Female Specific Basketball Shoes: An In-depth Analysis of the Effects of Underrepresentation in Basketball Footwear

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PROJECT OVERVIEW

Women started playing basketball less than a year after the game was invented and currently make up over a quarter of the playing community. However, less than 1% of all basketball shoes sold are female specific (Mirabella, 2018). When sports product companies do release a women's basketball shoe, they simply scale down an existing men's model and sell it in a feminine colorway, doing what is known in the industry as "shrink it and pink it". Most female basketball players spend their entire career playing in men's shoes. Due to the anatomical differences between men and women, men's basketball shoes are not only overdesigned for women, but they also do not properly address the structural differences between men's and women's feet. Playing in men's footwear perpetuates female underrepresentation within basketball and could be a factor in the massive gender gap of women's ACL injuries in the sport compared to men. This research explores opportunities to design a suite of female-specific basketball shoes that decrease ACL injury propensity and optimize player performance.

SPORT HISTORY

From its inception, women's basketball has sought equality. James Naismith developed the game of basketball in 1891 and, a year later, a physical education instructor named Senda Berenson adapted the rules and introduced the game to female students at Smith College in Massachusetts (History, 2019). Part of her motivation in adapting the game was to promote exercise and strengthening in women who, at the time, were perceived as weak and more prone to illness than men (Jenkins, 1997). Employers commonly used this reasoning to justify paying women less than men; therefore, Berenson wanted to promote health and exercise through the sport of basketball in hopes of creating equal pay for women in their jobs (Jenkins, 1997).

Although a progressive thinker, Berenson still altered Naismith's rules to make the women's game less strenuous and more elegant to play (Jenkins, 1997). Under these rules, the court was divided into three sections, with players required to stay in their section to prevent contact (History, 2019). Players were also forbidden to snatch the ball, hold it for more than three seconds, or dribble more than three times (History, 2019). These strict rules were made to prevent women from behaving "too rambunctiously" during the game and appearing "unladylike" (History, 2019). In the documentary *Women of Troy*, sportswriter Jackie MacMullan poignantly explains the evolution of women's basketball: "With men, they started to evolve on their own. Women, it was up to everybody else how they could play the game, not them" (Women of Troy, 2020).

Eleven months after Berenson's adaptations, the first women's college game was held between the University of California-Berkeley and Stanford and by 1895 women's games were held at colleges nationwide (Jenkins, 1997). Although there was concern about the psychological and physical effects of women playing a sport, women's basketball continued to grow. In 1926 the Amateur Athletic Union (AAU) held its first ever national women's championship (History, 2019). By 1938, the three-court format of the women's game changed to two courts with six players per side (History, 2019). Women were not considered strong enough to play a full-court game until 1971, when the rules of the game as we know today were established (History, 2019).

Title IX was signed into law in 1972, offering female students their first athletic scholarships in 1973 (History, 2019). Despite this momentum, the first women's NCAA college tournament did not occur until almost a decade later in 1982 (History, 2019). Women's basketball made its Olympic debut in 1976, a full 40 years after the men and the first professional women's basketball league, the WBL, was created two years later in 1978 (History, 2019). The WBL ran for three seasons before being disbanded by broadcasting channel owner Fox News (Jenkins, 1997). Consequently, female basketball players sought playing time overseas in the absence of post-college opportunities in the states. The Women's National Basketball Association (WNBA) was finally established in 1997 and has since blossomed into the professional women's league we know today (History, 2019).

PRODUCT HISTORY

The origin of basketball shoes can be traced back to 1917, when Converse released the Chuck Taylor All Star (Bowers, 2017). These canvas and rubber sneakers were the most popular basketball shoe until 1972, when Nike released its first shoe, the Nike Bruin, which was constructed of suede and leather (Bowers, 2017). A year later, Puma signed NBA player Clyde Frazier to create the first ever signature basketball shoe, the Puma Clydes which triggered a wave of companies releasing basketball shoes (Baker, 2020). However, it was not until 1985, when Nike signed Michael Jordan and introduced the iconic Air Jordan I that basketball shoes really gained consumer interest (Baker, 2020). Since then, over 50 different NBA players have signed with shoe companies to release their own signature shoe lines, some of them creating several different models (List, n.d.). Additionally, there are 16 current NBA players who have their own shoe deals with companies which include Nike, adidas, and Under Armour (Baker, 2020).

In the same amount of time, only eight female basketball players have created signature shoes, 70% of which were released in the 1990's (Click, 2013). In 1995, Sheryl Swoopes signed with Nike to become the first female athlete to have a signature shoe (Nike, n.d.). The Nike Air Swoopes line remains the most successful women's basketball shoe with seven different models, the last of which was released in 2002 (Click, 2013). A rise in interest in women's basketball in the late 1990's led to professional players Lisa Leslie, Cynthia Cooper, and Dawn Staley each getting their own signature shoe lines. However, none have matched the Air Swoopes' success. In fact, there has not been a women's signature basketball shoe on the market since the Adidas release of Candace Parker's third shoe "Adidas Ace3" in 2012 (Click, 2013). Sports companies have released general women's basketball shoes, such as the 2020 Under Armour HOVR Breakthru; however, basketball shoes made for women still make up less than 1% of all basketball shoes sold in the U.S. (Mirabella, 2018). Although numbers vary on how many women play basketball, it is safe to say they make up more than 1% of the sport's demographic and are severely underrepresented. Often, the releases of women's basketball shoes are limited to a few colorways and specific sizes which are often not even big enough to fit the female athletes for which the shoes are marketed. To overcome this, female players from the beginner level to the WNBA resort to playing in men's shoes.

Increased risk of injury and lack of representation are just two of many reasons for designing a women's specific basketball shoe.

PRODUCT CLASSIFICATION

Footwear, basketball, women's

RULES

The rules of women's basketball are identical to that of men's basketball. The circumference of the women's ball is one inch smaller and the location of the three-point line is one foot closer to the rim. High-level games consist of four 10-minute quarters with 30-second shot clocks.

SUCCESS

The highest form of success in basketball is winning games and being the most dominant team in a league. However, there are many different forms of individual success within the sport. A player can quantify her success through playing statistics such as points, assists, or rebounds per game, or through leadership statistics such as value added and player efficiency ratings. Additionally, a player can measure her basketball success through levels of personal enjoyment and physical health.

Keys to success depend on skill, basketball IQ, and athletic ability. The fast-paced nature of the sport requires constant quick lateral movements to get past and displace opposing players and jumping motions to reach the ball faster than others. This combination of motions led to the creation of basketball shoes, which provide athletes the ability and support to move quickly and explosively on the court.

ENVIRONMENT

A quality basketball court surface is essential to the game, allowing players the ability to change direction as fast as possible with minimal slipping. Court materials directly interface with basketball footwear and affect traction design and materiality. Elite-level courts are generally composed of hard maple (Newcomb, 2015). This wood variety is tightly grained and harder than most woods, making it durable for approximately 10 years athletic play (Newcomb, 2015). Hard maple is also lighter in color than most woods, reflecting arena lighting better and creating greater contrast between the floor and the ball (Newcomb, 2015). Regardless of the arrangement of the three-quarter inch thick maple slabs or the color of the stain used, every single hardwood floor is topped with a layer of high-gloss polyurethane coating to create a tacky playing surface (Newcomb, 2015).

ATHLETE EXPERIENCE NEEDS

Basketball is a fast-paced, dynamic game that requires specific skills while moving at multi-directional high speeds. Consequently, the most successful athletes have a combination of strength, explosive power, agility, and endurance (Ransone, 2017). The dynamic nature of the sport creates varying levels of playing speed during a game, with one study finding that players spend 34.1% of the time playing, 56.7% walking/jogging, and 9% standing (Ransone, 2017).

This mix of short-term high-intensity movement and lower intensity long-duration movement illustrates the need for both anaerobic and aerobic training to be successful in the sport.

In terms of anthropometrics, height plays a large factor in a player's advantage within the game as well as determining playing position on the court. Body composition (the amount of lean muscle mass compared to fat mass), is not as essential as height, but it should be noted that there is a strong relationship between body composition, aerobic fitness, and anaerobic power in elite basketball (Ransone, 2017). One study done by the Canadian Journal of Applied Sport Sciences analyzed the relationship of physiological, anthropometric, and motor fitness skills to performance in women's basketball. It was determined that that the factors which most discriminated between high and low performers were shooting accuracy, body fat percentage, and VO2max (Riezebos, Paterson, Hall, & Yuhasz, 1983).

Additionally, different player positions on court have different physical requirements for success. The guard positions generally employ smaller players who are faster, more agile, and possess skilled dribbling and long-range shooting ability. Inversely, post players are taller and have bodies that exude more power for actions like boxing out and rebounding when playing in the paint.

Lastly, it should be noted that, although physical factors such as height, strength, agility, and endurance are key indicators of success, the game requires a high degree of technique and basketball IQ, which are independent of athletic ability.

BIOMECHANICAL NEEDS

Basketball is a dynamic game that requires the athletic ability to outmaneuver opponents with swift changes in direction of movement and speed. Every athletic movement performed involves rapid exertion of skeletal muscle forces to accelerate, decelerate, and stabilize lower extremity joints (Pettitt & Bryson, 2002). In each basketball game, athletes run an average of 2 miles, complete 40-60 short sprints, and perform as many as 70 jumps (McClay et al., 1994). Athletes also perform around 100 high-intensity basketball-specific multi-directional movements and take over 1,000 shuffling and walking steps (Banda et al., 2019). Players abruptly change movement pattern over 1,000 times, with the changes occurring every 2.56 seconds (Ransone, 2017).

