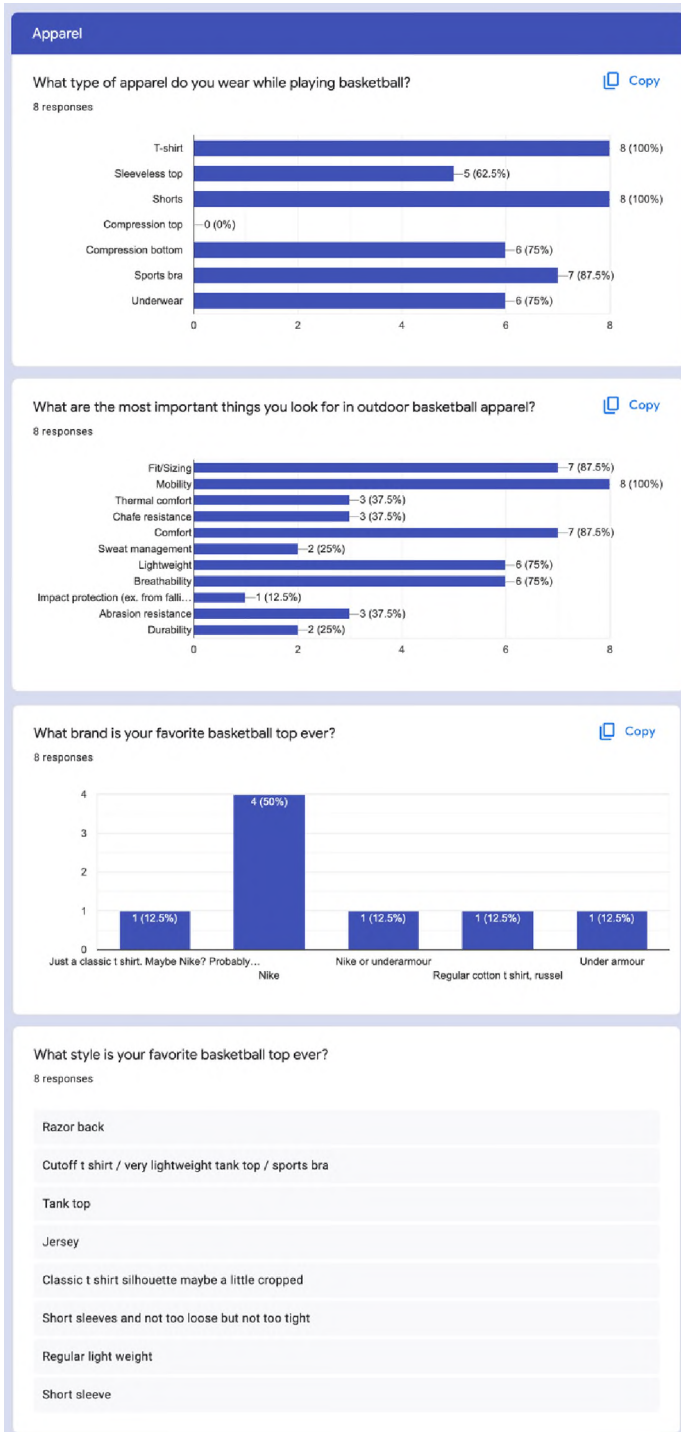
Additional Feedback

Any additional feedback or comments are greatly appreciated! Thank you for taking the time to fill out this survey!

2 responses

I like LIGHTWEIGHT shoes makes for easier mobility and faster running

Good luck!!



Why do you like this basketball top?

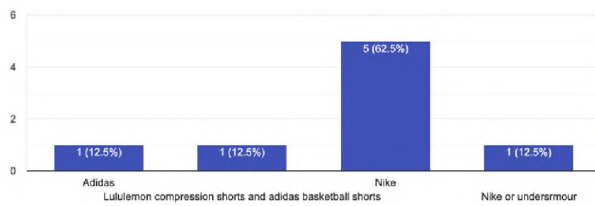
8 responses

- It's lightweight, and less fabric
- I don't get too hot
- It's easy to move around in and isn't restrictive
- Its lightweight and breathable
- Comfortable, had good mobility
- I don't want to feel constricted but I also don't like it feeling too baggy where it feels like it is holding me down
- Easy Mobility
- Comfortable

What BRAND is your favorite basketball bottom ever?

 Copy

8 responses



What STYLE is your favorite basketball bottom ever?

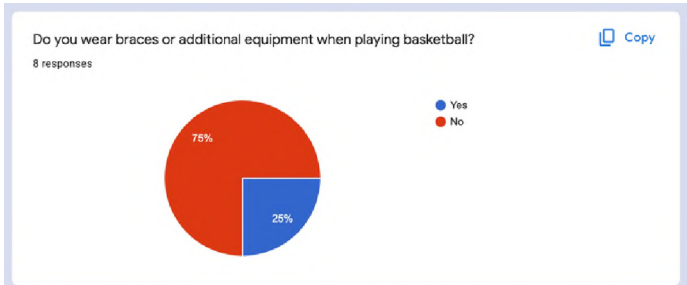
7 responses

- Correctly sized shorts, not baggy ones I have to roll a million times
- Basketball shorts
- Athletic shorts
- Long basketball shorts
- Shorts are baggy on top of compression shorts
- Not too short
- I hate basketball shorts so now I just wear the Tempo running shorts

Why do you like this basketball bottom?

8 responses

- Because I feel comfortable and confident in them
- They're a little shorter than Nike shorts
- They are comfortable and easy to move around in
- I dont chafe
- I feel the proprioception of the compression but like having shorts on top for more coverage
- Because you are squatting and getting low to the ground I don't like shorts that are too short
- No chaffing
- Sooo comfortable. Good length (maybe a little longer for basketball).



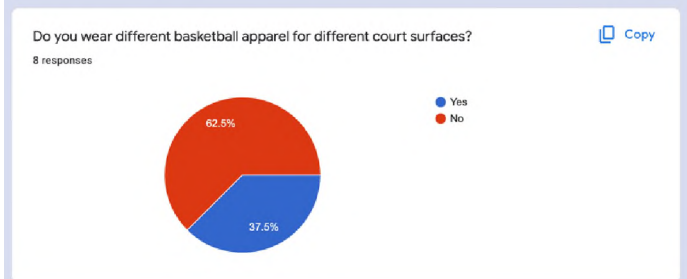
If you answered yes to the previous question, what brand, type of brace, for what body part, and do you wear it over or under your apparel?

3 responses

Knee compression sleeve

n/a

Ankle brace over my socks



Why?

5 responses

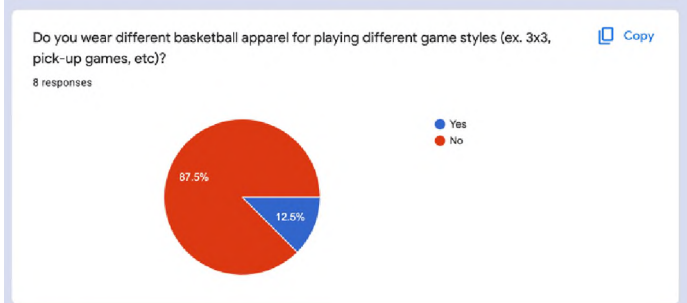
Because they are different terrain

Depends on outdoor weather/ temp

I just maintain the style, but my shoes change

n/a

Indoors for indoor only



Why?

5 responses

Same game

I just don't have anything specific

I like the style and performance of the clothes

n/a

I would probably wear a tank top for intense games and a t shirt for pick up/fun.

If you answered no, do you think different basketball apparel is necessary for different game styles? Please explain why or why not.

3 responses

Not really

Maybe for outdoors some sort of knee protection because scraping your knees on concrete could cause more of a cut into your skin than on the indoor wood court

no

**Additional Feedback**

Any additional feedback or comments are greatly appreciated! Thank you for taking the time to fill out this survey!

2 responses

Good luck! Lmk if you have any more questions!




Good luck :)

Appendix E – Competitor Product Testing Plan

BASELINE COMPETITOR PRODUCTS

Baseline products chosen based on user insight results





FOOTWEAR

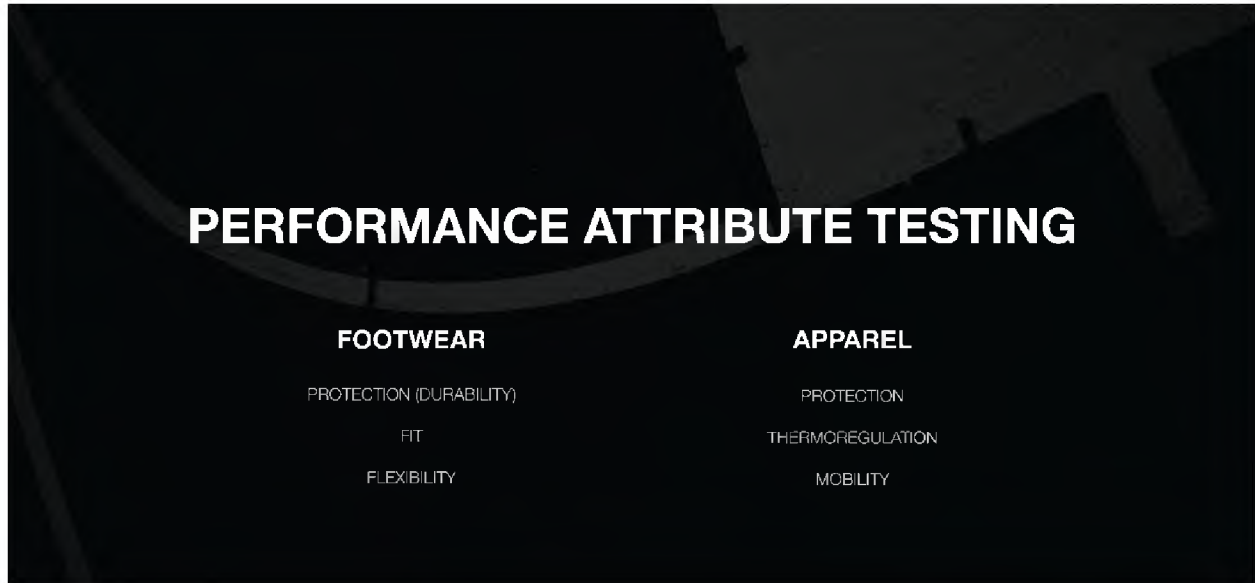
<p>1 UA FLOW BREAKTHRU 2</p>	<p>2 NIKE AIR ZOOM G.T. RUN</p>	<p>3 ADIDAS EXHIBIT A CANDACE PARKER</p>
<p>\$119.99 / W8.5</p>	<p>\$165.97 / M7 (W8.5)</p>	<p>\$109.99 / W8.5</p>
 <ul style="list-style-type: none"> <li>- Breathable engineered mesh upper strategically supported by no-sew films for enhanced comfort &amp; flex.</li> <li>- Women's-specific build with half-boost &amp; molded collar for incredible fit &amp; anatomically correct support.</li> <li>- External TPU wing for heel lockdown &amp; lateral containment.</li> <li>- UA Flow cushioning technology is super-light, bouncy &amp; provides insane grip.</li> <li>- Proprietary, 3D-molded TPE-blend sockliner with low compression set for energy return &amp; longevity.</li> </ul>	 <ul style="list-style-type: none"> <li>- Nike React technology for an extremely smooth ride.</li> <li>- The 2-layer upper is made with lightweight mesh for a broken-in feel and a textured haptic print layer for extra durability.</li> <li>- The thin rubber outsole has curvy ridges that bend and flex to provide traction in multiple directions.</li> <li>- Rubber is cut away under the arch and perforated to help reduce weight.</li> <li>- Foam tongue molds to your foot to help reduce lace pressure.</li> </ul>	 <ul style="list-style-type: none"> <li>- Regular fit for comfort.</li> <li>- Lace closure for secure lockdown.</li> <li>- Lightsrike midsole for smooth cushioned feel underfoot.</li> <li>- Rubber outsole for traction.</li> <li>- Textile upper with durable and supportive overlays for durability.</li> </ul>

BASELINE COMPETITOR PRODUCTS

Baseline products chosen based on user insight results

APPAREL

<p>1 NIKE DRI-FIT LEGEND T-SHIRT</p>	<p>2 NIKE TEMPO SHORTS</p>	<p>3 UA LOCKER T-SHIRT</p>	<p>4 UA PLAYUP SHORTS 3.0</p>
<p>\$25.00 / MEDIUM</p>	<p>\$30.00 / MEDIUM</p>	<p>\$25.00 / MEDIUM</p>	<p>\$25.00 / MEDIUM</p>
 <ul style="list-style-type: none"> <li>- Dri-FIT technology helps keep you dry and comfortable.</li> <li>- Color-resistant finish helps the shirt stay fresh.</li> <li>- Standard fit for a relaxed, easy feel.</li> <li>- 100% polyester</li> </ul>	 <ul style="list-style-type: none"> <li>- Lightweight woven fabric feels smooth as you run.</li> <li>- Curved mesh on the sides increases your airflow, helping you stay cool and mobile.</li> <li>- Elastic waistband with an internal drawcord gives a personalized fit.</li> <li>- 100% polyester</li> </ul>	 <ul style="list-style-type: none"> <li>- UA Tech fabric quick-dry, ultra-soft for comfort.</li> <li>- Material wicks sweat and keeps athletes dry.</li> <li>- Anti-odor tech to prevent growth of odor-causing microbes.</li> <li>- 100% polyester</li> </ul>	 <ul style="list-style-type: none"> <li>- Soft, lightweight knit construction for comfort and breathability.</li> <li>- Mesh waistband wicks and keeps athletes dry.</li> <li>- Anti-pilling/pile finish for extra durability.</li> <li>- 100% polyester</li> </ul>



**TESTING PLAN 01**

BASELINE PRODUCTS

**PORTLAND, OR**

Colonel Summers Park  
Two guard players with outdoor experience

**WHAT TO BRING**

Participants will be asked to wear their own apparel top and bottom and footwear. Participants will be asked to bring personal running footwear as well. Additional apparel tops and bottoms and footwear will be supplied for testing.

\*\*\*footwear will be the focus due to the court surface being a similar to UA 3x3 tournament environment and players performing in colder weather during the month of January\*\*\*

STEP	STEP DETAILS	METHOD OF DOCUMENTING	TIME
Paperwork / background info	- consent form - Name, age, height, weight, position, clothing and footwear sizes, level of play, etc.	Form Questionnaire	5 mins
Product Appearance	- Participants handed products and rate appearance and perception of fit, comfort, durability, and overall look to determine if bias is involved for later on after testing.	Questionnaire (Scale 1-10)	5 mins
Product Fit and Comfort	- Participants will put on footwear and apparel and asked if fit, flexibility, and support are noticeable factors prior to performing in the products.	Questionnaire (Scale 1-10) Photos	10 mins
Product Performance	- Running/Sprinting: Participants will be asked to run for 5 mins with footwear to determine breathability, comfort, and fit. - Lateral Movements: Participants will be asked to perform defensive sliding drills to determine lateral stability/durability, comfort, and fit. - Lay-up: Participants will perform left and right lay-ups in footwear to determine level of mobility, fit, comfort, and durability.	Photos and video Pressure insoles	15 mins
Post-test Questionnaire	- Participants will complete a post-test questionnaire to determine fit, comfort, breathability, and post-performance testing as well as determine if there is bias involved.	Questionnaire (Scale 1-10)	5 mins

**TESTING PLAN 02**

BASELINE PRODUCTS

**BROOKLYN, NY**

Willoughby Ave. Courts / Pratt Institute ARC  
Players with indoor and outdoor experience

**WHAT TO BRING**

Participants will be asked to wear their own apparel top and bottom and footwear. Participants will be asked to bring personal running footwear as well. Additional apparel tops and bottoms and footwear will be supplied for testing.