Biomechanical studies have found that most basketball injuries originate from high-stress related movements in which excessive doses of force are exerted on the musculoskeletal system (McClay et al., 1994). These forces are classified as a weighted combination of intensity, frequency, and duration. The same studies found that the jump landing and shuffling movements commonly performed in basketball result in greater absolute and relative ground reaction forces than any other sport (McClay et al., 1994). Ground reaction forces (GRFs) are widely used in biomechanics to analyze the intensity and duration of force the musculoskeletal system is subjected to during its contact with the ground. Notation for GRFs is shown below in Figure 1, illustrating that the forces are categorized into vertical, mediolateral, and anteroposterior directions. Positive values in the graphs indicate propulsion of the body whereas negative values imply braking forces (McClay et al., 1994).

It should be noted that impulse is defined as an amount of force over a given period of time, and as a result greater impulse values result in large amounts of stress on the body. Additionally, the slope on the Force vs Time graphs indicate the rate of change at which the impulse occurs, which happens through the rapidness of each movement. The steeper each peak is, the greater the amount of stress applied to the body over a shorter period of time (McClay et al., 1994).

The following paragraphs analyze the GRFs of the most common basketball movements: jumping, sprinting, cutting, and shuffling.

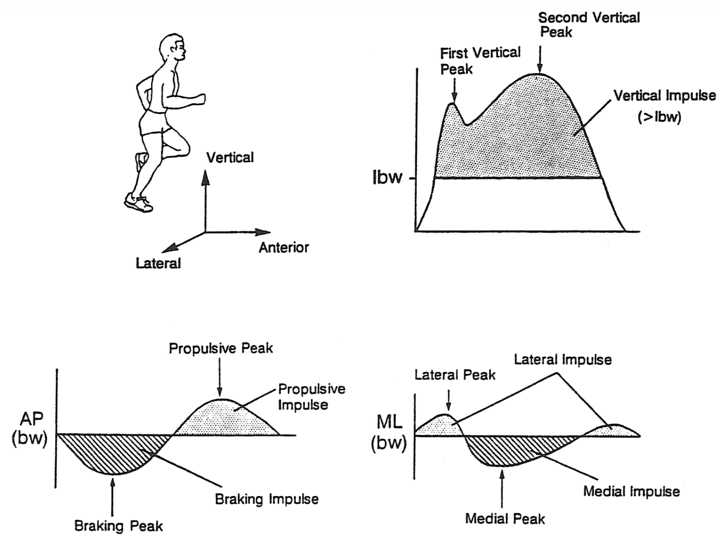


Figure 1: Conventions for ground reaction forces (McClay et al, 1994)

Jumping

Whether a player is jumping to catch a rebound, block a shot, or shoot a jump shot, jumping is an integral part of basketball. Studies have found correlations between vertical jump ability and increasing level of play, suggesting that the best players possess the ability to jump higher than others (Ransone, 2017). Testing has also reported significant relationships between jumping ability and sprint and agility performance, suggesting the importance of overall lower-body power within the sport of basketball (Banda et al., 2019). Vertical jump landings result in large GRFs in all three directions, with the greatest force in the vertical direction (McClay et al.,1994). Jumping movements result in the largest angular velocities and strain rates at the knee and ankle compared to other movements analyzed (McClay et al., 1994).

Due to the dynamic nature of basketball, capturing realistic movement data in a lab is difficult and often not reflective of live game scenarios. Biomechanical labs aim to simulate the jump movements performed during layups and jump shots in their studies; however, it can be assumed that the data found is conservative compared to the forces experienced during live playing time (McClay et al, 1994). That being said, jump landings experienced after a layup produce the greatest vertical GRFs at seven times the athlete's body weight on a single foot (McClay et al., 1994). The same study revealed jump shot GRFs five times the athlete's body weight on each foot. The GRF analysis of a layup landing is shown below in Figure 2 (McClay et al., 1994). It is important to note the sudden impact peak resulting in a rapid force rise time and subsequent great amount of force exerted on the body.

The graph also indicates that a jump landing is biphasic: that of initial contact and then the application of the total body weight. In the first phase, the toe and forefoot region typically make initial contact with the ground after a jump and the GRFs are around one and a half times the athlete's body weight (McClay et al., 1994). In the second phase, the GRF migrates posteriorly along the foot and GRFs as high as four times the bodyweight are experienced near the heel (McClay et al., 1994). It should be noted however, that players who tend to land flat-footed load force in their midfoot only and experience GRFs as high as six times their body weight (McClay et al., 1994). Therefore, forefoot strike landings have the ability to reduce GRFs by as much as 50% compared to midfoot landings. It is theorized that forefoot landings increase joint range of movement and the amount of time the body takes to decelerate from the movement, reflecting a flatter impulse curve on the Vertical Force vs Time graph (McClay et al., 1994).

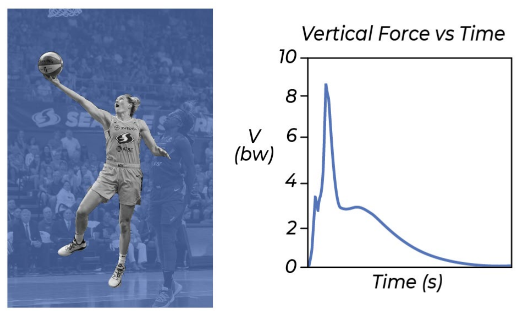


Figure 2: Vertical GRFs of a Layup Landing (McClay et al., 1994)

Sprinting

Running is a crucial component of basketball, with athletes spending almost 50% of a basketball game performing some form of running (Hoffman et al., 1996). The most skilled players are generally faster and more agile than less skilled players and the ability to quickly execute sprints and change direction has been linked with increased playing time in collegiate basketball (Hoffman et al., 1996).

A study analyzing the movement patterns of Italian elite women's basketball games found that that high-intensity specific movements occur every 16.6 seconds and sprints occur every 33.3 seconds of live playing time (Conte et al., 2015). Additionally, 86.7% of these sprints in the study occurred over distances shorter than 10 meters, with the most common sprint distance traveled being between one to five meters. The study also broke down the type of sprints performed during games and found that linear sprints made up 48.3% of total sprinting, followed by 31% of curved sprints and 20.7% of change of direction movements (Conte et al., 2015). Repeated sprint activity is a significant component of elite women's basketball and therefore the ability to perform repeated sprint activity is a crucial biomechanical element to success.

Figure 3 indicates low amounts of mediolateral GRFs experienced during sprinting but notably high vertical forces (McClay et al., 1994). The peaks in the anteroposterior graph indicate the propulsive starting and braking forces experienced by the athlete when starting and ending a sprint (McClay et al., 1994).

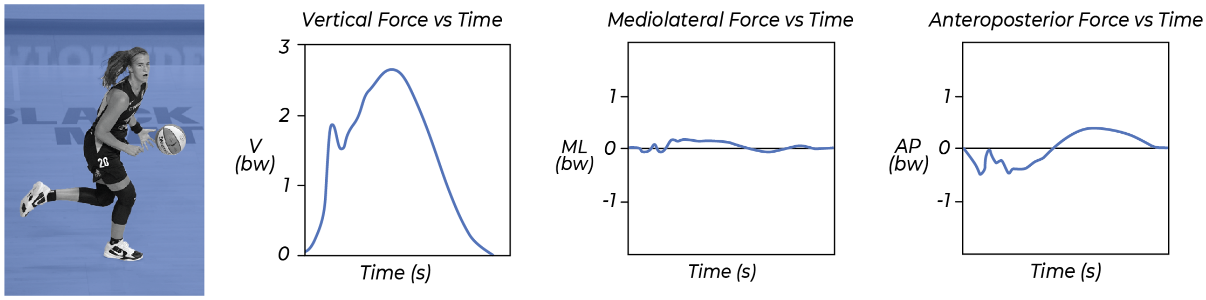


Figure 3: Vertical, Anteroposterior, and Mediolateral GRFs of Sprinting (McClay et al., 1994)

Cutting

Cutting is defined as a sudden change of direction performed during a sprint, commonly used on offense to outmaneuver defending basketball players on the floor. Although vertical GRFs experienced during cutting are similar to those experienced during sprinting, athletes also experience mediolateral forces as high as 1.6 times their body weight, shown in Figure 4 (McClay et al., 1994). The positive values on the mediolateral graph indicate that the forces are entirely lateral. This loads increased amounts of stress on the lateral border of the foot, specifically the fifth metatarsal (McClay et al., 1994).

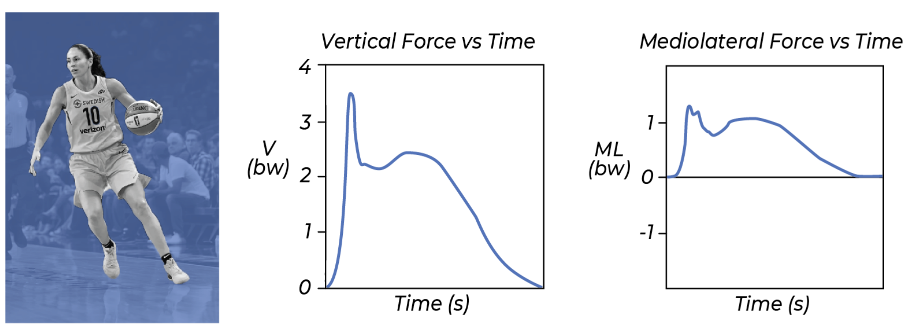


Figure 4: Vertical and Mediolateral GRFs of a cutting movement (McClay et al., 1994)

Shuffling

Shuffling is commonly performed during defense as a counter to the opposing player’s cutting maneuver in an effort to stay squarely in between the player and the basket. The negative values of the mediolateral graph in Figure 5 indicate that shuffling exhibits the largest peak medial forces and lowest lateral forces of any other basketball movement studied (McClay et al., 1994). This implies that shuffling is a primarily medially applied force and can be as great as two times a player’s body weight on each foot (McClay et al., 1994). It should also be noted that the Vertical Force vs Time graph is the only graph that presents three force peaks, suggesting that shuffling produces the largest amount impulse of the studied movements.

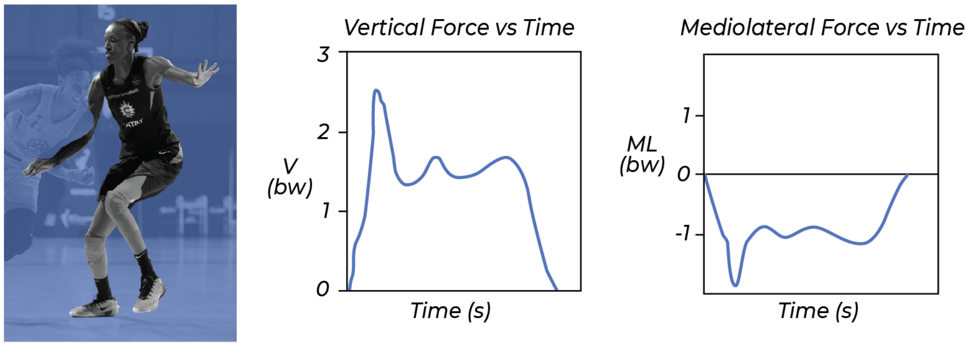


Figure 5: GRFs of a shuffling movement (McClay et al., 1994)

PLAYING POSITIONS

Athlete biomechanical and physiological loads experienced during a basketball game greatly depend on playing position. The playing positions within basketball are categorized as guards, forwards, and centers. A standard lineup generally consists of two guards (point guard and shooting guard), two forwards (small forward and power forward), and one center. Athlete sizes vary drastically between playing levels and positions (Basketball, n.d.). The average height and weight of WNBA athletes by playing position is shown below in Figure 6 (WNBA Advanced Stats, 2020). Guards are typically lighter, shorter, and have a more mesomorphic build than forwards and centers. Forwards are taller than guards but shorter and lighter than centers, who are customarily the largest players on the team. These anthropometric differences reflect vastly different playing styles and responsibilities within each playing position.

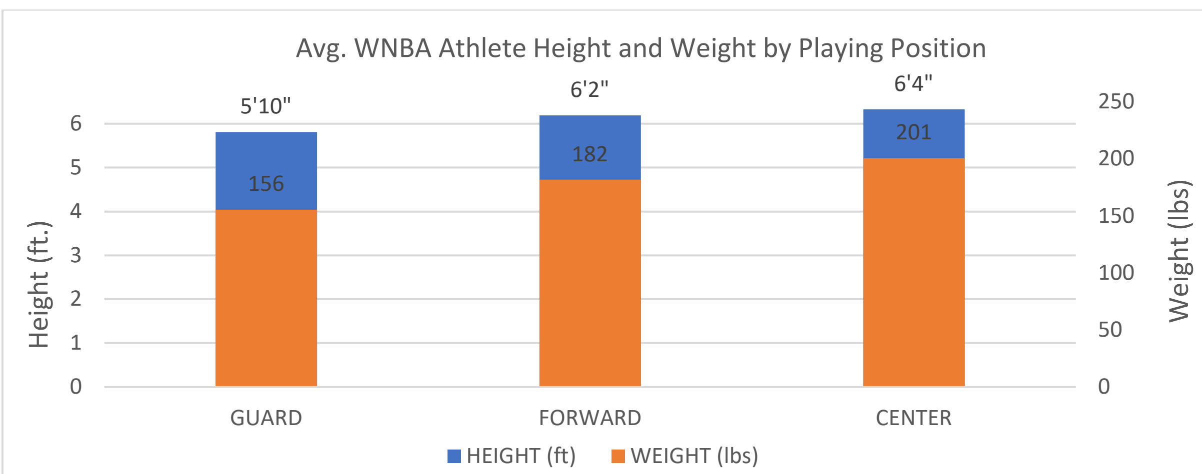


Figure 6: Average Female Athlete Height and Weight by Playing Position

Guards

Guards are the primary ballhandlers and are responsible for coordinating the team's offense. Their movements include passing, dribble penetration, defensive pressure, transition offense, and outside shooting, resulting in longitudinal movements along the court (Trninić & Dizdar, 2000). Guard players perform the greatest number of high-intensity movements in a game, resulting in better agility performance and speed than forwards and centers (Trninić & Dizdar, 2000).

Outside players typically have a lower body mass than inside players and thus require less force to accelerate than post players. Consequently, players in the guard position tend to perform more accelerations at a higher intensity than forwards and centers (Trninić & Dizdar, 2000). One study found that guards perform side-shuffles over longer distances than forwards and centers, producing greater medial forces on their lower limbs more often. (Delextrat & Cohen, 2009). Players at the guard position perform agile movements more frequently and at quicker speeds than the rest of the team, experiencing peak outputs for longer amounts of time, shown in Figure 7 (Delextrat & Cohen, 2009). As a result, guards have the highest VO2 max and blood lactate levels, awarding them the highest anaerobic capacity of any position on the team (Delextrat & Cohen, 2009).

Forwards

Forwards are all-around players that have a stronger inside game than guards and better outside shooting capabilities than centers. Forwards typically move horizontally in their positional play to get open, with common movement patterns including dribble penetration, off-ball offense, setting and working off screens, and shooting (Trninić & Dizdar, 2000). Forwards chiefly play around the perimeter and use various moves to destabilize their opponents, resulting in many high-intensity accelerations and decelerations. Each of these movements require high anaerobic power and lower leg strength. Studies have found that forwards have the greatest leg flexor strength and peak torque knee extensor values, depicted in Figure 8 (Delextrat & Cohen, 2009). As a result, players at the forward position have the highest anaerobic power on the team as they experience agile movements less frequently than guards but with more force, resulting in greater force peak outputs over shorter periods of time (Delextrat & Cohen, 2009).

Centers

Centers' movement is focused near the basket as they dominate inside the paint, focusing on offensive and defensive rebounding, blocking shots, setting screens, and posting up to get open (Trninić & Dizdar, 2000). As a result, centers typically perform the most jumps in a game. Additionally, centers perform the greatest amount of high-intensity full-extension jumps as opposed to smaller jumps commonly performed by guards when making a shot or pass (McClay et al., 1994). As the largest players on their team, centers accelerate slower and at a lower intensity, taking longer to achieve adequate speeds (Reina et al., 2019). This is because these taller athletes also require more force exertion to accelerate than smaller players (Delextrat & Cohen, 2009). Instead, center movement is vertical with a strategy focusing on player's use of footwork and strength to maneuver around opponents under the rim. Their greater body mass results in the highest power output levels, making them vastly more explosive than the rest of the team (Delextrat & Cohen, 2009).

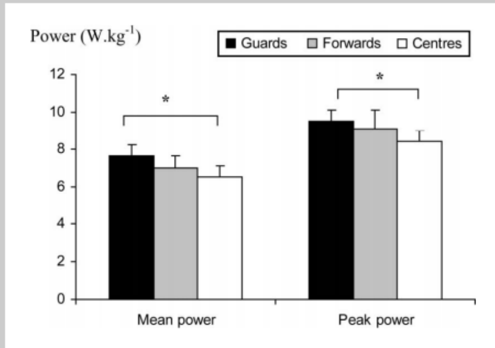


Figure 1. Mean power and peak power achieved by guards, forwards, and centers during the 30-second Wingate test. *Significant difference, $p < 0.05$. Values are expressed as mean ± *SD*.

Figure 7:Positional Mean and Peak Power Output over 30-Second Duration (Delextrat & Cohen, 2009).

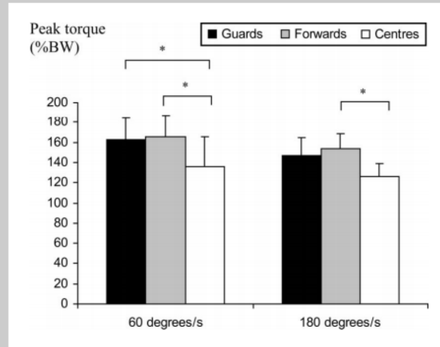


Figure 2. Relative peak torques (PT, % of body weight [BW]) developed by guards, forwards, and centers during knee extension of the dominant limb at 2 velocities: 60 and 180 degrees/s^{-1}. *Significant difference, $p <$ 0.05. Values are expressed as mean ± *SD*.