\*\*\*apparel testing will be completed indoors due to warmer environment similar to UA 3x3 tournament environment (footwear will also be included in this testing because of the gym's rubber flooring)\*\*\*

STEP	STEP DETAILS	METHOD OF DOCUMENTING	TIME
Paperwork / background info	- consent form - Name, age, height, weight, position, clothing and footwear sizes, level of play, etc.	Form Questionnaire	5 mins
Product Appearance	- Participants handed products and rate appearance and perception of fit, comfort, durability, and overall look to determine if bias is involved for later on after testing.	Questionnaire (Scale 1-10)	5 mins
Product Fit and Comfort	- Participants will put on footwear and apparel and asked if fit, flexibility, and support are noticeable factors prior to performing in the products.	Questionnaire (Scale 1-10) Photos	10 mins
Product Performance	- Running/Sprinting: Participants will be asked to run for 5 mins with footwear and apparel to determine breathability, comfort, and fit. - Lateral Movements: Participants will be asked to perform defensive sliding drills to determine lateral stability/durability, comfort, and fit. - Lay-up: Participants will perform left and right lay-ups in footwear and apparel to determine level of mobility, fit, comfort, and durability.	Photos and video Pressure insoles	15 mins
Post-test Questionnaire	- Participants will complete a post-test questionnaire to determine fit, comfort, breathability, and post-performance testing as well as determine if there is bias involved.	Questionnaire (Scale 1-10)	5 mins

**METHODS OF COLLECTING DATA**

BASELINE PRODUCTS

**2D MOTION CAPTURE**

Using photo, video, and markers placed on the joints, movement analysis will be recorded for each athlete and movement.

**PRESSURE ANALYSIS**

Lay-up "second step" pressure and shoe cushion will be determined using pressure insoles (ARION).

**QUESTIONNAIRES**

Asking participants questions directly prior and post testing will provide insights that may not be measurable through systems.

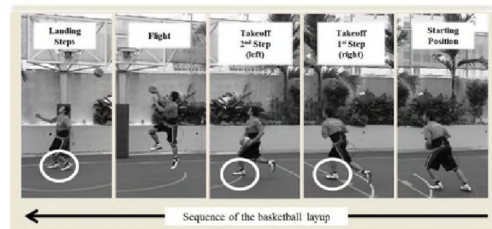


Table 1. Ten-trial mean (standard deviation) of peak force (N), peak pressure (kPa) and pressure time integral (kPa-s) obtained during the basketball lay-up.

Illustration	Step	Variable	Heel	Lower Foot	Medial Forefoot	Central Forefoot	Lateral Forefoot	Medial Arch	Lateral Arch	Ball
Takeoff (right)	PP	FF	42.6 (42.3)	187.0 (25.4)	179.2 (21.0)	298.4 (33.4)	121.9 (39.9)	67.0 (45.0)	198.0 (41.7)	321.2 (139.6)
		PP	241.7 (66.3)	268.4 (85.1)	331.2 (89.5)	363.2 (71.5)	134.4 (87.2)	75.9 (35.8)	61.3 (32.3)	186.8 (79.0)
		PTI	34.2 (24.0)	39.3 (22.4)	53.2 (24.4)	48.4 (21.4)	21.7 (8.3)	12.1 (7.8)	16.4 (11.1)	21.2 (11.3)
Takeoff (left)	PP	FF	65.1 (53.7)	295.5 (83.9)	197.2 (42.0)	347.6 (32.2)	264.9 (79.8)	90.9 (47.5)	218.8 (51.1)	496.1 (102.1)
		PP	296.5 (112.3)	338.5 (79.3)	266.2 (88.5)	271.6 (65.6)	255.8 (52.9)	115.4 (29.3)	182.0 (35.9)	403.6 (87.2)
		PTI	36.1 (16.6)	46.3 (8.6)	32.7 (13.8)	37.4 (9.3)	38.6 (9.2)	13.3 (5.1)	28.8 (7.2)	35.8 (8.4)
Landing (right)	PP	FF	70.6 (52.4)	199.0 (69.7)	166.4 (68.8)	278.0 (72.5)	186.0 (64.9)	142.0 (31.4)	207.3 (84.4)	424.7 (219.1)
		PP	210.4 (86.9)	272.9 (87.4)	291.9 (84.5)	293.0 (95.3)	194.6 (88.4)	168.4 (86.3)	182.2 (55.6)	258.4 (28.5)
		PTI	42.1 (24.4)	82.1 (26.4)	79.1 (48.5)	80.9 (36.8)	58.3 (27.5)	21.5 (8.4)	27.2 (7.9)	39.9 (21.0)
Landing (left)	PP	FF	101.2 (29.4)	142.3 (88.3)	181.4 (31.0)	258.3 (60.6)	163.6 (33.9)	93.8 (27.4)	148.2 (27.0)	197.4 (166.9)
		PP	244.0 (86.4)	221.8 (74.3)	261.4 (78.0)	234.0 (84.2)	193.9 (89.3)	101.7 (89.0)	140.2 (88.4)	124.9 (84.1)
		PTI	34.6 (18.9)	32.6 (22.6)	36.9 (17.2)	32.4 (13.1)	20.5 (11.4)	5.6 (6.1)	6.9 (7.3)	8.5 (9.7)

FF = peak force (N); PP = peak pressure (kPa); PTI = pressure time integral (kPa-s)  
<https://repository.nyu.edu/cgi/bitstream/10487/19726/1/SM-16-1-13.pdf>  
<https://doi.org/10.1007/s40278-018-0068-3>



**COMPETITOR PRODUCT TESTING**

FOOTWEAR

**DURABILITY**

- 1 Cut fabric into 6x6" swatches (8 total) and tape down to board. Clamp orbital sander frame over fabric and lock in using clamps on either side of sander.
- 2 Use 80 grit sand paper and orbital sander (1285g, Speed 2) and sand fabric for up to 1 minute, documenting time til wear or failure every 10 seconds using photography.
- 3 Document time of wear or fail using photos inputed into an excel table. After 1 minute test, take detail photos of wear to determine materials that will be used in prototyping and design phase.



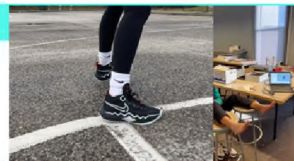
**FLEXIBILITY**

- 1 Clamp toe of shoe at forefoot flex point to table. Clamp power drill approximately 24" from shoe.
- 2 Tie string to heel tab of shoe, force gauge, and drill. Each should be approximately 12" apart.
- 3 Use power drill to pull heel of shoe to 90 degrees. Measure peak force in Newtons and repeat 5x for each shoe (left and right).



**FIT**

- 1 Scan left and right foot of female outdoor basketball athlete (women's size 9). Scan with sock on and sock off. Utilize wear testing data collected from athletes and Ansur Research Data during this step.
- 2 Compare scans with men's basketball last and women's running last. Overlay scans in X, Y, and Z views in Rhino to identify locations needing adjustments.
- 3 Using sub-D, create a new last with adjustments based on scan overlays and athlete data. Then print last using 3D printing methods.



**COMPETITOR PRODUCT TESTING**

APPAREL

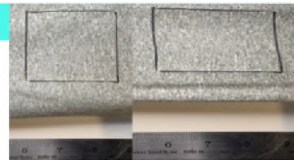
**DURABILITY**

- 1 Cut fabric into 6x6" swatches (8 total) and tape down to board. Clamp orbital sander frame over fabric and lock in using clamps on either side of sander.
- 2 Use 80 grit sand paper and orbital sander (1285g, Speed 2) and sand fabric for up to 1 minute, documenting time til wear or failure every 10 seconds using photography.
- 3 Document time of wear or fail using photos inputed into an excel table. After 1 minute test, take detail photos of wear to determine materials that will be used in prototyping and design phase.



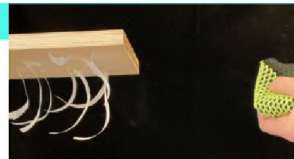
**MOBILITY**

- 1 2' grid drawn on baseline product tops and bottoms.
- 2 Using a camera and ruler, stretch fabric til peak stretching point.
- 3 Identify distance of stretch and subtract from 2.0" to get amount of stretch allowed.



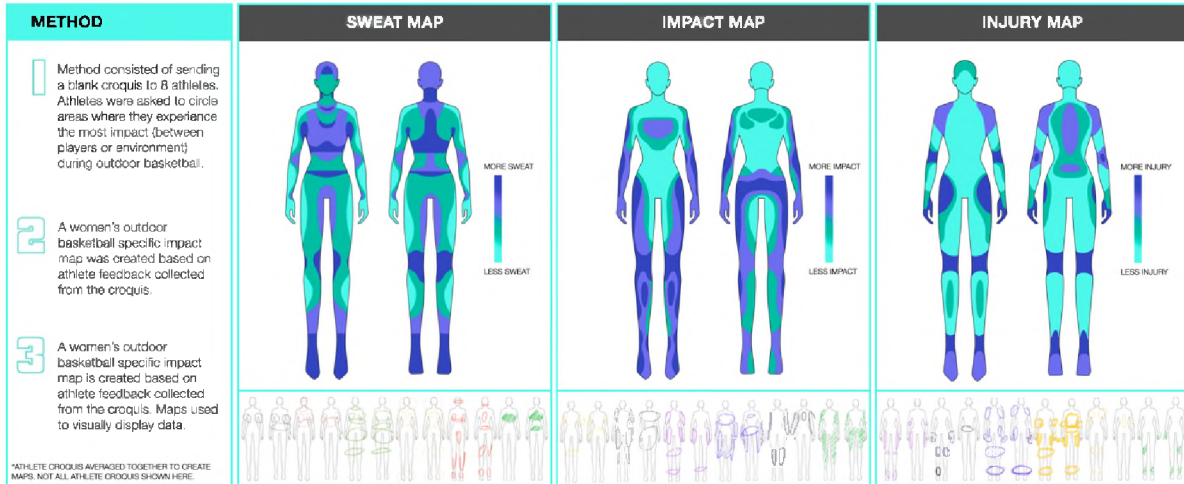
**THERMOREGULATION**

- 1 Line up fabric swatch with air pressure and in front of wind strips.
- 2 Blow air through fabric for 5 seconds.
- 3 Use videography to determine amount of movement by wind strips for baseline textiles.



**PERFORMANCE TESTING**

APPAREL DATA MAPS



**PERFORMANCE TESTING**

FOOTWEAR WEAR MAPS



Appendix F – Product Testing and Design Development



SPD 668

EMILY GUERRA



EMILY GUERRA



**MY PASSION AS A SPORTS PRODUCT INNOVATOR IS TO DESIGN SOLUTIONS THAT MAXIMIZE ATHLETE PERFORMANCE AND HEALTH WHILE CHALLENGING THE STATUS QUO FOR THE FUTURE OF FOOTWEAR AND APPAREL.**



Having vast experience in sport and rehabilitation has allowed me to witness first-hand the inequalities in men's and women's sports all the way up to the college level not only in opportunity but product as well. Being a female athlete has taught me a lot about teamwork and how to push oneself to challenge what is seen as the limit or "norm".

Goal Post: Graduation: Footwear/Apparel Innovation Design



Pratt Institute / Bachelor of Industrial Design  
University of Oregon / MS Sports Product Design

SPD 668

EMILY GUERRA

**BACKGROUND**



**OVER 100 YEARS, BUT STILL ZERO PRODUCTS**

Due to men not being allowed to see women exercising, schools and universities who had men's and women's teams gave the indoor courts to the men's teams, forcing women to play outdoors.

**415,576**

The number of high school and college level female basketball athletes during the 2018-19 according to the NCAA.

**1,800**

New York City has over 1,800 maintained basketball court across the 5 boroughs and is commonly known as the "Mecca" of basketball due to its rich history of outdoor basketball, or streetball.

Female outdoor basketball athletes are wearing product not built with a performance focus for the outdoor environment, despite there being product lines for both indoor and outdoor versions of other team sports.



SPD 688

EMILY GUERRA

A large graphic with a black background. At the top, there is a stylized, textured representation of a basketball court floor. Below this, the text "WHY ARE THERE NO" is in white, followed by "WOMEN'S" in a large, bold, outlined font. Underneath "WOMEN'S", the words "OUTDOOR BASKETBALL" are in white, and "FOOTWEAR AND APPAREL" is in white. To the right of "FOOTWEAR AND APPAREL" is a large, outlined question mark. A horizontal teal bar is positioned behind the words "OUTDOOR BASKETBALL".

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EMILY GUERRA

HOW CAN WE CREATE INNOVATIVE PERFORMANCE

OUTDOOR BASKETBALL FOOTWEAR AND APPAREL

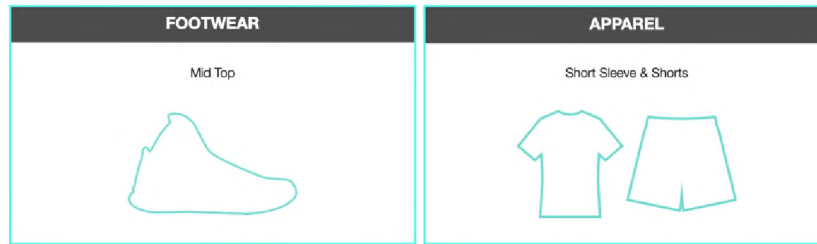
FOR **FEMALE ATHLETES** INVESTIGATING  
COURT SURFACE AND DURABILITY?