Figure 8: Positional Knee Extension Peak Torques Developed at 60° and 180° Knee Angles (Delextrat & Cohen, 2009).

INJURY

Females are almost twice as likely to sustain an injury while playing basketball than men (Zelisko, Noble, & Porter, 1982). An epidemiologic breakdown of women's basketball injuries found that over 60% of both game and practice injuries incurred are to lower extremities, most commonly being ankle ligament sprains followed by anterior cruciate ligament (ACL) tears (Agel et al., 2007). In fact, female basketball players are up to eight times more likely to tear an ACL than their male counterparts (MacMillan, 2020). ACL tears are devastating injuries that require surgery 96% of the time and generally take 6-12 months for recovery (LaBella et al., 2011).

The ACL is one of four main ligaments that stabilizes the knee and is crucial to agility sports like basketball. The ligament runs diagonally through the knee and is responsible for stabilizing rotational movements that occur during cutting and pivoting activities. The ACL does this in two ways: first acting mechanically through its connections to the tibia and femur as a passive restraint to excessive movement; second, the ACL uses proprioception to help sense the knee joint's position in space (University of Wisconsin Hospitals and Clinics Authority, n.d.). This sends signals to the brain and spinal cord when the joint exceeds its normal range of movement and consequently stimulates the appropriate muscles to re-stabilize the joint (University of Wisconsin Hospitals and Clinics Authority, n.d.). 70% of knee injuries occur from non-contact situations such as sudden changes in direction like pivoting, cutting, and landing from jumps (University of Wisconsin Hospitals and Clinics Authority, n.d.). The mechanism of injury occurs when the knee enters what is referred to as "the point of no return" in which there is a loss of neuromuscular control and the brain is unable to stabilize the joint. In this brief state of instability, excessive forces are loaded onto the ACL, causing it to stretch and, in most cases, tear (Pettitt & Bryson, 2002). Although this phenomenon occurs in both genders, females are predisposed to enter this "point of no return" more often than men and are thus anatomically more inclined to tear their ACL (Pettitt & Bryson, 2002). Although every knee injury is multifactorial and uniquely situational, researchers have been able to narrow down the cause of this undeniable gender discrepancy to three main factors: female differences in the ligament itself, wider hips, and a lower center of mass.

Within the knee itself, MRI analysis studies have found that men have greater ACL thickness than women in proportion to lean body mass (Anderson et al., 2001). Additionally, women tend to have a narrower intercondylar notch in proportion to their body size (Pettitt & Bryson, 2002). This notch is a groove that the ACL runs through and is located on the femur's interface with the tibia. Research has found correlations between narrower notches and ACL tears, placing women at greater vulnerability (Pettitt & Bryson, 2002).

The remaining two factors, wider hips and lower center of mass, are evolutionary responses to childbirth. Women typically have wider hips than men to strategize giving birth, resulting in a greater "Q-angle", shown in Figure 9 (Pettitt & Bryson, 2002). Greater Q-angles consequently affect knee alignment and result in knee valgus, or the tendency of knees to rotate inward during movement, as shown in Figure 10. "Athletes with Q-values above 15° generally have leg postures of greater genu valgus and excessive external tibial rotation" (Pettitt & Bryson, 2002).

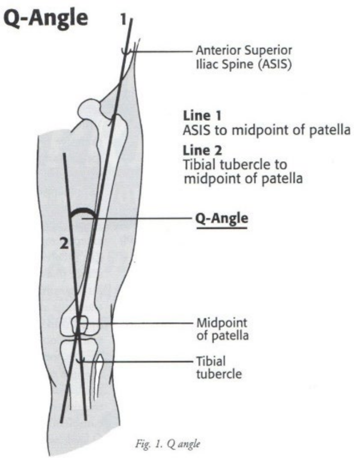


Fig. 9: Q-angle (Pettit & Bryson, 2002)

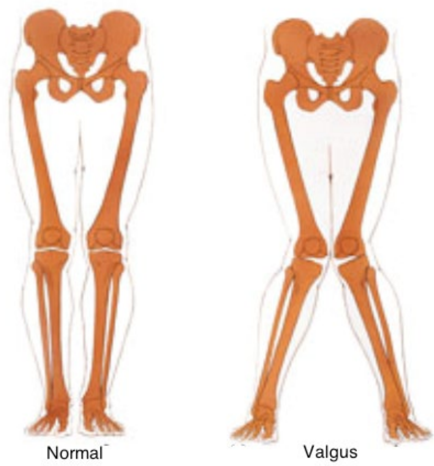


Fig. 10: Normal vs Knee Valgus Alignment (Pettitt & Bryson, 2002)

Knee valgus alignment is troublesome because it places hip stabilizing muscles in lengthened positions more frequently than correct knee alignment (Pettitt & Bryson, 2002). Muscles are less strong when they are placed in lengthened positions because there are fewer cross-bridges between them (Pettitt & Bryson, 2002). This weakens the lower leg's ability to stabilize the knee and channels more load onto the knee's ligaments and tendons, consequently placing more stress on the ACL (Pettitt & Bryson, 2002).

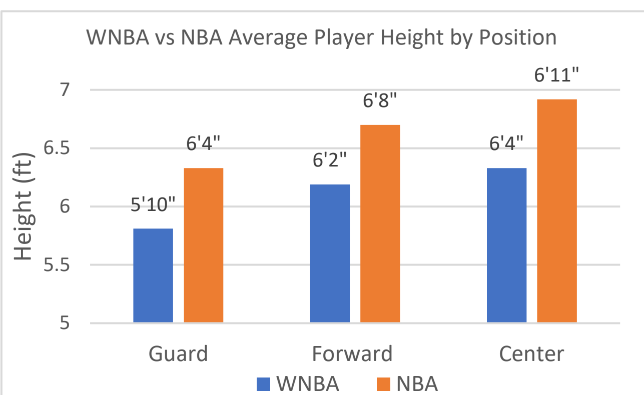
Lastly, through evolution women have developed bodies with lower centers of mass to improve balance while carrying children (Fields, 2012). This lower center of mass consequently results in different movement patterns in which women hold their trunks more upright during activities than men (Fields, 2012). However, it was found that excessive ACL shear forces can be avoided in over 90% of athletes if the knee and trunk are flexed more than 30° during movement (Pettitt & Bryson, 2002). Therefore, women's anatomical disinclination to hinge at the hips during movements prevents the activation of key knee stabilizing muscles in the posterior chain, most important being the hamstrings. This results in females having imbalanced strength in their lower leg muscles where typical movements are quad-dominant with a delay in hamstring activation (Pettitt & Bryson, 2002). Imbalanced quadricep-to-hamstring ratio has been identified as a mechanism for non-contact injuries because hamstrings act as an agonist with the ACL to help prevent anterior tibial translation and stabilize the knee (Pettitt & Bryson, 2002). Some studies also theorize that this causes athletes to land from movements flat-footed rather than on the balls of their feet, which does not activate calf and hamstring muscles and places higher load on the knee ligaments (National Institutes of Health Medicine Plus, 2013).

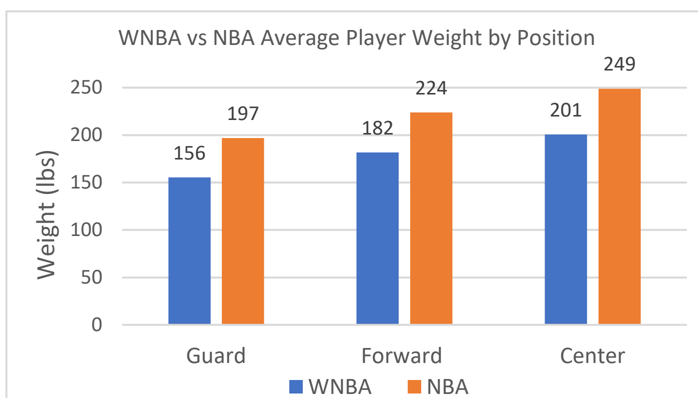
ANATOMICAL DIFFERENCES BY GENDER

Although the sport is played in the exact same environment under identical rules, there are countless differences between men and women's basketball. These differences illustrate the importance and need for female-specific basketball footwear.

Size & Playing Style

Men's basketball greatly emphasizes athleticism; a large amount of the game is played above the rim and male athletes rely on speed and explosiveness for success. Women's basketball alternatively places an emphasis on basketball IQ and finesse in the absence of sheer brawn. These differing playing styles are in direct reflection to the anatomical differences between men and women. It is no surprise that men typically have higher verticals and faster sprinting times than their female counterparts. Male NBA players are on average 6.5 inches taller and 40 pounds heavier than female WNBA players at the same position, illustrated in Figures 11 and 12 (WNBA Advanced Stats, 2020). Because men weigh more and generally have more muscle mass, larger GRFs are produced with every step. Greater muscle mass also produces more explosive energy with each movement. As a result, the sports product industry has designed cushioning in basketball shoes to withstand the large forces exerted by men. Female athletes, on the other hand, do not require such overdesigned footwear and could instead benefit from lighter, more flexible, female-specific cushioning systems which would be inadequate for male athletes.