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**MONARCH COLLECTION**

PRODUCT LINE









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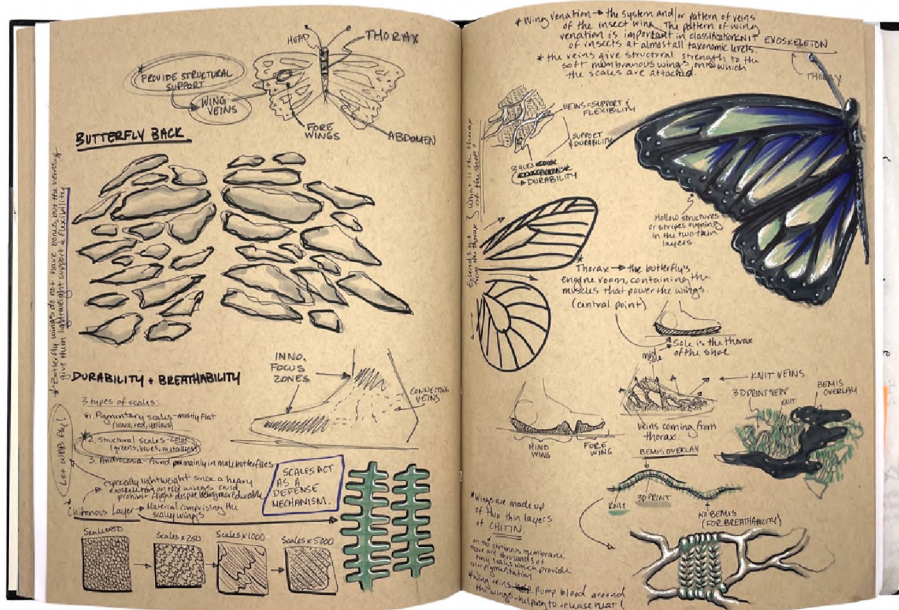
**MONARCH GOALS**

METRICS TO BEAT

 <b>DURABILITY</b>	 <b>FIT</b>	 <b>FLEXIBILITY</b>
 <p><b>10%</b></p> <p><b>PILLING AND FIBER SHEDDING OCCURS AFTER 35 SEC.</b></p> <p>Pilling is the formation of fuzzy balls formed on the surface of fabric due to rubbing or abrasion during wear. It often results in a worn out look.</p>	<p><b>3%</b> OVERALL COMFORT USING FEMALE BASKETBALL ATHLETE FOOT SCAN AND ANSUR DATA MEASUREMENTS.</p>	<p><b>3%</b> PEAK FORCE TO 90 DEGREES IS 24-36 NEWTONS.</p>
 <b>MOBILITY</b>	 <b>THERMOREGULATION</b>	<p><b>3%</b> APPAREL MEETS DURABILITY REQUIREMENTS WHILE STAYING BREATHABLE.</p>
<p><b>3%</b></p> <p>STRETCH IN FABRIC IS <math>&gt;0.425"</math> FROM THE 2" STRETCH ZONE.</p>	<p><b>3%</b></p>	<p><b>3%</b></p>

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**FUNCTIONAL DIRECTION**

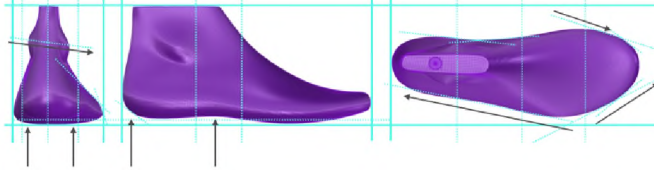


**LAST DESIGN**

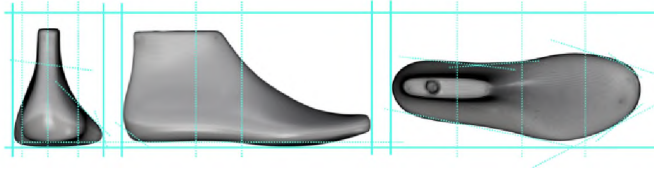
FOOTWEAR

ANSUR DATA V. MONARCH LAST		
FOOT LENGTH / MEAN=9.7"	9.875"	MAX=11.28"
MIN=7.8"		
BALL OF FOOT LENGTH (TO HEEL) / MEAN=7.17"	7.4"	MAX=8.5"
MIN=5.94"		
BALL OF FOOT CIRCUMFERENCE / MEAN=8.98"	8.65"	MAX=10.63"
MIN=7.64"		
FOOT BREADTH (HORIZONTAL) / MEAN=3.65"	3.38"	MAX=4.25"
MIN=3.03"		
HEEL BREADTH / MEAN=2.54"	2.8"	MAX=3.5"
MIN=2.09"		
LATERAL MALLEOLUS HEIGHT / MEAN=2.47"	2.6"	MAX=3.11"
MIN=1.69"		

MONARCH LAST



MEN'S BASKETBALL LAST

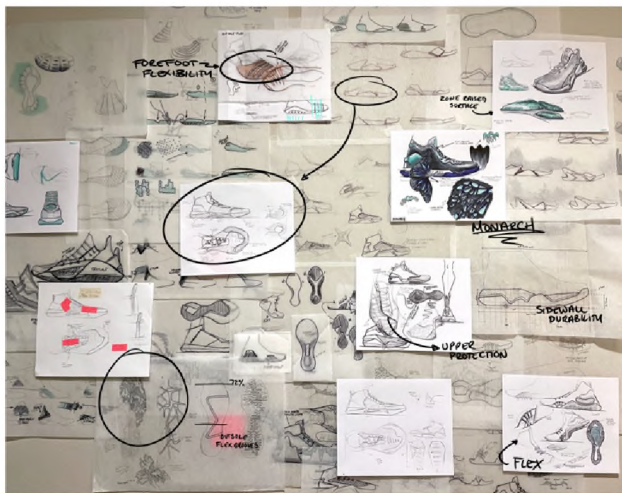


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**IDEATION**

FOOTWEAR



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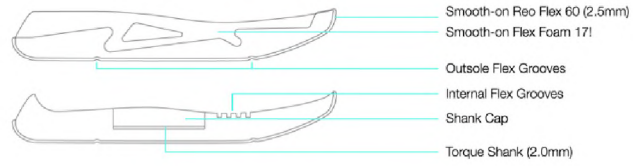
EMILY GUERRA



**PERFORMANCE TESTING**

FOOTWEAR FLEXIBILITY

RESULTS	
Right 01	27.0 N
Right 02	26.6 N
Right 03	25.6 N
Right 04	26.1 N
Right 05	25.2 N
Average	26.1 N

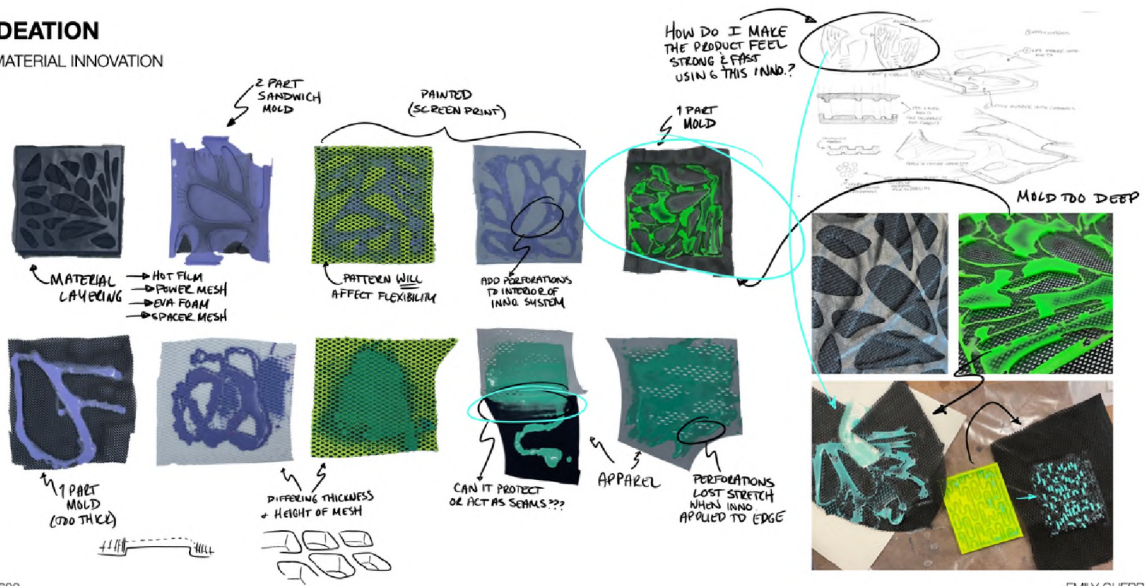


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**IDEATION**

MATERIAL INNOVATION




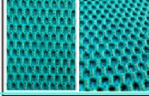

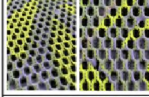




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**PERFORMANCE TESTING**

FOOTWEAR/APPAREL DURABILITY

MATERIAL (0 s)	10 s	20 s	30 s	40 s	50 s	60 s	FINDINGS / DOCUMENTATION
 TPU FILM TPU / POLY MESH / EVA FOAM							 <ul style="list-style-type: none"> <li>- Mesh failed ~40 sec.</li> <li>- High wear on TPU film.</li> </ul>
 URETHANE RUBBER POLY MESH KNT / REC.FLIX 60							 <ul style="list-style-type: none"> <li>- Slight pilling occurred ~50 sec. where rubber thins.</li> </ul>
 NERVURE TECH SILICONE POLY MESH KNT / SILICONE RUBBER							 <ul style="list-style-type: none"> <li>- Pilling occurred ~40 sec.</li> <li>- Silicone rubber wore away more than urethane rubber.</li> </ul>
 POLY NERVURE KNT 100% POLYESTER / SMOOTH ON							 <ul style="list-style-type: none"> <li>- No noticeable pilling.</li> <li>- Slight wear in silicone rubber.</li> </ul>

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**IDEATION**

APPAREL

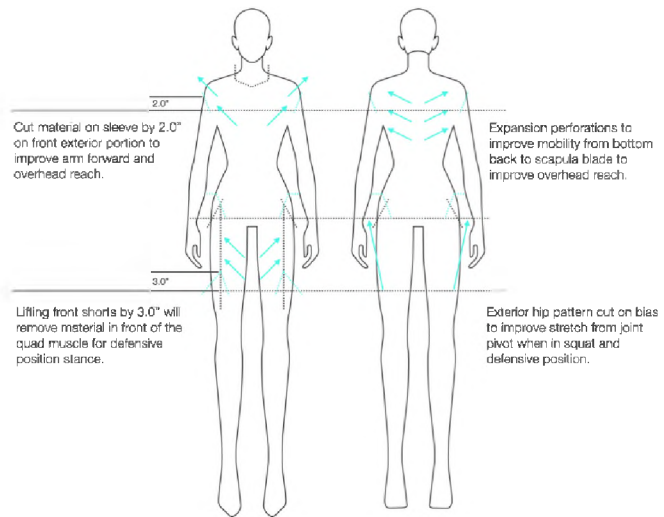
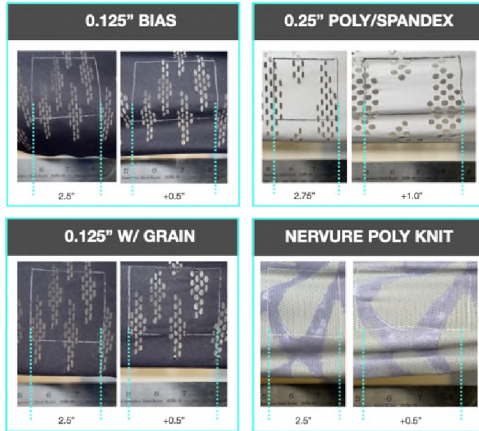


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**PERFORMANCE TESTING**

APPAREL MOBILITY

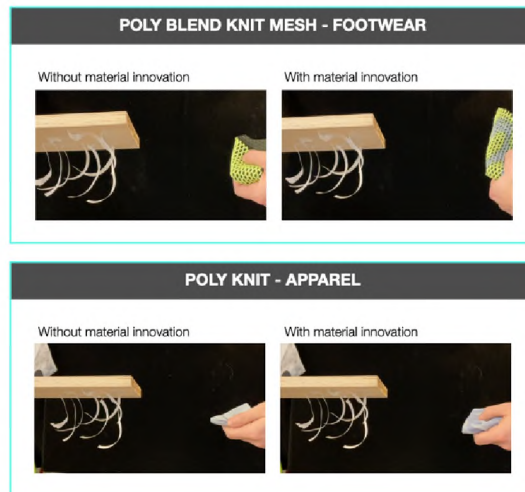
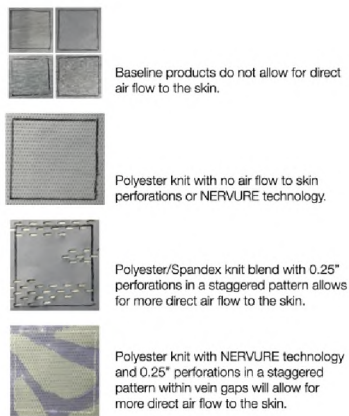


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**PERFORMANCE TESTING**

APPAREL THERMOREGULATION

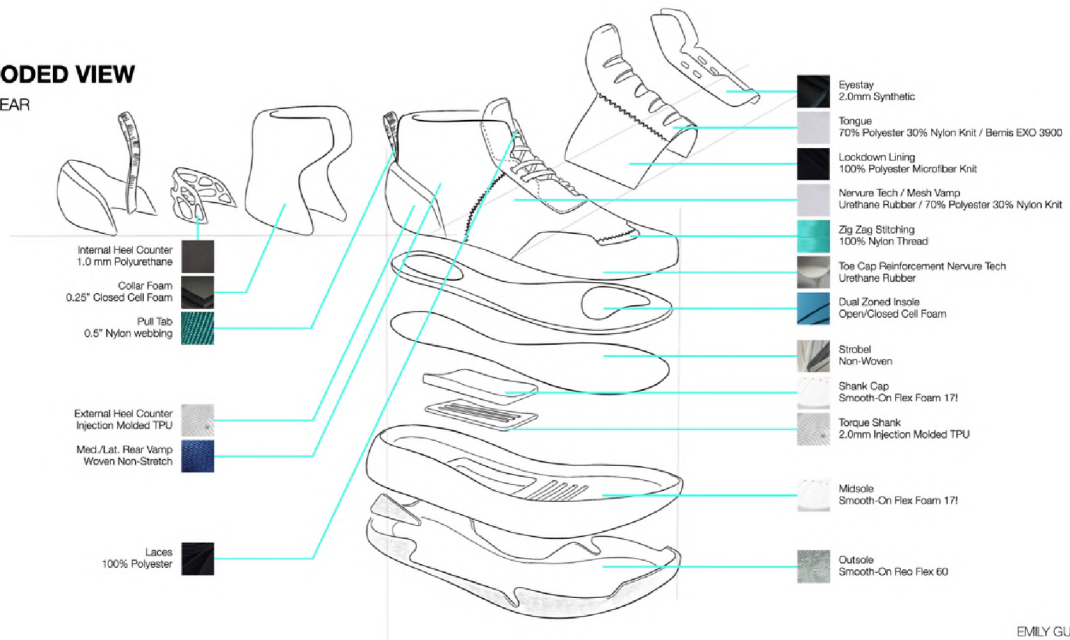


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**EXPLODED VIEW**

FOOTWEAR

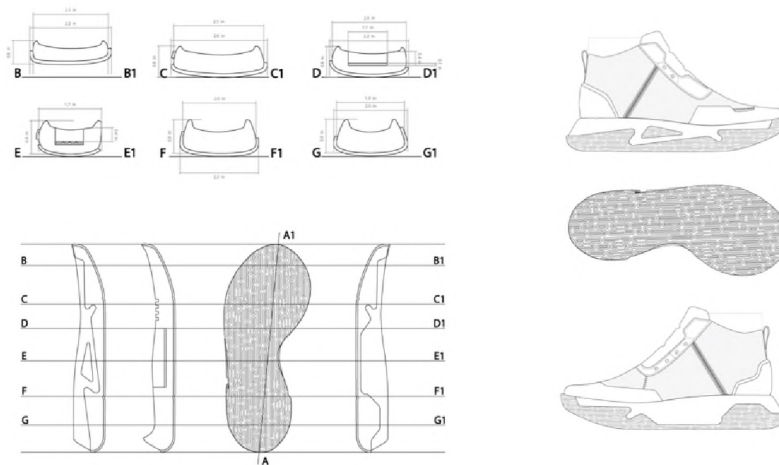


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**TECH PACK**

FOOTWEAR



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**TECH FLATS**

APPAREL








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**MONARCH TECHNOLOGIES**

FOOTWEAR/APPAREL

 <p><b>NERVURE TECH</b></p> <p>Technology using rubberized print integrated into material to provide lightweight, breathable durability.</p>	 <p><b>TRIFIT</b></p> <p>Last design based on female basketball athlete foot scans and ANSUR Research Data measurements to provide an overall more comfortable fit.</p>	 <p><b>REFLEX</b></p> <p>Midssole and outsole flexibility technology built to the female athlete's game so she can stay quick on her feet ready for any rebound or lay-up opportunity.</p>
	 <p><b>MOVE2</b></p> <p>Patterning and removal of material in zoned locations based on female outdoor basketball movements.</p>	 <p><b>THERMOZONE</b></p> <p>Durable breathability technology zoned to the specifications of the female athlete and outdoor game.</p>