Figures 11 and 12: Height and Weight Differences by Position and Gender

Foot Anatomy

Basketball footwear is traditionally designed on a unisex last that is predominantly sized for men's feet. When basketball shoes are released in 'women's' sizing, the initial designs based off male lasts are usually just made smaller. However, women's feet have significantly different proportions than men and cannot be replicated by simply scaling down men's sizing. Wearing incorrectly fitting footwear while performing high-intensity movements can severely affect comfort and performance and increase injury risk. Wearing shoes that fit incorrectly can lead to gapping or shifting of the foot inside the shoe, which results in instability and can place undue amounts of stress on knee and ankle joints.

Additionally, female feet generally have a wider forefoot and narrower heel than men's, creating a triangular shape as opposed to male's rectangular shaped foot (Carelock, 2020). Women also have a naturally higher arch (Carelock, 2020). As a result of the anatomical differences mentioned, women have different movement patterns which load their feet differently, requiring alternative cushioning needs than what is found in current basketball footwear. Due to the higher arch, greater amounts of force are placed on the lateral column of the foot than men, who typically experience the highest loads in the forefoot directly under the balls of their feet (Carelock, 2020). Wearing men's shoes that are too narrow in the forefoot can create blisters and discomfort among female users, as well as increase the danger of collapsed arches in the absence of proper support. Collapsed arches can affect lower leg and knee joint alignment, resulting in greater knee valgus angles and increased risk of ACL tears. Studies have also found that proper arch support provides better proprioception to the athlete, which can increase stability by as much as 25% and reduce the incidence of ankle rolls (Han, Anson, Waddington, Adams, & Liu, 2015).

ATHLETE DEMOGRAPHIC

The athlete is an elite female basketball player, 17– 40 years old, who plays multiple times a week at levels ranging from AAU to the WNBA.

MARKET SIZE

Around 24 million people played basketball in 2018, making it one of the most popular sports in the U.S. (Lock, 2020). An estimated 25% of those players are female, therefore the potential market size for a women's basketball shoe is 6 million (Lynn, 2020). Of the 6 million players, 399,067 of them play in high school, 16,509 play in the NCAA, and 144 play in the WNBA (Women's, 2020). Recent trends also suggest that these numbers are growing despite the countless barriers surrounding women's sports. Social media platforms like Twitter and Instagram have helped create exposure to the sport: in 2018 there was a 30% increase in women's NCAA basketball social media interactions and a 1,900% increase in social medial video views (NCAA, 2018). The market size is expected to continue expanding as viewership, participation, and salaries for women's basketball rise each year (Durham, 2019).

COMPETITOR ANALYSIS

Basketball shoes are split into three gender categories: men's, women's and unisex shoes. Within these categories are shoes designed specifically for smaller guard players, larger post players, and all-around hybrid players who are typically forwards. The men's category offers a wide variety of shoe options for each playing position in terms of pricing, sizes, and features like graphics and color ways. Women's basketball shoes are so uncommon that they typically do not specialize in specific playing positions and are generally designed as basic all-around playing shoes. Due to this, the market analysis and SWOT analysis lists in Appendix A are comprised of men's shoes for each position type along with the few women's models on the market.

In September 2020, Under Armour released the "HOVR Breakthru", their first ever women's specific basketball shoe (see Figure 13). This is currently the only basketball shoe on the market that caters explicitly to women's feet with a higher arch, narrower heel collar, and flexible mesh upper. Detailed SWOT analysis of the HOVR Breakthru is detailed in Figure 14.

UA Women's UA HOVR™ Breakthru
MSRP: $110
Features & Benefits
- Breathable mesh upper with strategic support films, designed specific to women
- Half-bootie construction with molded collar for a comfortable fit & support
- 3D molded sockliner for underfoot cushioning & support
- UA HOVR™ technology provides 'zero gravity feel' to maintain energy return
- Compression mesh Energy Web contains & molds UA HOVR™ foam for maximum cushion

(UA, n.d.)

Figure 13: UA Women's HOVR Breakthru Basketball Shoe

Product	Strengths	Weaknesses	Opportunities	Threats
UA HOVR Breakthru	Women's specific fit, great cushioning via midsole HOVR energy web system	Only offered in mid cut Small colorway selection	Only women's specific shoe in the market	Small market size may have poor sales

Figure 14: UA Women's HOVR Breakthru SWOT Analysis

Product Anatomy

Basketball places significant and spontaneous forces on the lower limbs and feet. Therefore, basketball footwear needs to have features of support, cushioning, flexibility, and stability. The extent of each of these components within a shoe greatly depends on each player's body type and playing position. Post players with heavier frames typically wear shoes that emphasize stability, ankle support, and cushioning, whereas smaller guards seek out shoes that are lighter and more flexible to aid quick movements and acceleration (Basketball Shoes, n.d.).

The state-of-the art basketball shoe is composed of three main parts: the upper, midsole, and outsole.The upper is the fabric part of the shoe that interfaces with the top of the athlete's foot. Its main functions are to keep the foot comfortably secure within the shoe and promote stability. Excess movement of the foot within the shoe can result in feet striking the ground in a fashion that creates risk of ankle rolls and places undue stress on the Achilles tendon or knee joint. Uppers contain the shoe's heel collar, which is designed in various styles: high, mid, and low top cuts. High-top shoes generally extend over the top of the ankle and provide the greatest degree of stabilization whereas low-tops provide more flexibility and better turning capability. State-of-the-art uppers have thermoregulation components to prevent the foot from overheating. Uppers also contain the shoe's lacing system, tongue, vamp, heel panel, and toe cap. Many basketball shoes also include a strap in addition to the lacing system to offer extra foot lockdown for stability. Basketball uppers commonly have thermoplastic polyurethane (TPU) overlays near the toe and outside edges for added durability and abrasion resistance. Many brands have proprietary upper technology such as Nike Flywire and adidas Techfit.

The midsole is arguably the most engineered component as cushioning technology has rapidly advanced in the last few decades. The midsole is the main cushioning element of the shoe and is designed to strategically absorb the forces of running and jumping while also providing high energy return. The midsole is usually comprised of three main elements: the main sole that runs the entire length of the shoe, specialized cushioning units in the heel and forefoot, and a shank which adds structure and prevents torsion. Basic principles of physics show that stiffer midsole materials create better energy return, allowing players to explode from the ground with greater force. Softer materials are better at dampening impact forces and thus provide more cushion. Finding the most strategic balance between these material characteristics and dimensions such as midsole thickness is an important factor of footwear selection among players of different body types and playing styles. Guard-specific shoes generally have thinner midsoles like the Nike VaporMax, which is low to the ground and attached directly to the shoe's upper, resulting in greater spring and flexibility. Additionally, technologies like Zoom Air have revolutionized cushioning especially for larger post players and is used extensively in Nike Lebron shoes (Nike, n.d.).

The final main component of the shoe is the outsole. The outsole is the interface of the shoe and the ground and is chiefly responsible for traction control. Herringbone patterns are typically the most successful traction patterns; however, different sports product companies have varying proprietary traction patterns and zoning. State-of-the art shoes have traction patterns that also cater to player position. The Nike Kyrie is a good example of this as its traction pattern extends up the sidewalls of the midsole's shoe, an addition the Nike designers made after observing the amount of time Irving spent on the sides of his feet when making quick lateral movements (Kyrie, n.d.). Patents pertaining to each of these proprietary technologies can be found in Appendix B.

Materials

Basketball shoe uppers are composed of a layered combination of synthetic engineered knits, air mesh or PU foam, TPU films and hot melt additions for durability, and sometimes details like synthetic leather. Each brand generally has their own proprietary engineered knit, such as Nike Flyknit and adidas PrimeKnit. The material used for footwear knits is generally a blend of polyester, nylon, and spandex. Technologies like Nike KnitPosite, seen in the Lebron 17's, blend Flyknit with more durable materials like pre-twisted heat-molded yarns to create a basketball-specific upper material that is more durable than original Flyknit (Lebron, n.d.). Midsole materials are generally made of EVA or some type of foam compound. However, each company uses a proprietary design and construction to create a unique cushioning feel. Nike React, Under Armour MicroG, and adidas UltraBoost are examples of different proprietary foam technologies. Thermo-plastic polyurethane (TPU) is another common foam type and is used in UltraBoost (Jane, 2018). However, many state-of-the-art basketball shoes also have cushioning technologies within the midsole in addition to the foam. Nike extensively uses air for this in their zoom airbag units which are designed in various shapes and sizes depending on the shoe. Under Armour uses

HOVR technology, which utilizes a mesh energy web that wraps around the cushioning core to deliver enhanced responsiveness and energy return (Hodge & Writer, 2020). Shanks that are housed within the midsole are generally made from a rigid plastic to provide reinforcing stability. Lastly, outsoles are typically made of rubber. The rubber's composition, however, depends on the playing surface. Outdoor-specific shoes utilize a harder, more durable rubber whereas indoor shoes made for wood floors use a softer rubber. Adidas is partnered with Continental tires and utilizes the exact rubber compound found in car tires as the material for their footwear outsoles.

Manufacturing

The manufacturing process of making the footwear upper consists of die-cutting each upper component and stitching the ensemble together. Materials like engineered knits require their own manufacturing process and are made on CNC knitting machines (Motawi, 2017). The upper is then stitched to the mesh and lining layers and any TPU reinforcements or padding are heat bonded or cemented to the upper before the entire piece is attached to the bottom strobel sock (Motawi, 2017). Once the upper is complete it is placed on a shoe last to take form before being attached to the midsole and outsole. The midsole foam is made through compression molding and any additional cushioning such as airbag or gel units are glued into place (Motawi, 2017). Each company has a proprietary blend of mixing, molding, heating, and cooling resulting in the slightly different foam types seen on the market. The outsole rubber is made through injection molding where natural rubber is mixed, cut, and dyed before being cured inside a mold of the shoe tread pattern (Motawi, 2017). To create differences in outsole rubber stiffness for outdoor versus indoor shoes, natural rubber is heated at precise temperatures for specific amounts of time. This heating process determines the rubber's composition and firmness as the rubber becomes stiffer the longer it is heated (Nike, n.d.). Once all three main components are individually made, the upper is glued to the midsole which is then glued to the outsole.

Graphics, Logos, Color

Basketball footwear typically does not include graphic applications but instead utilizes color blocking and different textures within the upper. The Kobe series is a good example of this through its use of subtle snakeskin patterning on the upper. Some models apply graphical patterns like color marbling on the outsole. Logo use is predominantly on the tongue, lateral and medial sides, and heel. The largest logo is generally presented on the lateral side of the shoe. There are countless colorways available in men's and unisex sizes. However, filtering by gender results in severely more limited color options, typically leaving only a standard black and white and pink variations. It is common for sports companies to simply release men's footwear models in "female" colorways which generally include various shades of pink and purple. This marketing strategy is immediately seen on the Nike website when searching "women's basketball shoes" versus "men's basketball shoes", shown in Figures 15 and 16. However, many female athletes do not desire these colors and instead want the wider range of options provided in the men's sizes. A quote by *Marketing to Women* author Marti Barletta explains the situation perfectly: "when pink is a color women can choose, they will choose it. When it is the only color that isn't the 'normal' one, women will not choose it," says Barletta: "they don't want it forced on them" (Barletta, 2006).

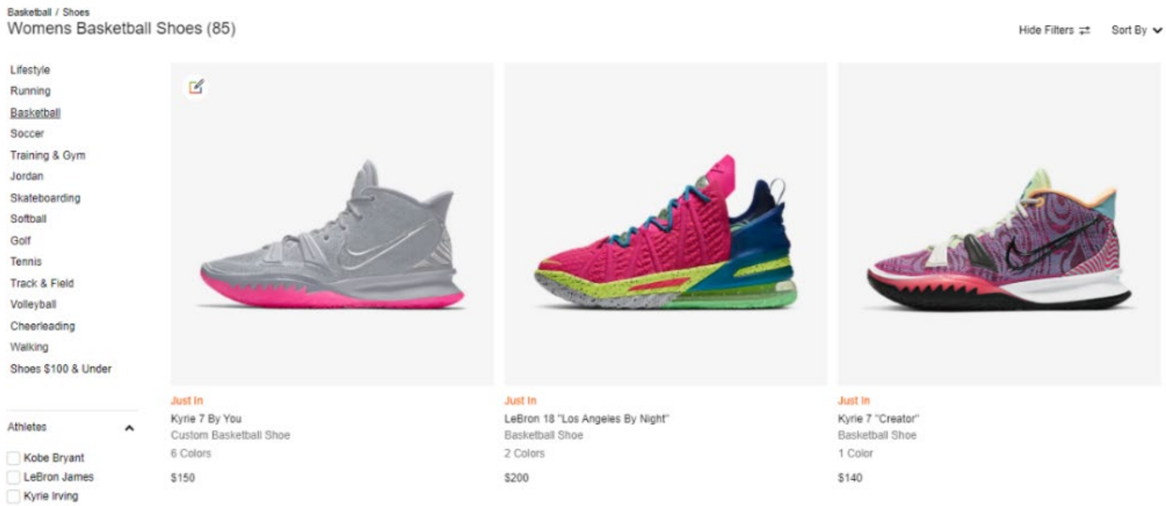


Figure 15: Nike “Women’s Basketball Shoes” Webpage (Nike, n.d.)

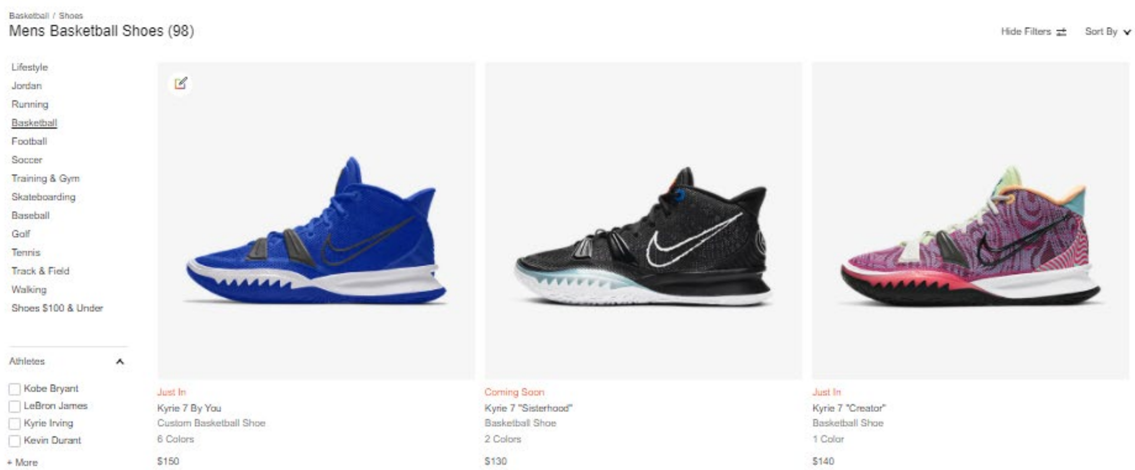


Figure 16: Nike “Men’s Basketball Shoes” Webpage (Nike, n.d.)

CONCLUSION

Females who play sports are generally more successful; they are more likely to graduate high school, receive post-graduate degrees, and earn more money (Glass, 2013). In fact, 96% of female C-suite executives played sports as teenagers (Glass, 2013). However, the same study found that by the age of 14 girls drop out of sports twice as often as boys (Glass, 2013). Although reasoning for this is multifactorial, lack of representation in the sports product industry certainly plays a factor. Additionally, the non-existence of female-specific footwear in basketball could be contributing to the large gender gap of ACL injuries. Female-specific basketball shoes have the potential to increase participation rates, player performance, and player safety.

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APPENDIX A – MARKET ANALYSIS & SWOT ANALYSIS

Guard Position Shoes – Men

Nike Kyrie 7
MSRP: $130
Features & Benefits
- Curved Nike Air Zoom Turbo Unit under the forefoot provides responsive cushioning
- lightweight foam midsole
- Molded fins in lacing system lock down foot
- Traction pattern extends up the shoe's sidewall to provide more grip during cutting movements
- Mesh forefoot is lightweight and breathable
- Reinforced toe resists abrasion (Kyrie, n.d.)

Nike Kobe V Protro
MSRP: $180
Features & Benefits
- Nike Air Zoom Turbo unit provides responsive cushioning
- Padded collar and heel counter offer locked-in stability
- Minimalistic upper is lightweight and durable
- Split outsole provides unlimited traction
- Cushion foam provides lightweight support
- Perforated tongue and toe box comfortably support the foot (Kobe, n.d.)

adidas Dame 7
MSRP: $110
Features & Benefits
- Lightstrike is a superlight cushioning with traction for explosive movement
- A rubber outsole provides outstanding traction

Ultra-lightweight textile upper with allover graphic (adidas, n.d.)

Under Armour Curry 7
MSRP: $140
Features & Benefits
- UA HOVR™ technology returns energy to get you where you're going faster
- Micro G® cushioning keeps your first step & every cut more explosive
- Flexible plate adds support & stability to every move
- Decoupled heel for more natural motion to help stabilize the foot
- Rubber outsole uses herringbone traction pattern to provide maximum grip (UA, n.d.)

Post Position Shoes – Men

Nike LeBron 17
MSRP: $200
Features & Benefits
- KnitPosite upper provides durable yet lightweight support
- The largest heel Max Air unit to date absorbes more force than previous designs
- Maximum-volume Zoom Air units under forefoot provide quick responsiveness
- Soft foam pod directly under Max Air unit adds heel cushioning
- Stabilizing plastic clip wraps around heel to lock in foot (LeBron, n.d.)

Air Jordan 34
MSRP: $180
Features & Benefits
- Visible Zoom Air cushioning under the heel and forefoot has a springy, responsive feel
- Eclipse plate made from molded TPU that is hollowed out reducing the shoe's weight
- Mix of textiles and translucent materials for a lightweight, breathable upper
- Herringbone outsole offers multidirectional traction (Jordan, n.d.)

Under Armour Embiid One
MSRP: $120
Features & Benefits
- Lightweight textile upper with open-hole mesh for ultimate breathability
- TPU wing provides superior midfoot lockdown & enhanced lateral stability
- Die-cut EVA sockliner provides underfoot cushioning & support
- Micro G® foam midsole turns cushioned landings into explosive takeoffs
- Rubber outsole with unique traction pattern for lateral movements & grip (UA, n.d.)

Jordan "Why Not?" Zer0.3
MSRP: $130
Features & Benefits
- Air Zoom Turbo unit in the front of the shoe is curved to follow the foot's natural shape
- adjustable midfoot strap fastens in one fluid motion to keep foot locked in and stable
- The rubber outsole is split into 2 sections to help reduce weight
- Multidirectional traction helps you stay in control (Jordan, n.d.)