SPD 688

EMILY GUERRA



Appendix G – Final Midterm



## ENVIRONMENT

LOCATION: NEW YORK CITY

SEASON: SPRING/FALL




## THE ATHLETE

- FEMALE ATHLETE / AGE 15-21
- HIGH SCHOOL LEVEL
- POINT GUARD / SHOOTING GUARD
- LOOKING TO GET RECRUITED FOR COLLEGE LEVEL
- USES OUTDOOR COURTS AND LEAGUES AS OFF-SEASON TRAINING
- TAKES SUBWAY TO COURTS IN 5 BOROUGHES

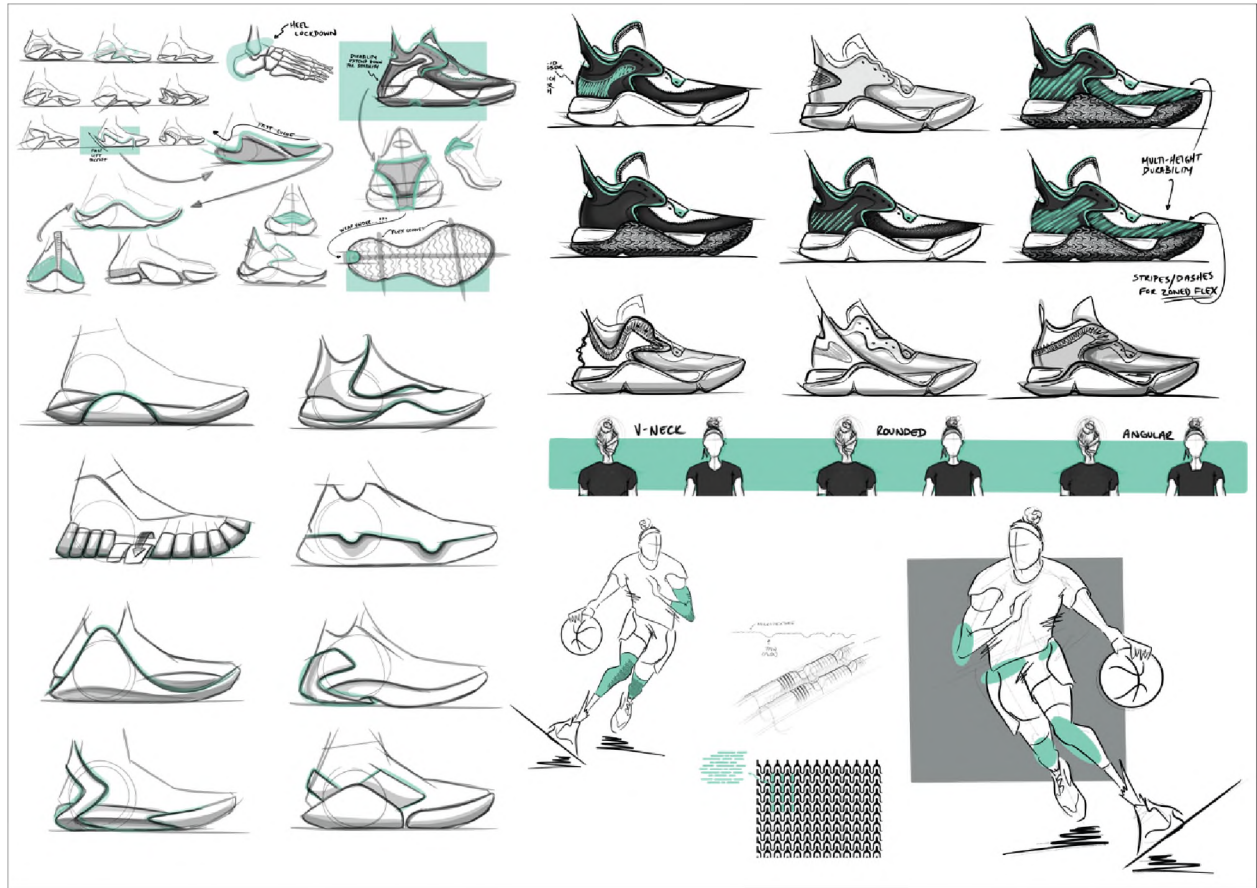


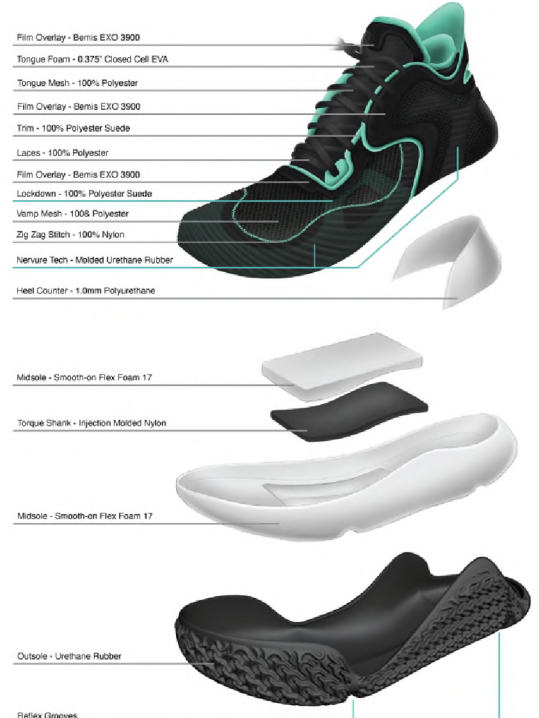
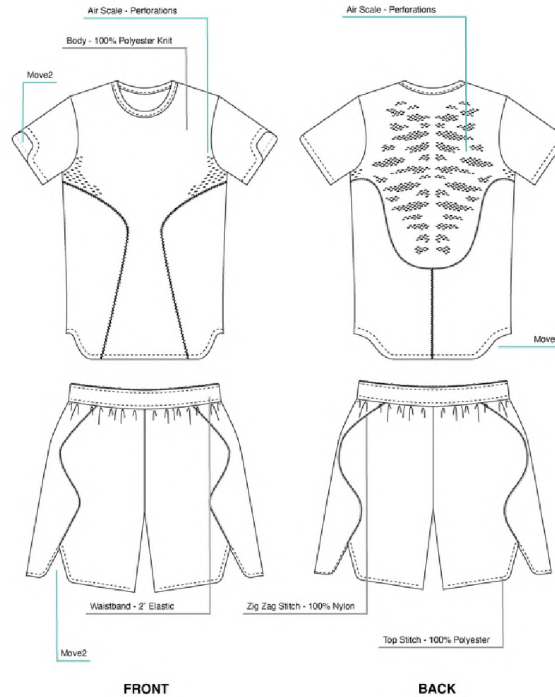
CONTEXT



<p><b>FOOTWEAR</b></p> 	<b>ATTRIBUTES</b>	<p><b>FIT</b></p> <p>Last design based on female basketball athlete foot scans and ANSUR Research Data measurements to provide an overall more comfortable fit for improved lockdown.</p>	<p><b>FLEXIBILITY</b></p> <p>Midssole and outsole flexibility technology built to the female athlete's game so she can stay quick on her feet ready for any rebound or lay-up opportunity.</p>	<p><b>DURABILITY</b></p> <p>Textile protection from environmental abrasion based on women's outdoor basketball footwear long term wear pattern maps created from photo documentation from female athletes.</p>
	<b>TECHNOLOGIES</b>	<p><b>MONARCH LAST</b></p>  <ul style="list-style-type: none"> <li>- Narrower forefoot</li> <li>- Lower midfoot height</li> <li>- Higher and more sensitive arch</li> <li>- Shorter 5th met. to heel length</li> <li>- Narrower heel</li> <li>- Lower Metatarsal height</li> </ul>	<p><b>REFLEX</b></p> <p>Outsole flex channels targeting forefoot and heel flexibility in forward/backward movements and medial and lateral flex channels targeting movement in horizontal directions.</p>	<p><b>NERVURE TECH</b></p> <p>Technology using rubberized print integrated into material to provide lightweight, breathable durability and stability.</p>
<p><b>APPAREL</b></p> 	<b>ATTRIBUTES</b>	<p><b>MOBILITY</b></p> <p>Increased ease of movement in zoned locations based on female outdoor basketball movements.</p>	<p><b>BREATHABILITY</b></p> <p>Breathability zones based on women's outdoor basketball specific sweat maps collected from female athletes.</p>	<p><b>DURABILITY</b></p> <p>Textile protection from environmental abrasion based on women's outdoor basketball apparel long term wear pattern maps created from photo documentation from female athletes.</p>
	<b>TECHNOLOGIES</b>	<p><b>MOVE2</b></p> <p>Patterning and removal of material in shoulders, back, hip, and quad locations based on female outdoor basketball movements.</p>	<p><b>AIR SCALE</b></p> <p>Larger ratio of direct air flow to the skin based on women's outdoor basketball specific sweat maps collected from female athletes.</p>	<p><b>NERVURE TECH</b></p> <p>Technology using rubberized print integrated into material to provide lightweight, breathable durability and stability.</p>





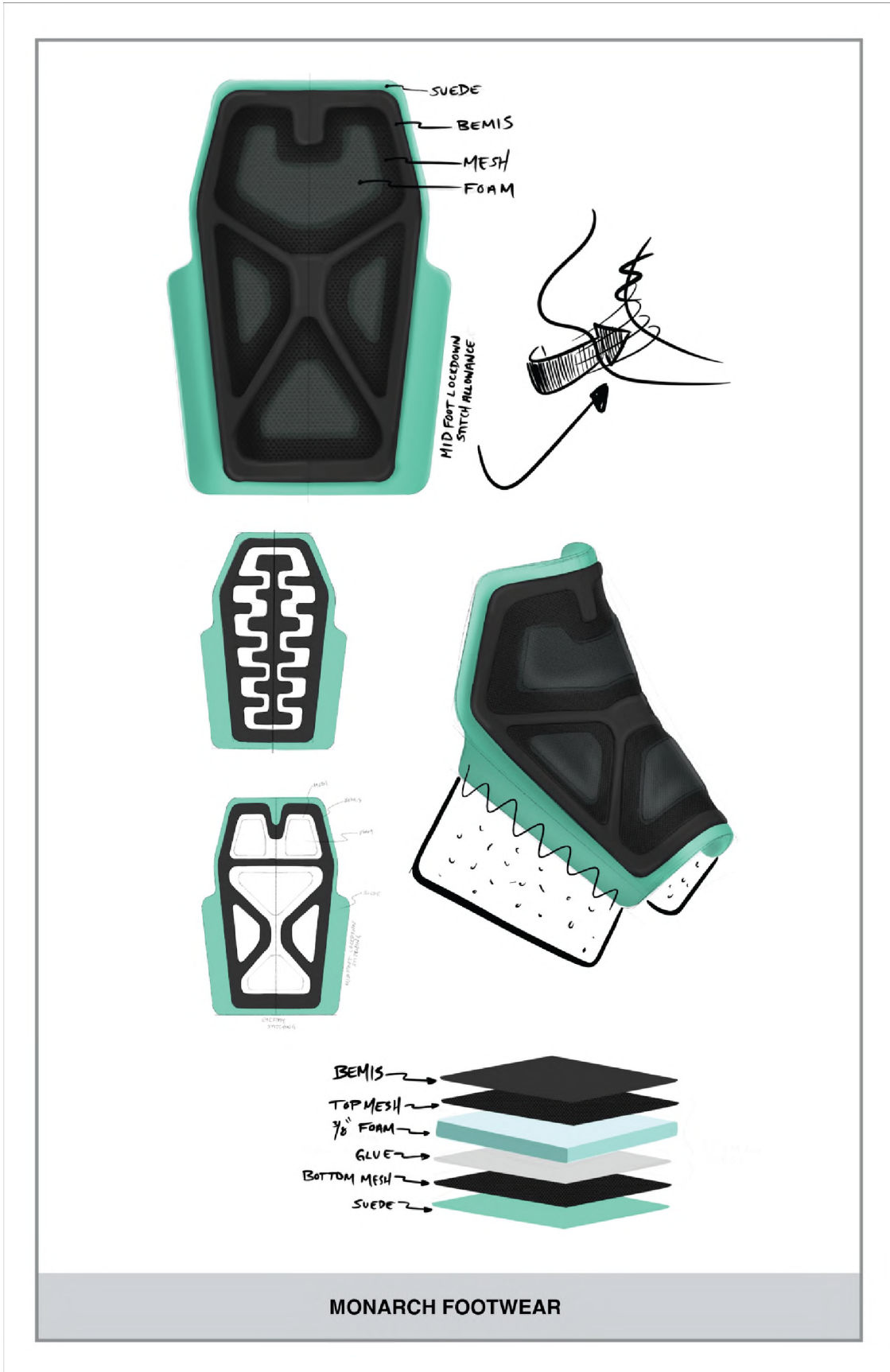
 <p>Film Overlay - Bemis EXO 3900</p> <p>Tongue Foam - 0.375" Closed Cell EVA</p> <p>Tongue Mesh - 100% Polyester</p> <p>Film Overlay - Bemis EXO 3900</p> <p>Trim - 100% Polyester Suede</p> <p>Laces - 100% Polyester</p> <p>Film Overlay - Bemis EXO 3900</p> <p>Lockdown - 100% Polyester Suede</p> <p>Vamp Mesh - 100% Polyester</p> <p>Zig Zag Stitch - 100% Nylon</p> <p>Neuville Tech - Molded Urethane Rubber</p> <p>Heel Counter - 1.0mm Polyurethane</p> <p>Midsole - Smooth-on Flex Foam 17</p> <p>Torque Shank - Injection Molded Nylon</p> <p>Midsole - Smooth-on Flex Foam 17</p> <p>Outsole - Urethane Rubber</p> <p>Relief Grooves</p>	 <p>Air Scale - Perforations</p> <p>Body - 100% Polyester Knit</p> <p>Move2</p> <p>Air Scale - Perforations</p> <p>Move2</p> <p>Wastband - 2" Elastic</p> <p>Zig Zag Stitch - 100% Nylon</p> <p>Top Stitch - 100% Polyester</p> <p>Move2</p> <p><b>FRONT</b></p> <p><b>BACK</b></p>
<p><b>MONARCH FOOTWEAR</b></p>	<p><b>MONARCH APPAREL</b></p>

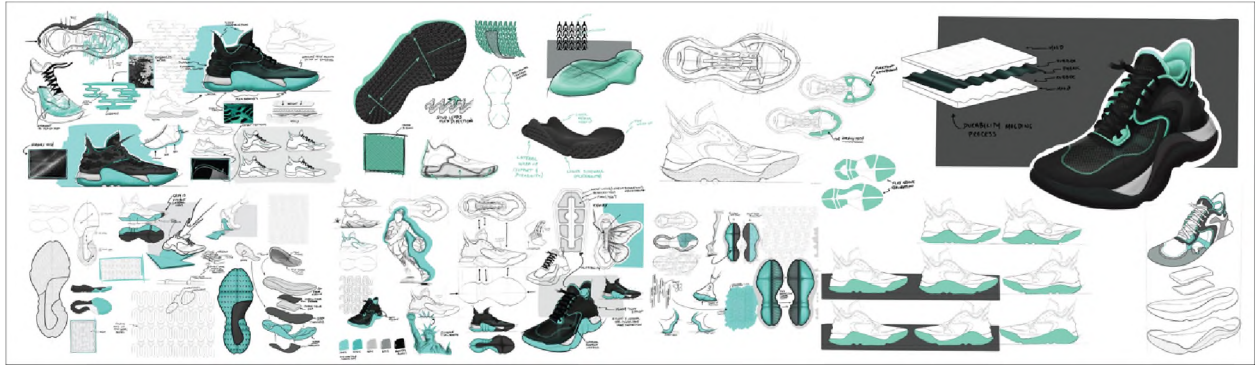


**FEATURES & BENEFITS**

1. NERVURE TECH- Textile durability in lateral/medial forefoot and heel.
2. LOCKDOWN- 3 point lockdown in forefoot, midfoot, and heel with additional heel stability feature with Nervure Tech.
3. FLEX- Zoned Nervure Tech for directional textile flexibility and concaved outsole flex grooves in forefoot, heel, and midfoot.
4. Mid height upper for ankle stability.
5. Breathable, cushioned tongue allowing for flexibility when in motion.
6. Stud/herringbone traction pattern for multi-directional movement on concrete surface.
7. Integrated pull tab for pull across entire heel.
8. Raised outsole sides for stability and durability on concrete surface.

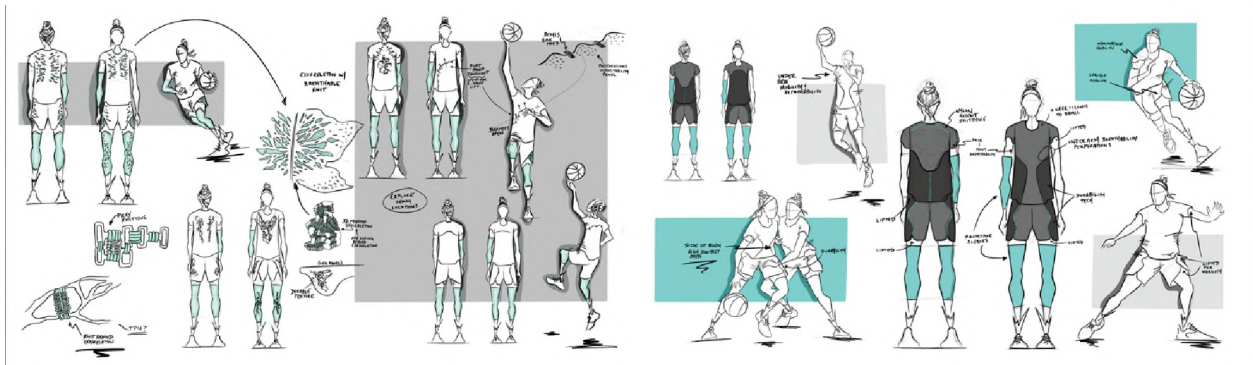
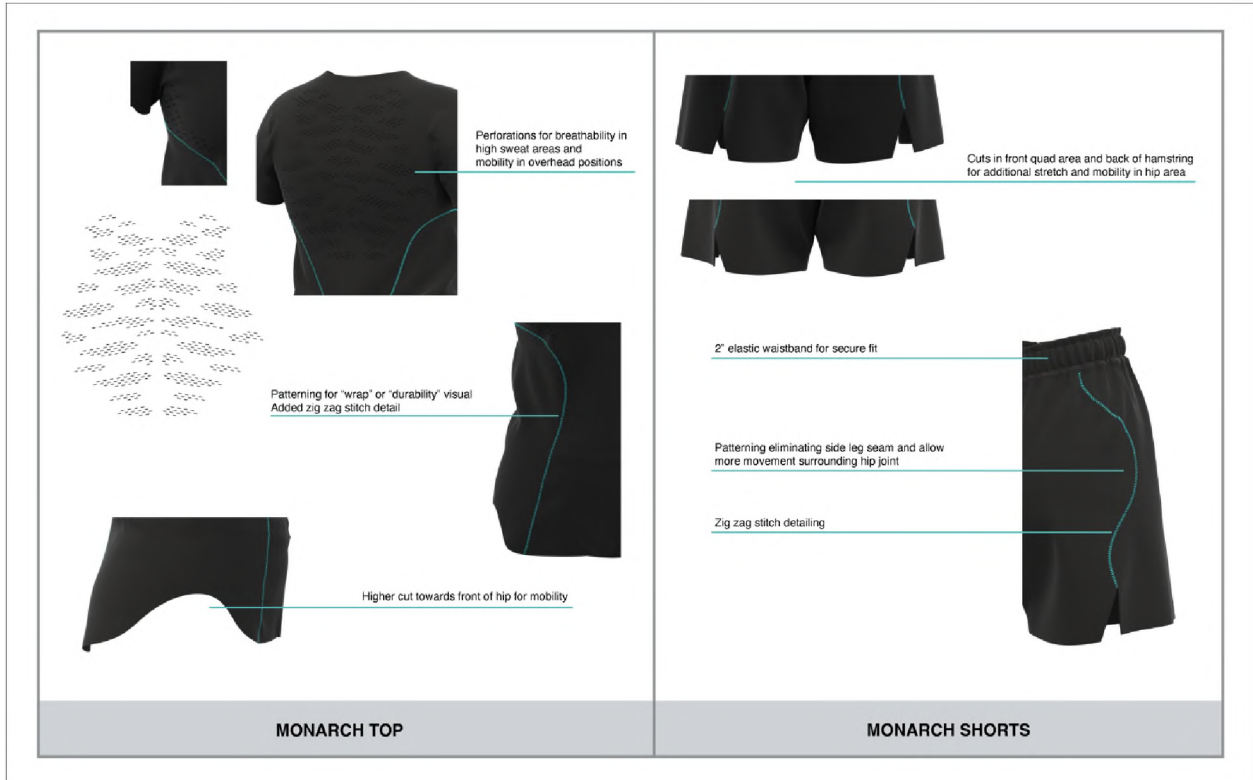
MONARCH FOOTWEAR



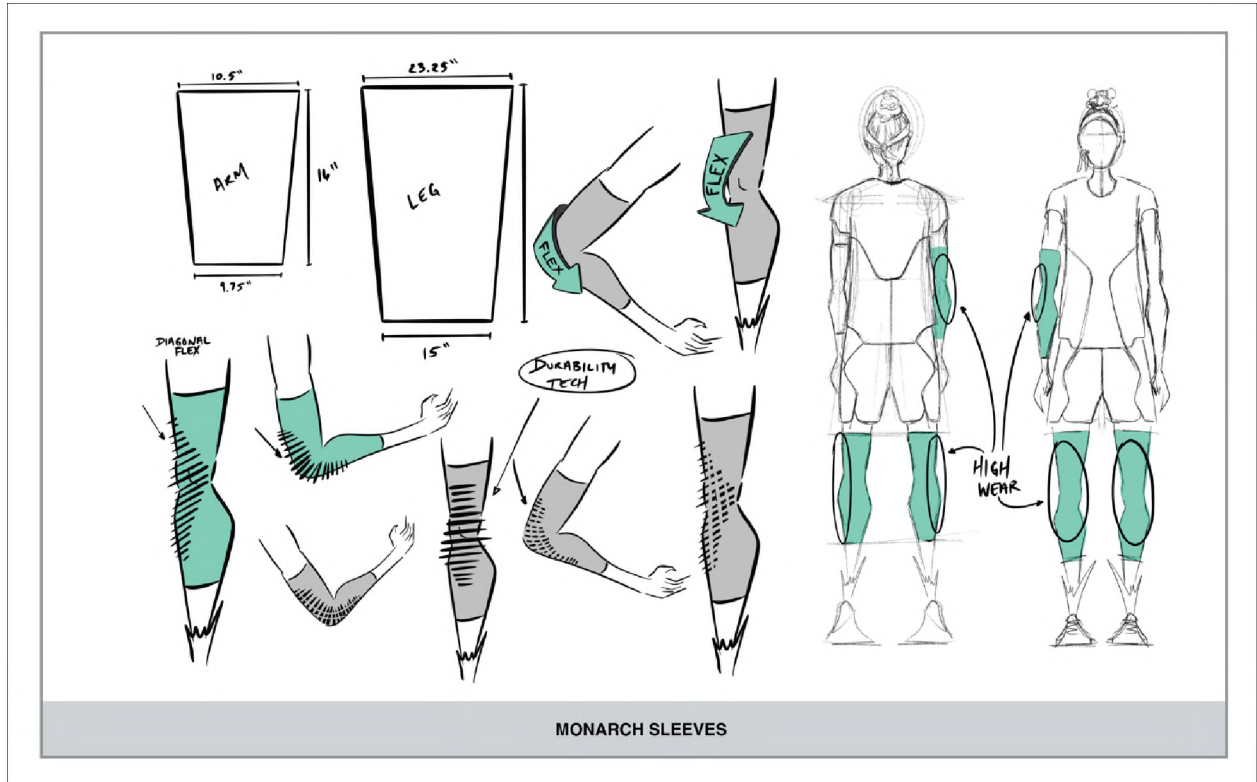




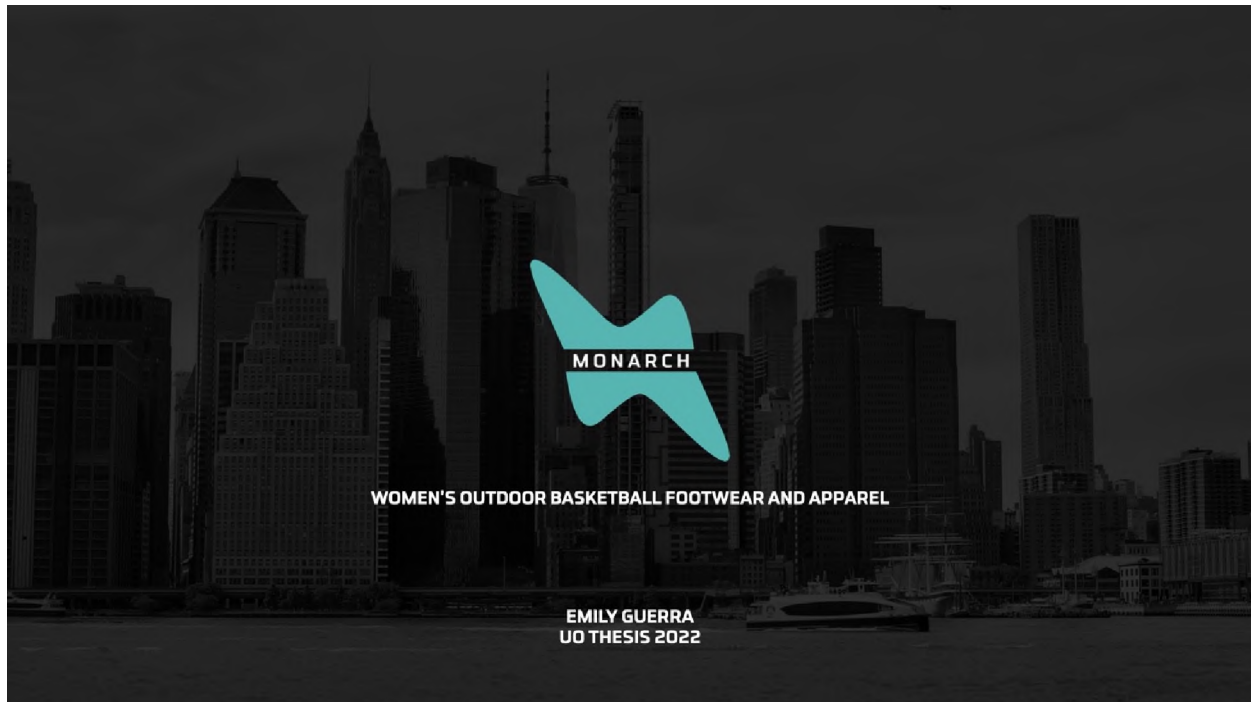








## Appendix H – Final Presentation



### EMILY GUERRA

**MY PASSION AS A SPORTS PRODUCT INNOVATOR IS TO DESIGN SOLUTIONS THAT MAXIMIZE ATHLETE PERFORMANCE AND HEALTH WHILE CHALLENGING THE STATUS QUO FOR THE FUTURE OF FOOTWEAR AND APPAREL.**

Having experience in sport and rehabilitation has allowed me to witness first-hand the inequalities in men's and women's sports all the way up to the college level not only in opportunity but product as well. Being a female athlete has taught me a lot about teamwork and how to push oneself to challenge limitations.



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**1893**

Women have been playing basketball outdoors for over 100 years.

**415,576**

The number of high school and college level female basketball athletes during the 2018 -19 season according to the NCAA.

**500**

Approx. number of outdoor courts across NYC's 5 boroughs.

WHY ARE THERE FEW **Women's** **?**

**OUTDOOR BASKETBALL FOOTWEAR AND APPAREL OPTIONS**



**WEATHER VARIATIONS**

HEAT AND RAIN BECOME FACTORS PLAYERS  
NEED TO WATCH OUT FOR

**VARYING SURFACES**

COURTS MAY VARY BETWEEN SLICK AND ROUGH  
SURFACE TRACTION

**UNEVEN SURFACES**

SURFACE IMPERFECTIONS CAN DIFFER BETWEEN  
BASE LINES





ATHLETE



TYPE OF SHOE

- HIGH TOP
- MID TOP
- LOW TOP



WHAT ADDITIONAL EQUIPMENT DO YOU WEAR?

- KNEE PADS/SLEEVE
- SHOOTING SLEEVE
- ANKLE BRACES

ARE DIFFERENT SHOES NECESSARY FOR OUTDOOR BASKETBALL?

- "Never wear your indoor shoes outdoors because you will wreck the indoor floor and your shoes."
- "Yes because the bottoms would get worn out much quicker on a concrete or pavement surface than indoors, also for indoors they need to stick to the ground well and not be slippery."
- "Yes, for the different surfaces of the ground."
- "Not really, I wear running sneakers if I'm outdoors so I don't ruin my pair of basketball sneakers."
- "Outdoor shoes need to be more durable and more cushioned."

“ THE COURT, ENERGY, GAME... EVERYTHING JUST FEELS DIFFERENT ”



USER INSIGHTS

27	PARTICIPANTS
18-24	AVG. AGE
9	AVG. W. SHOE SIZE
5'7"	AVG. HEIGHT



“THE COURT, ENERGY, GAME... EVERYTHING JUST FEELS DIFFERENT”

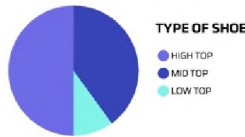


80%

OF ATHLETES SAID THEY EXPERIENCED A LOWER/UPPER LIMB INJURY.

FASTER PACED GAME WITH MORE OFFENSIVE TOUCHES BUT YOU STILL PLAY CONSERVATIVELY TO NOT SLIP OR HIT THE GROUND TOO HARD.

FOOTWEAR USER INSIGHTS

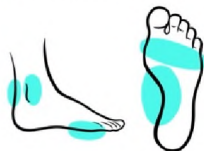


“THERE IS ONLY LIKE 1 PAIR THAT EXISTS”

90%

WHERE?

OF ATHLETES EXPERIENCE PAIN DURING/AFTER SPORT BECAUSE OF THEIR FOOTWEAR

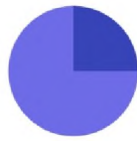


- 1 AESTHETICS
- 2 BREATHABILITY
- 3 FIT/SIZING
- 4 DURABILITY

ARE DIFFERENT SHOES NECESSARY FOR OUTDOOR BASKETBALL?