All-Around Position Shoes – Men

Nike KD13
MSRP: $150
Features & Benefits
- Full-length Nike Air Zoom cushion stitched directly to the upper provides max energy return
- Second Air Zoom unit stacked under the forefoot for ultra-responsive cushion
- Soft upper constructed from minimal materials provides a lightweight, broken-in feel
- Midsole cutouts reduce weight and enhance flexibility (KD13, n.d.)

Nike PG4
MSRP: $110
Features & Benefits
- Ultralightweight footbed made with Nike Air runs the entire length of the shoe
- Dual-mesh, semi-transparent zippered overlay fastens over the laces to provide supportive containment and ideal breathability
- A low-cut collar, full bootie construction, and internal webbing system provides an easy entry, plush comfort, and secure fit (PG4, n.d.)

adidas Harden Vol. 4
MSRP: $130
Features & Benefits
- Ultralight Lightstrike cushioning in the midsole creates explosive movement
- Innovative rubber outsole provides excellent traction
- Midfood lockdown band holds foot in place
- Textile upper is lightweight and comfortable (adidas, n.d.)

adidas Harden Stepback
MSRP: $80
Features & Benefits
- Ergonomic lacing system provides snug, all-day comfort
- Bounce cushioning is lightweight and flexible, enhancing your on-court comfort
- Textile upper with synthetic toe cap
- Supergrip rubber outsole (adidas, n.d.)

Women's Shoes

UA Women's UA HOVR™ Breakthru
MSRP: $110
Features & Benefits
- Breathable mesh upper with strategic support films, designed specific to women
- Half-bootie construction with molded collar for a comfortable fit & support
- 3D molded sockliner for underfoot cushioning & support
- UA HOVR™ technology provides 'zero gravity feel' to maintain energy return
- Compression mesh Energy Web contains & molds UA HOVR™ foam for maximum cushion

(UA, n.d.)

Nike Air Zoom BB NXT
MSRP: $180
Features & Benefits
- *Three layers of Nike React foam consist of two layers in the midsole and a sock liner*
- *Two Zoom units under the ball of the foot help absorb energy in every step*
- *Mesh utilizes reinforced layers to create support around the toe, heel and midfoot*
- *The circular outsole pattern provides traction for multidirectional movements*
- *A plush foam tongue and padded collar with a notch to support the Achilles tendon for a snug, comfortable fit*

(Nike, n.d.)

Nike Kyrie 6 "Asia Irving"
MSRP: $140
Features & Benefits
- Curved Nike Air Zoom Turbo Unit under the forefoot provides responsive cushioning
- lightweight foam midsole
- Adjustable strap locks down foot
- Traction pattern extends up the shoe's sidewall to provide more grip
- Mesh forefoot is lightweight and breathable
- Reinforced toe resists abrasion

(Kyrie, n.d.)

Nike Air Zoom UNVRS FlyEase
MSRP: $160
Features & Benefits
- FlyEase technology works with a magnetized heel that folds down and connects to the midsole, opening up the back of the shoe so you can slide your foot in without hands
- *Articulated strap is connected to Flywire cables that lock the upper down over your foot with one upward pull*
- *Full-length Nike Air Zoom cushioning is stitched directly to the shoe's upper*
- *Re-engineered Flyknit construction is lightweight, breathable and supportive*

(Nike, n.d.)

SWOT ANALYSIS

Guard Position Shoes – Men

Product	Strengths	Weaknesses	Opportunities	Threats
Nike Kyrie 7	Superior cushioning responsiveness and traction	Shoe is a little heavy	Could be made in different cuts (high and low tops)	There are lighter shoes on the market
Nike Kobe V Proto	Incredibly comfortable and responsive guard shoe	Very little ankle stability. Typically run narrow	Kobe shoes are currently in high demand	Kobe shoes are exclusive and difficult to find. Fit is narrow and doesn't accommodate wide feet.
Adidas Dame 7	great traction and cushioning system	Textiles used in upper feel cheap and have poor ventilation	Create a low-top version with better-ventilating upper material	Saturated market for guard-specific shoes
UA Curry 7	Great traction on any surface	Cushioning is too firm and provides little impact protection	Elevate upper and midsole materials	Materials are cheaper than other sneakers on the market at the same price point

Post Position Shoes – Men

Product	Strengths	Weaknesses	Opportunities	Threats
Nike Lebron 17	The largest Air Max unit in existence creates great cushioning. Knitposite upper is very durable	Poor traction. Knitposite has poor ventilation	Iterate a lighter version of the Knitposite upper	High pricepoint ($200) makes this the most expensive shoe on the market
Air Jordan 34	Traction pattern works very well. Cushioning is lightweight. Very lightweight. Eclipse plate in midfoot provides stability	Materials are not premium	Use deluxe upper materials focusing on foot lockdown to respond to the traction pattern	High pricepoint ($180) and non-traditional Jordan aesthetic
UA Embiid 1	Great support, breathable materials	Slightly heavy, outsole is not durable, cheap materials	Elevate all aspects of the shoe. Good shoe for lower price point	Outperformed by other shoes in the market
Jordan "Why Not?" Zer0.3	Zoom Air unit provides less bulky cushion	Poor lateral traction. Cheap upper materials	Recreate traction pattern	Aesthetic does not look premium

All – Around Shoes - Men

Product	Strengths	Weaknesses	Opportunities	Threats
Nike KD 13	Comfortable full-length cushioning via stacked Zoom Air and wide base. Great traction on any surface	Thin, flimsy materials	Provide more stability in the upper	Fit is narrow and doesn't accommodate wide feet
Nike PG4	Great cushioning system and circular traction pattern	Poor lateral support and lockdown, inconsistent sizing	Affordable, basic sneaker	Saturated market for guard shoes.
Adidas Harden Vol. 4	Lightstrike cushioning is responsive and lightweight	Absence of Boost cushioning	Multiple colorways and upper material choices	Not as technologically advanced as other shoe offerings
Adidas Harden Stepback	Very stable and supportive	Midsole is very firm resulting in minimal cushioning	Good sneaker at lower price point	Basic aesthetic design

Women's Shoes

Product	Strengths	Weaknesses	Opportunities	Threats
UA HOVR Breakthru	Women's specific fit, great cushioning via midsole HOVR energy web system	Low top provides little ankle stability	Only women's specific shoe in the market	Small market size may have poor sales
Nike Air Zoom BB NXT	Pattern provides great multi-directional traction and double-stacked react and zoom air provide great cushioning	Poor lateral stability due to high cushioning	One of the most high-tech shoes in the market	Very high pricepoint
Nike Kyrie 6 "Asia Irving"	Great support and lockdown from Nike Zoom Turbo cushioning and upper strap	Runs slightly small	Great storytelling in marketing	Exclusive sizing
Nike Air Zoom UNVRS FlyEase	Comfortable full-length Zoom strobel and adaptive FlyEase lacing system	Poor traction and heel lockdown due to lacing system	Adaptive-friendly basketball shoe	Poor elite basketball performance

APPENDIX B – PATENT LANDSCAPE

Relevant patents in this area include innovations related to female fit and cushioning.

Cushioning Systems

- Shoe with lattice structure (U.S. Patent No. 10470520B2)
- Footwear midsole with lattice structure formed between platforms (U.S. Patent No. 20200281310A1)
- Sole and Shoe (U.S. Patent No. 20200329812A1)
- Sole for a Shoe (U.S. Patent No. 20200329809A1)
- Fluid-filled chamber with a stabilization structure (U.S. Patent No. 20200221822A1)
- Sole structure for article of footwear (U.S. Patent No. 20200329810A1)
- Stacked cushioning arrangement for sole structure (U.S. Patent No. 20200281311A1)
- Footwear Arch Support (U.S. Patent No. 20200214388A1)

Outsole

- Articles of Footwear and Sole Structures for Articles of Footwear (U.S. Patent No. 20190142108A1)

Upper

- Articles of footwear and apparel having a partially fused fabric portion and methods of making the same (U.S. Patent No. 20200324499A1)
- Article of footwear incorporating a knitted component with an integral knit ankle cuff (U.S. Patent No. 20200315284A1)
- Woven footwear upper with integrated tensile strands (U.S. Patent No. 20200329818A1)
- Article of Apparel with Zonal Force Attenuation Properties (U.S. Patent No. 20200281315A1)
- Article with Directional Tensioning (U.S. Patent No. 20200268105A1)
- Lightweight knitted upper and methods of manufacture (U.S. Patent No. 20200329816A1)
- Shoe upper (U.S. Patent No. D696853S1)
- Footwear Designing Tool (U.S. Patent No. 0366293A1)

Lacing

- Dynamic lacing system (U.S. Patent No. 20200268094A1)

APPENDIX C – PROFESSIONAL DEVELOPMENT

There are various ways my "Strengths Finder" strengths of harmony, focus, competition, significance, and individualization will shine through in this project. "Harmony", or my ability to work well with people will be employed during the testing and research phase when I am working with athletes to collect data. My "focus" strength will keep me on task and driven for the duration of this capstone project. Lastly, "competition", "significance", and "individualization" each address my goal of increasing representation in women's sports through basketball shoes.