- “Never wear your indoor shoes outdoors because you will wreck the indoor floor and your shoes.”
- “Yes because the bottoms would get worn out much quicker on a concrete or pavement surface than indoors, also for indoors they need to stick to the ground well and not be slippery.”
- “Yes, for the different surfaces of the ground.”
- “Not really, I wear running sneakers if I'm outdoors so I dont ruin my pair of basketball sneakers.”
- “Outdoor shoes need to be more durable and more cushioned.”

APPAREL USER INSIGHTS



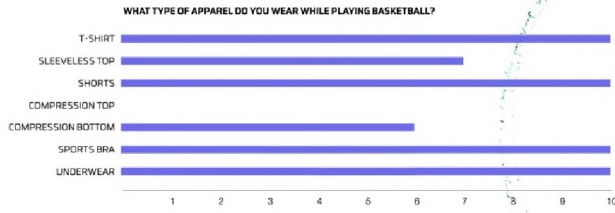
DO YOU WEAR BRACES OR ADDITIONAL EQUIPMENT?  
 YES  
 NO



WHAT ADDITIONAL EQUIPMENT DO YOU WEAR?  
 KNEE PADS/SLEEVE  
 SHOOTING SLEEVE  
 ANKLE BRACES



DO YOU WEAR DIFFERENT APPAREL FOR DIFFERENT GAME STYLES?  
 YES  
 NO



- 1 MOBILITY
- 2 FIT/SIZING
- 3 LIGHTWEIGHT
- 4 BREATHABILITY

I LIKE THE PROPRIOCEPTION OF COMPRESSION SHORTS, BUT WEAR SHORTS ON TOP FOR MORE COVERAGE

FOOTWEAR BASELINE

Baseline products chosen based on user insight results

- 1 UA FLOW BREAKTHRU 2 \$119.99 / W8.5
- 2 NIKE AIR ZOOM G.T. RUN \$165.97 / M7 (W8.5)
- 3 ADIDAS EXHIBIT A CANDACE PARKER \$109.99 / W8.5



- Breathable engineered mesh upper strategically supported by no-sew films for enhanced comfort & flex.
- Women's-specific build with half-booster & molded collar for incredible fit & anatomically correct support.
- External TPU wing for heel lockdown & lateral containment.
- UA Flow cushioning technology is super-light, bouncy & provides insane grip.
- Proprietary, 3D-molded TPE-blend sockliner with low compression set for energy return & longevity.



- Nike React technology for an extremely smooth ride.
- The 2-layer upper is made with lightweight mesh for a broken-in feel and a textured haptic print layer for extra durability.
- The thin rubber outsole has curvy ridges that bend and flex to provide traction in multiple directions.
- Rubber is cut away under the arch and perforated to help reduce weight.
- Foam tongue molds to your foot to help reduce lace pressure.



- Regular fit for comfort.
- Lace closure for secure lockdown.
- Lightstrike midsole for smooth cushioned feel underfoot.
- Rubber outsole for traction.
- Textile upper with durable and supportive overlays for durability.



APPAREL BASELINE

Baseline products chosen based on user insight results

<p>1 NIKE DRI-FIT LEGEND T-SHIRT \$25.00 / MEDIUM</p>	<p>2 NIKE TEMPO SHORTS \$30.00 / MEDIUM</p>	<p>3 UA LOCKER T-SHIRT \$25.00 / MEDIUM</p>	<p>4 UA PLAYUP SHORTS 3.0 \$25.00 / MEDIUM</p>
			
<ul style="list-style-type: none"> <li>- Dri-FIT technology helps keep you dry and comfortable.</li> <li>- Odor-resistant finish helps the shirt stay fresh.</li> <li>- Standard fit for a relaxed, easy feel.</li> <li>- 100% polyester</li> </ul>	<ul style="list-style-type: none"> <li>- Lightweight woven fabric feels smooth as you run.</li> <li>- Curved mesh on the sides increases your airflow, helping you stay cool and mobile.</li> <li>- Elastic waistband with an internal drawcord gives a personalized fit.</li> <li>- 100% polyester</li> </ul>	<ul style="list-style-type: none"> <li>- UA Tech fabric quick-dry, ultra-soft for comfort</li> <li>- Material wicks sweat and keeps athlete dry.</li> <li>- Anti-odor tech to prevent growth of odor-causing microbes.</li> <li>- 100% polyester</li> </ul>	<ul style="list-style-type: none"> <li>- Soft, lightweight knit construction for comfort and breathability.</li> <li>- Material wicks sweat and keeps athlete dry.</li> <li>- Anti-pill/anti-pick finish for extra durability.</li> <li>- 100% polyester</li> </ul>

PERFORMANCE TESTING

SCORES OUT OF 7			
	UA Flow Breakthru 2	Adidas Exhibit A	Nike Air Zoom GT Run
Comfort	5.7	2.0	5.3
Cushion	6.3	1.0	6.0
Durability	5.7	3.0	5.7
Breathability	5.3	2.3	6.3
Support	5.7	1.0	6.0
Pain Points			
<b>TOTALS</b>	<b>5.74</b>	<b>1.86</b>	<b>5.86</b>

UA FLOW BREAKTHRU 2

"The arch of my foot felt supported. They were very squishy and my foot did not feel like it was suffocating."

"My toes felt like they were sliding forward as I ran around and shuffled/jumped/pivoted despite this being the size I normally wear."

"Very comfortable and supportive. I wouldn't choose these because there are cooler looking shoes out there."

"Cushioned bottom and good flexibility. Soft and cushioned upper part but my toes were a problem."

ADIDAS EXHIBIT A

"Felt like a board under my foot and they were uncomfortable to run in."

"Soles were hard and uncomfortable."

"Not cushioned and low top...wouldn't wear these because I have bad ankles."

"They felt heavy and were stiff so I'd assume they are durable?"

NIKE AIR ZOOM GT RUN

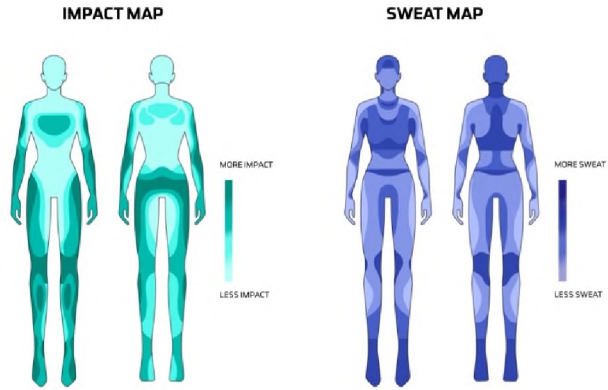
"Very comfortable and supportive. It felt like I had a bounce to my step as I ran. The arch of my foot felt supported and comfortable."

"They look cool and are preferred size. The only thing I'd say is that the bottom felt hard and around the ankle felt cushioned."

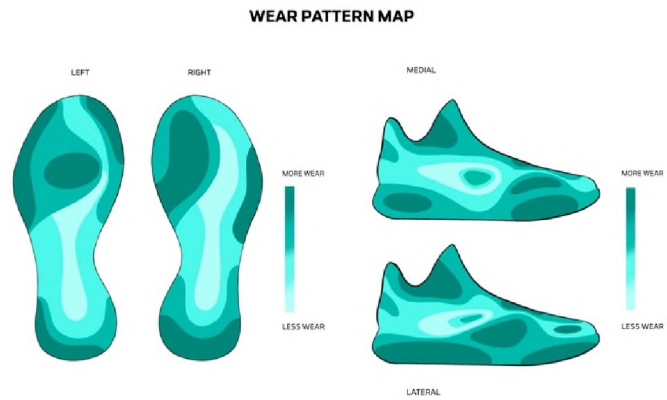
"Cushioned and felt like I was propelling off the ground. I like the height of these shoes. They seem very breathable too."

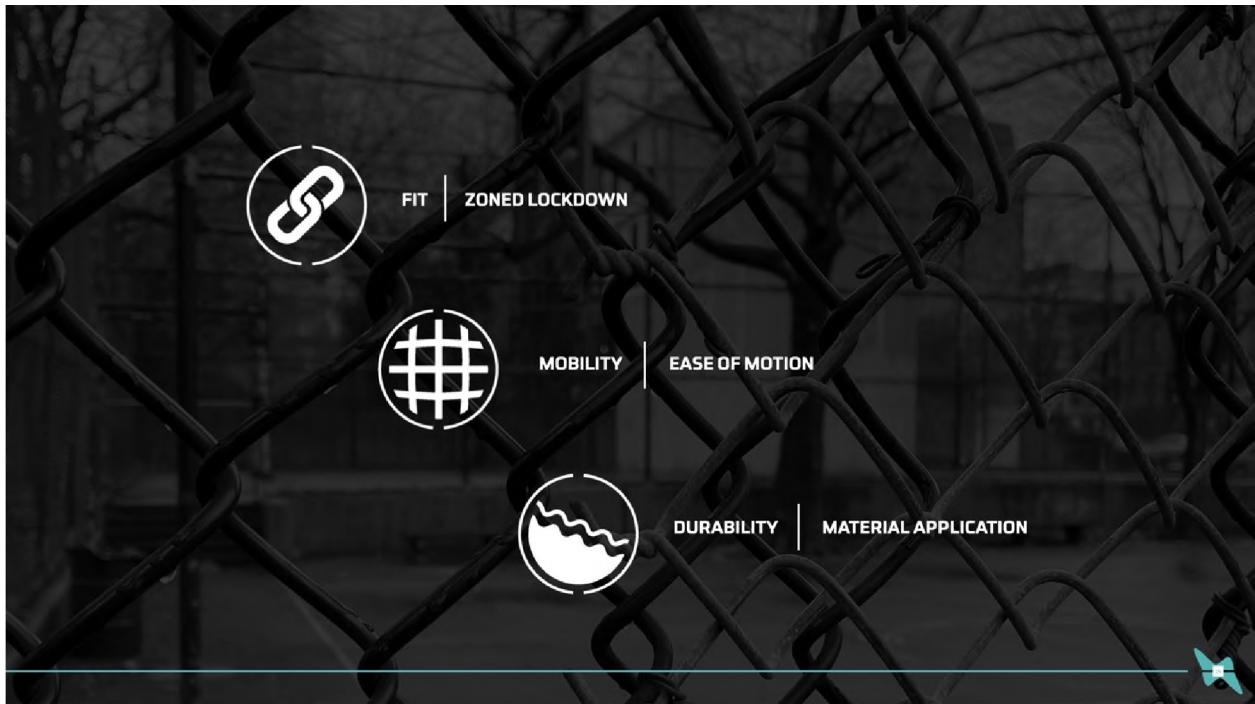
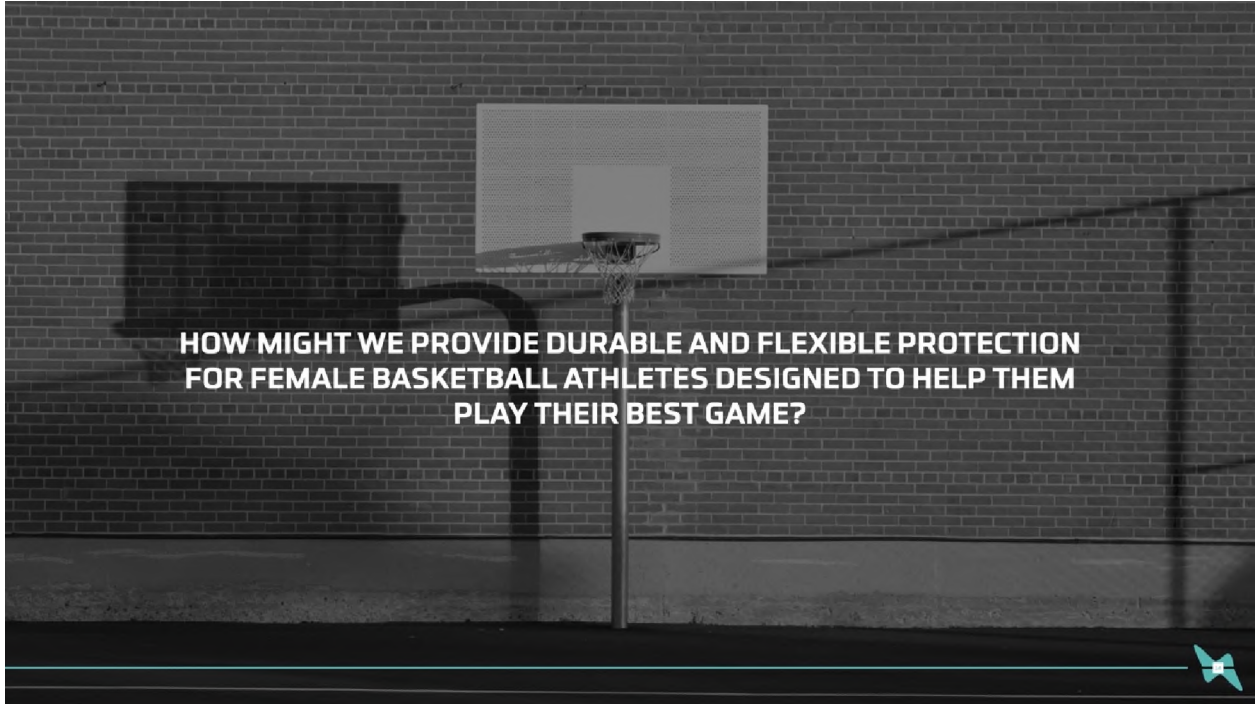


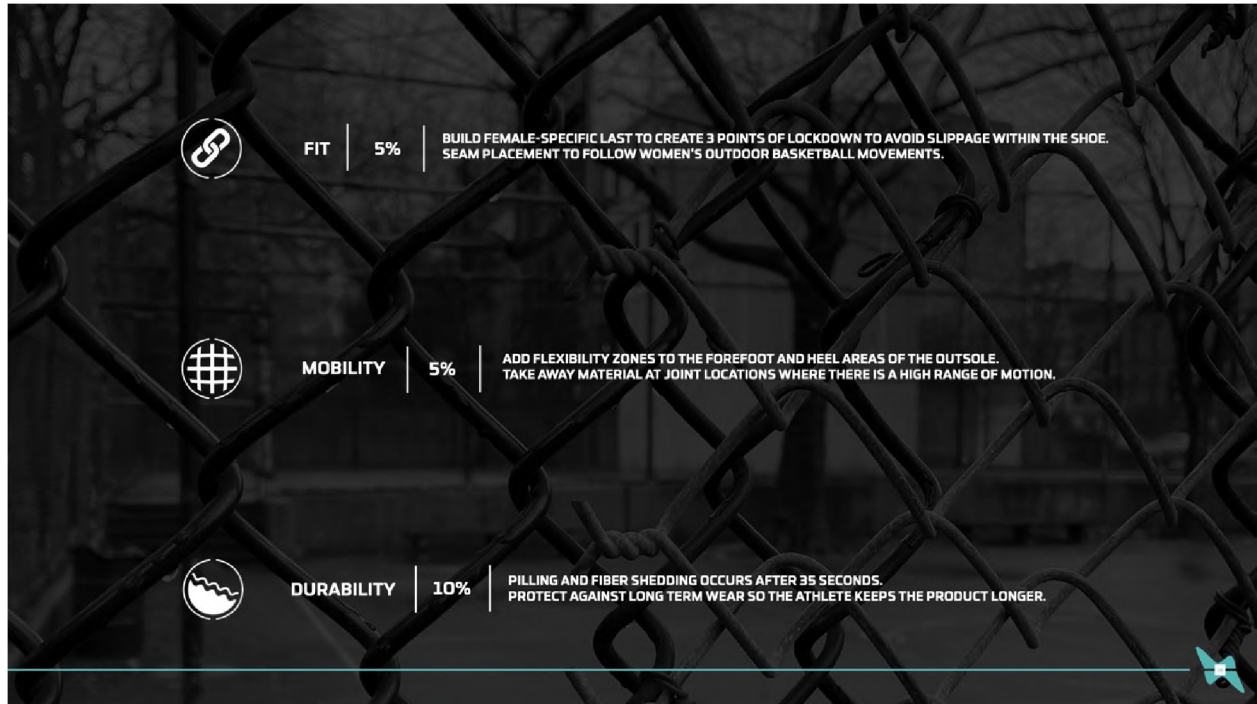
APPAREL RESEARCH



FOOTWEAR RESEARCH



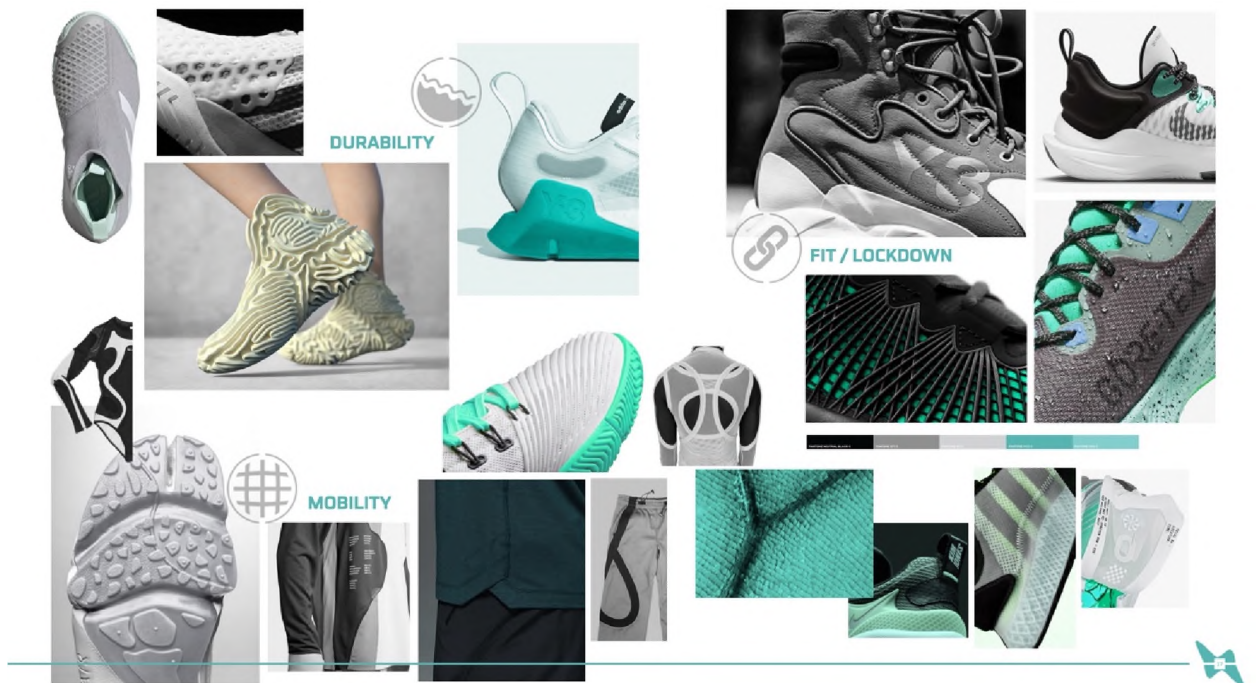




**FIT** | 5% | BUILD FEMALE-SPECIFIC LAST TO CREATE 3 POINTS OF LOCKDOWN TO AVOID SLIPPAGE WITHIN THE SHOE. SEAM PLACEMENT TO FOLLOW WOMEN'S OUTDOOR BASKETBALL MOVEMENTS.

**MOBILITY** | 5% | ADD FLEXIBILITY ZONES TO THE FOREFOOT AND HEEL AREAS OF THE OUTSOLE. TAKE AWAY MATERIAL AT JOINT LOCATIONS WHERE THERE IS A HIGH RANGE OF MOTION.

**DURABILITY** | 10% | PILLING AND FIBER SHEDDING OCCURS AFTER 35 SECONDS. PROTECT AGAINST LONG TERM WEAR SO THE ATHLETE KEEPS THE PRODUCT LONGER.

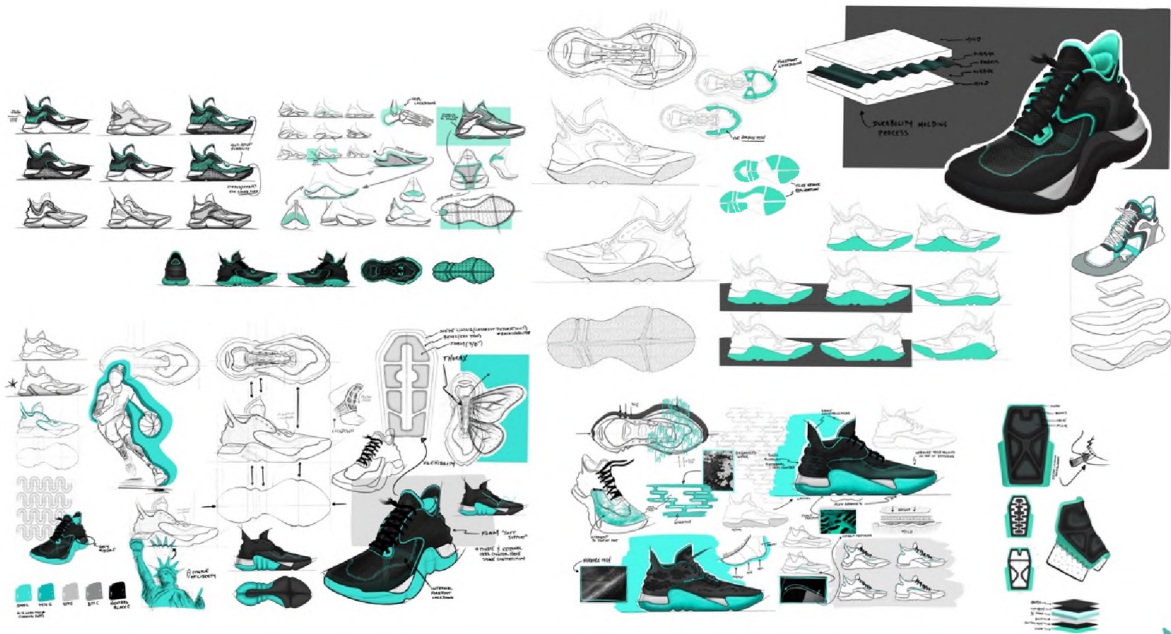
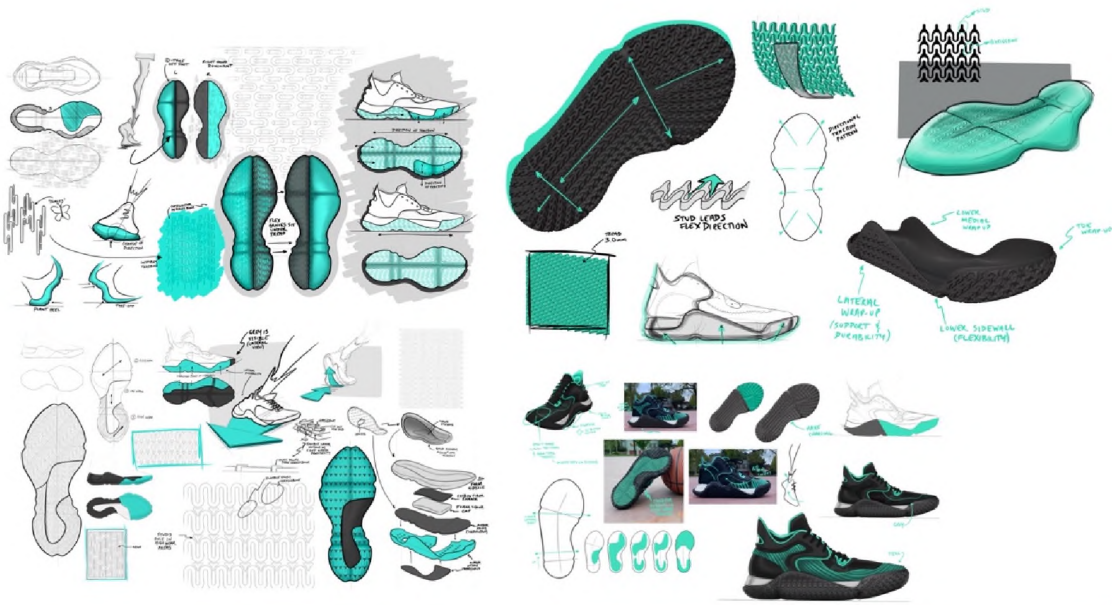


**DURABILITY**

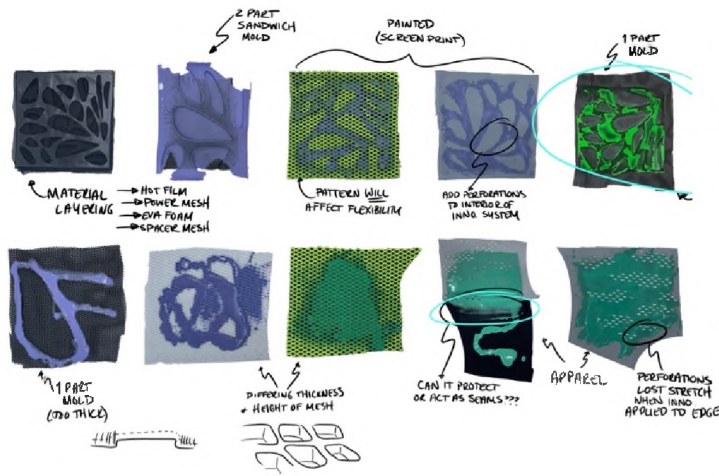
**FIT / LOCKDOWN**

**MOBILITY**





**DURABILITY PROCESS**



**DURABILITY TESTING**

MATERIAL (0 s)	10 s	20 s	30 s	40 s	50 s	60 s	FINDINGS / DOCUMENTATION
 TPU FILM TPU / POLY MESH / EVA FOAM							 - Mesh failed - 40 sec. - High wear on TPU film.
 URETHANE RUBBER POLY MESH KNT / RED FLEX 60							 - Slight pilling occurred - 50 sec. where rubber thins.
 NERVURE TECH SILICONE POLY MESH KNT / SILICONE RUBBER							 - Pilling occurred - 40 sec. - Silicone rubber wore away more than urethane rubber.
 POLY NERVURE KNT 100% POLYESTER / SMOOTH-ON							 - No noticeable pilling. - Slight wear in silicone rubber.



**MONARCH LAST**



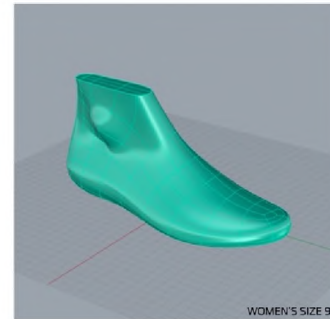
**NARROWER HEEL  
LOWER MALLEOLI HEIGHT**



**NARROWER FOREFOOT  
SHORTER 5TH MET. TO HEEL LENGTH**



**LOWER MIDFOOT HEIGHT  
HIGHER/SENSITIVE ARCH**



WOMEN'S SIZE 9

FOOT LENGTH / MEAN=9.7"  
MIN=7.8" 9.675" MAX=11.28"

BALL OF FOOT CIRCUMFERENCE / MEAN=8.98"  
MIN=7.84" 8.98" MAX=10.63"

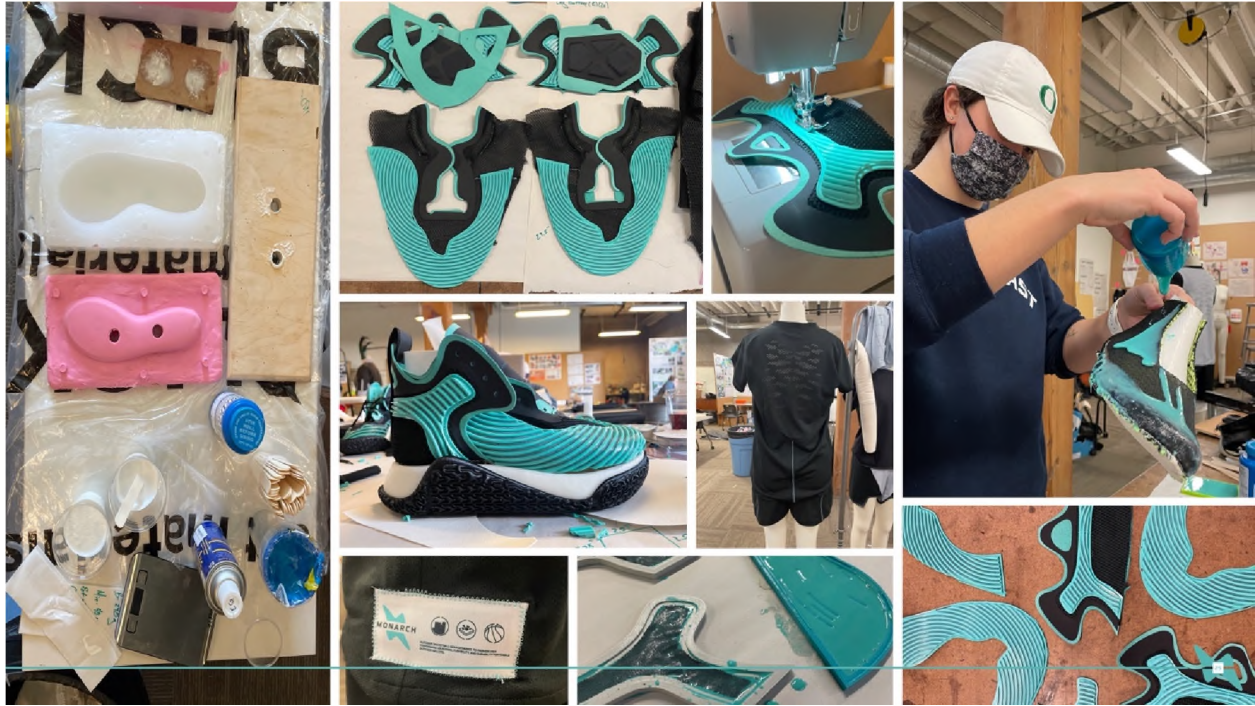
HEEL BREADTH / MEAN=2.64"  
MIN=2.09" 2.6" MAX=3.5"

BALL OF FOOT LENGTH (TO HEEL) / MEAN=7.17"  
MIN=5.94" 7.4" MAX=8.5"

FOOT BREADTH @ HORIZONTAL / MEAN=3.65"  
MIN=3.03" 3.95" MAX=4.25"

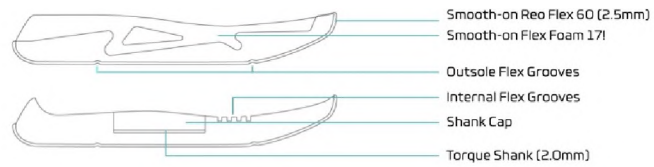
LATERAL MALLEOLUS HEIGHT / MEAN=2.47"  
MIN=1.89" 2.8" MAX=3.11"





**FLEXIBILITY TESTING**

RESULTS	
Right 01	27.0 N
Right 02	26.6 N
Right 03	25.6 N
Right 04	26.1 N
Right 05	25.2 N
Average	26.1 N







**MOBILITY TESTING**


**METHOD**

- 1 2" grid drawn on baseline product tops and bottoms.
- 2 Scan athlete in outdoor basketball positions wearing baseline apparel.
- 3 Identify areas of stretch and bunching of fabric to focus on during prototyping phase.

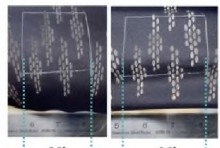
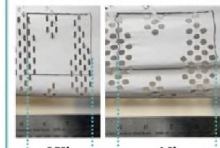
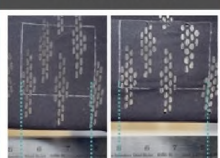




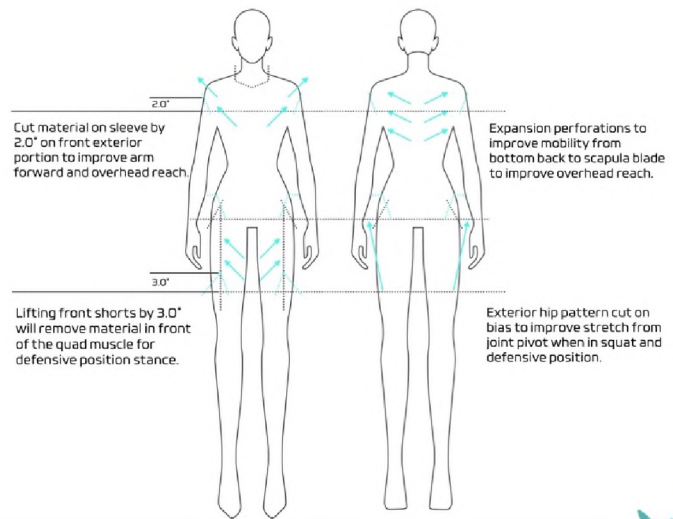
**FINDINGS**

**BACK**      **HIP**      **SHOULDER**



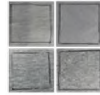
**MOBILITY TESTING**

<p><b>0.125" BIAS</b></p>  <p>2.5"      +0.5"</p>	<p><b>0.25" POLY/SPANDEX</b></p>  <p>2.75"      +1.0"</p>
<p><b>0.125" W/ GRAIN</b></p>  <p>2.5"      +0.5"</p>	<p><b>NERVURE POLY KNIT</b></p>  <p>2.5"      +0.5"</p>

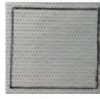


### BREATHABILITY TESTING

\* Focus was to determine pattern of durability would not affect breathability



Baseline products do not allow for direct air flow to the skin.



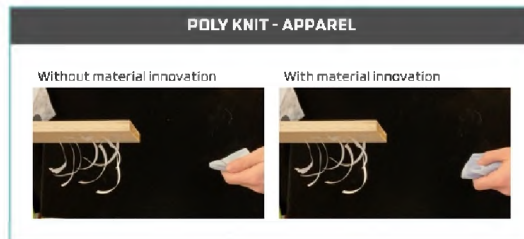
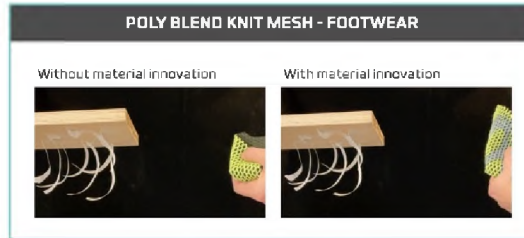
Polyester knit with no air flow to skin perforations or NERVURE technology.



Polyester/Spandex knit blend with 0.25" perforations in a staggered pattern allows for more direct air flow to the skin.



Polyester knit with NERVURE technology and 0.25" perforations in a staggered pattern within vein gaps will allow for more direct air flow to the skin.



### APPAREL TESTING



**FIT**  
SEAM LOCATIONS



**MOBILITY**  
MATERIAL CUT AWAYS



**DURABILITY**  
TEXTILE FOCUSED





FOOTWEAR TESTING



**FIT**  
ZONED LOCKDOWN



**MOBILITY**  
UNDERFOOT FLEXIBILITY



**DURABILITY**  
TEXTILE FOCUSED

APPAREL



**FLEXIBILITY**  
CUT AWAYS AT ANTERIOR ARM TO ALLOW FOR OVERHEAD/FORWARD MOBILITY  
**THERMOREGULATION**  
BACK AND UNDER-ARM PERFORATIONS FOR DIRECT AIR FLOW TO THE SKIN



**DURABILITY TECH (ARM)**  
SEPARATED TO ALLOW FOR JOINT FLEXIBILITY



**FLEXIBILITY**  
CUT AWAYS AT HIP TO ALLOW FOR HIP/LEG MOBILITY



**FIT**  
ELASTIC WAISTBAND ON EXTERIOR FOR COMFORT



**THERMOREGULATION**  
MOISTURE-WICKING KNIT FOR COMFORT AND BREATHABILITY



**FIT**  
SEAM LOCATIONS AND PATTERNS DESIGNED AROUND BODY AND MOTION



**FLEXIBILITY**  
3" CUT AWAYS AT ANTERIOR QUAD TO ALLOW FOR HIP/LEG MOBILITY



**DURABILITY TECH**  
SEPARATED TO ALLOW FOR JOINT FLEXIBILITY



100% POLYESTER KNIT

EXO 3900 BEMIS

100% POLYESTER KNIT

DURABILITY TECH

100% POLYESTER KNIT

TECH PATCH / 100% NYLON THREAD

2" ELASTIC WAISTBAND

100% POLYESTER KNIT

100% NYLON THREAD

EXO 3900 BEMIS

100% POLYESTER KNIT

DURABILITY TECH



**APPAREL TECH PACK**

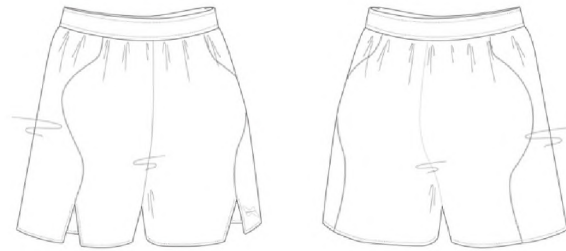


FRONT

BACK



**APPAREL TECH PACK**

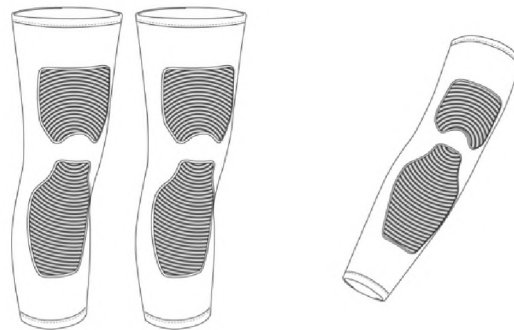


FRONT

BACK



APPAREL TECH PACK



LEG SLEEVES

ARM SLEEVE



FOOTWEAR

<p><b>BREATHABILITY</b> THIN MESH TONGUE TO ALLOW FOR HEAT LOSS</p> <p><b>LOCKDOWN</b> 3 POINTS OF LOCK DOWN LOCATED IN THE FOREFOOT, MIDFOOT, AND HEEL</p> <p><b>BREATHABILITY</b> MESH VAMP TO ALLOW FOR HEAT LOSS</p> <p><b>DURABILITY TECH</b> LOCATED ON FOREFOOT MEDIAL AND LATERAL SIDES AND AROUND HEEL *ADDITIONAL BENEFIT- PROVIDES STABILITY</p> <p><b>LOCKDOWN</b> HEEL COUNTER MOLDED AROUND MONARCH FEMALE LAST</p> <p><b>STABILITY</b> TORQUE SHANK IN MIDFOOT OF MIDSOLE</p> <p><b>FLEXIBILITY GROOVES</b> LOCATED UNDER FOREFOOT AND AT HEEL (APPROX. 75% FROM TIP OF SOLE)</p> <p><b>DURABILITY</b> HIGH WRAP OUTSOLE FOR EXTRA PROTECTION DURING EXTREME MOVEMENTS</p> <p><b>TRACTION</b> STUD-HERRINGBONE TRACTION PATTERN DESIGNED FOR OUTDOOR COURTS</p> <p><b>FLEXIBILITY GROOVES</b> LOCATED UNDER FOREFOOT AND AT HEEL (APPROX. 75% FROM TIP OF SOLE)</p>	<p>1</p> <p>2</p> <p>3</p>	<p>100% POLYESTER 0.75" WEBBING</p> <p>100% POLYESTER SUEDE</p> <p>0.375" OPEN CELL FOAM</p> <p>EXO 3900 BEMIS</p> <p>100% POLYESTER KNIT</p> <p>100% POLYESTER MESH</p> <p>1.0MM POLYURETHANE</p> <p>EVA FOAM</p> <p>2.0MM INJECTION MOLDED TPU</p> <p>EVA FOAM</p> <p>URETHANE RUBBER</p>
--	----------------------------	---



**FOOTWEAR TECH PACK**



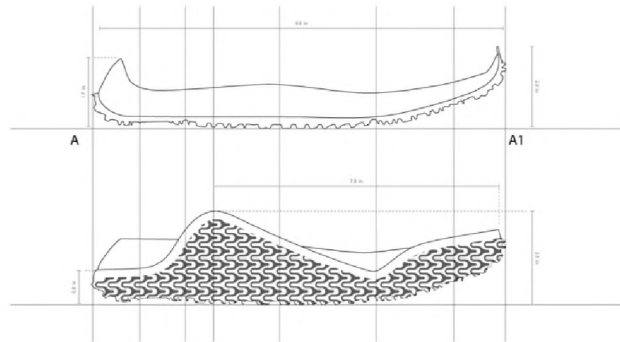
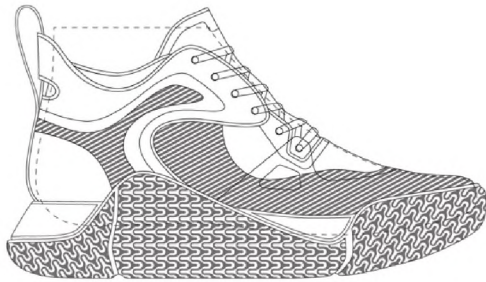
LATERAL



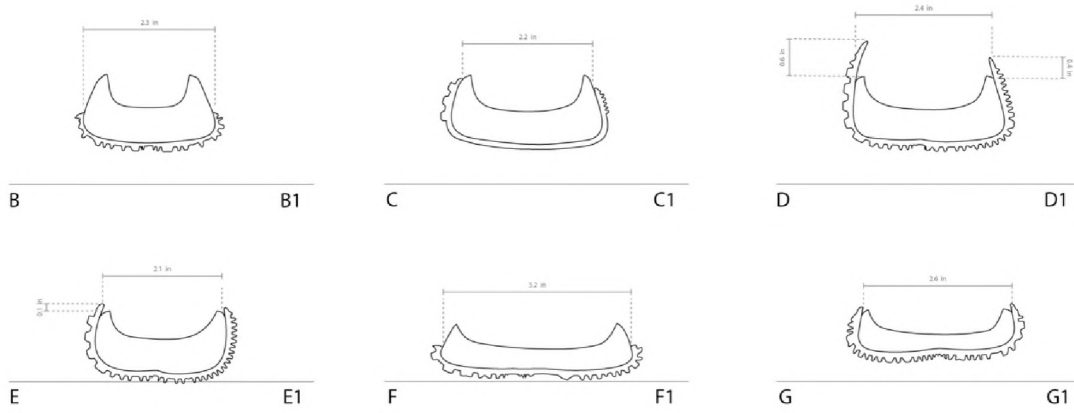
MEDIAL



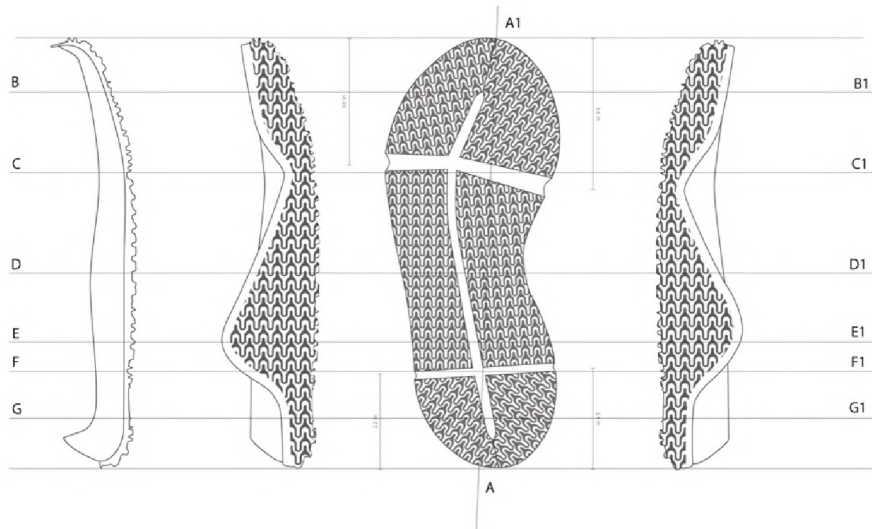
**FOOTWEAR TECH PACK**



**FOOTWEAR TECH PACK**



**FOOTWEAR TECH PACK**













**PACKAGING**



**FINAL RENDER**



COLORWAYS



VALIDATION

EMILY CARNEY

DIRECTOR MATERIAL DEVELOPMENT  
FOOTWEAR

DAVID LITTON

SR. MATERIALS DEVELOPMENT  
FOOTWEAR

Experimentation with different materials and integration into textile is really interesting and exciting. The last development has a lot of overlap with new women's lasts being developed and could be a great tool for the future of women's basketball specific footwear especially since these athletes can vary more in height.



KINAKO

WOMEN'S OUTDOOR  
BASKETBALL ATHLETE

Loving the aesthetic and function you added. I think the lockdown features would be really helpful and the teal portions would definitely protect my shoes. The shoes look like they'd hug my ankle to provide support in addition to lockdown.

The apparel looks strong with the bright teal. I really like the cut away features in the apparel. The sleeves I wear always end up slicing down and ripping above and below the knee area so I really like the separated protective pads for both durability and flexibility.



**FIT** | 5% | BUILD FEMALE-SPECIFIC LAST TO CREATE 3 POINTS OF LOCKDOWN TO AVOID SLIPPAGE WITHIN THE SHOE. SEAM PLACEMENT TO FOLLOW WOMEN'S OUTDOOR BASKETBALL MOVEMENTS.

**MOBILITY** | 5% | ADD FLEXIBILITY ZONES TO THE FOREFOOT AND HEEL AREAS OF THE OUTSOLE. TAKE AWAY MATERIAL AT JOINT LOCATIONS WHERE THERE IS A HIGH RANGE OF MOTION.

**DURABILITY** | 10% | PILLING AND FIBER SHEDDING OCCURS AFTER 35 SECONDS. PROTECT AGAINST LONG TERM WEAR SO THE ATHLETE KEEPS THE PRODUCT LONGER.

**MONARCH ADDRESSES THE NEEDS FOR DURABILITY, MOBILITY, AND FEMALE-SPECIFIC FIT IN THE SPONTANEOUS AND FLUCTUATING ENVIRONMENTS OF OUTDOOR BASKETBALL.**