Additionally, my strengths as an innovator are rooted in research and technical problem solving. These assets will be recruited when addressing the biomechanical aspects of the project, specifically the injury components. This capstone project addresses my desire to work in female-specific sports product and high-performance basketball footwear in the sport product industry. The course of the project will not only provide me with biomechanical human testing experience but also footwear development and making skills needed in the industry.

Mentor Mapping

Reuben Bligh: adidas Senior Manager, Future Footwear Innovation

That sounds great to me, an hour should be fine.

Once you have a date/time in mind, please let me know and we can book something in.

Kind regards,

Reuben Bligh

Senior Manager, Future Footwear Innovation

Shannon Pomeroy: Nike Explore Team, Applied Product Connection

Shannon Pomeroy
Mon 11/16/2020 10:25 PM
To: Nicole Demby

Hey Nicole,

Great to see that you're sticking with your guns here. Would love to work with you more in-depth where I can. Let's chat again early December if that works? Feel free to send anything through in the meantime for research/what you're thinking! Hope you're doing well, all things considered.

Shannon

PHASE II: TESTING & IDEATION

WINTER 2021

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TESTING

BENCHMARK FIELD RESEARCH PLANNING

PERFORMANCE RESEARCH TESTING

REASONING

Female athletes are 8x more likely than male athletes to tear their ACL while playing basketball (MacMillan, 2020)

70% of these ACL injuries occur from non-contact situations such as jumping, cutting, and shuffling (University of Wisconsin Hospitals and Clinics Authority, n.d.)

3 main reasons that place female athletes at heightened risk for ACL tear are: landing from jumps flat footed, incorrect knee alignment, and poor muscle recruitment during athletic movements.

PERFORMANCE CHARACTERISTICS TO TEST

Plantar Loading (GRFs), Knee valgus angle, and muscle recruitment

TESTING METHODS

The test goal is to obseve the effects of arch support and specific female fit on these characteristics.

To do this, each athlete will perform the following tests in three different pairs of shoes: men's basketball shoes (their own), women's running shoes (their own), UA HOVR Breakthru Women's basketball shoes

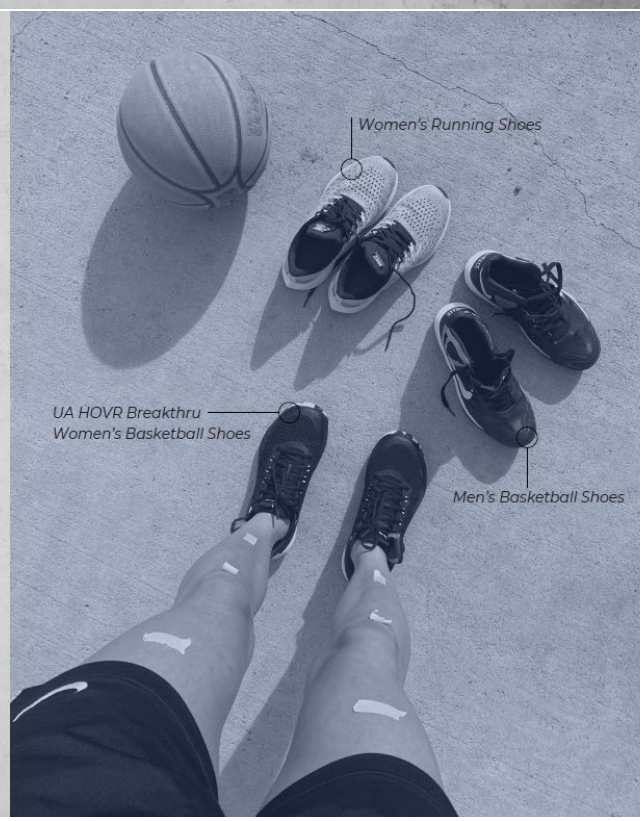
TEST SUBJECTS

Testing will be performed on members of the Montezuma-Cortez High School Women's basketball team

THIS RESEARCH WILL

Obseve the effects of arch support and female-specific shoe fit on ***plantar loading, knee valgus angle, and muscle recruitment*** *during basketball-related movement.*

In each of the following tests, the subject will perform movements in their personal men's basketball shoes, personal women's running shoes, and provided UA HOVR Breakthru women's basketball shoes



KNEE ALIGNMENT - 2D MOTION CAPTURE

SIGNIFICANCE

Female athletes tend to have wider hips which result in a greater Q-angle and knee valgus angles

Large knee valgus angles create poor limb alignment which weaken's the the lower leg's ability to stabilize the knee and ***channels increased load onto the ACL***

Can arch support and female-specific fit encourage correct knee alignment in female athletes?

TESTING TOOL

2D Motion Capture - Frontal Plane

DATA REPRESENTATION

Bar Graph

use Iphone camera

MOVEMENT TESTED

Depth Jump

PLANTAR LOADING - PRESSURE INSOLE

SIGNIFICANCE

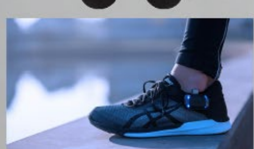
Female athletes are more likely to land flat-footed than male athletes

Landing flat-footed from jumps creates Ground Reaction Forces (GRFs) as high as ***6x*** *an athlete's body weight*

Can arch support and female specific fit encourge safer landing in female athletes?

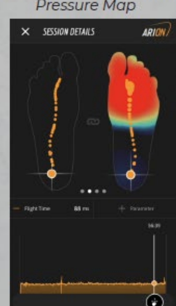
TESTING TOOL

ARION Pressure Insoles



DATA REPRESENTATION

Pressure Map



MOVEMENT TESTED

DEPTH JUMP
Simulate rebounding

REACTIVE SHUTTLE RUN
Simulate lateral cutting movement

FULL COURT SPRINT
Simulate longitudinal court movement

CONSUMER RESEARCH TESTING

GOOGLE SHEETS QUESTIONNAIRE

BASIC INFO

- *Name*
- *Age*
- *Height*
- *Weight*
- *Shoe Size*
- *Basketball playing position*
- *List any previous injuries*

UA HOVR BREAKTRHU

- *How do these shoes compare to your other basketball shoes? (1-5)*
- *Do you notice any differences in how these shoe fit compared to your current basketball shoes? If so, what are the differences?*
- *How do these shoes feel compared to your current running shoes? (1-5)*
- *Do you notice any differences in how these shoe fit compared to your current running shoes? If so, what are the differences?*
- *Do you like the added arch support? (Y/N)*
- *Which shoe do you find most comfortable to wear?*
- *Which shoe feels the most lightweight?*
- *Do you like how the HOVR shoes look? (Y/N)*
- *Would you buy these shoes for yourself? (Y/N)*

BENCHMARK PRODUCT PERFORMANCE RESEARCH PLAN

Phase of Study	Phase of Data Collection	Procedure	Data Collected	Timing
Data Collection (Subject is at testing location)	Paperwork/ background info	Subject reads and signs consent form and photo release.	Consent (name and signature) to participate in the study and have pictures taken	5 min
		Subject fills out informational survey	Age, height, weight, shoe size, injury history, and basketball playing position	5 min
	Test 1: Plantar Loading GRF Analysis	Subject places ARION Pressure insoles inside personal basketball shoes. System is turned on and test session begun on phone app	NONE	2 min
		Subject performs "Depth Jump Test": - Subject steps off platform - Subject lands and jumps as high as possible (one movement) - Subject lands	Plantar loading (GRF and foot strike) data from 3 key points during movement: - Initial landing - Loading for jump - Second landing	1 min
		Subject performs "Reactive Shuttle Run" agility test: - Subject starts in between two cones - When prompted, subject runs to one cone, picks it up and cuts laterally to run to the second cone - Once the subject reaches the second cone they pick it up and laterally cut again to return to the starting point in the center	Plantar loading (GRF and foot strike) data from 4 key points during movement: - Initial takeoff - Lateral cut #1 - Sprint - Lateral cut #2	2 min
		Subject performs sprint test - Subject starts at baseline - When prompted, subject sprints to half court	Plantar loading (GRF and foot strike) data from 3 key points during movement: - Initial takeoff - Sprint - Stop	1 min
		Subject places ARION Pressure Insoles inside personal running shoes.	NONE	2 min
		Subject performs "Depth Jump Test"	Plantar loading (GRF and foot strike) data from 3 key points during movement: - Initial landing	1 min

			- Loading for jump Second landing	
		Subject performs "Reactive Shuttle Run" agility test	Plantar loading (GRF and foot strike) data from 4 key points during movement: - Initial takeoff - Lateral cut #1 - Sprint - Lateral cut #2	2 min
		Subject performs sprint test	Plantar loading (GRF and foot strike) data from 3 key points during movement: - Initial takeoff - Sprint - Stop	1 min
		Subject places ARION Pressure Insoles inside provided UA HOVR Breakthru shoes	NONE	2 min
		Subject performs "Depth Jump Test"	Plantar loading (GRF and foot strike) data from 3 key points during movement: - Initial landing - Loading for jump Second landing	1 min
		Subject performs "Reactive Shuttle Run" agility test	Plantar loading (GRF and foot strike) data from 4 key points during movement: - Initial takeoff - Lateral cut #1 - Sprint - Lateral cut #2	2 min
		Subject performs sprint test	Plantar loading (GRF and foot strike) data from 3 key points during movement: - Initial takeoff - Sprint - Stop	1 min
	Test 2: Knee Valgus Angle 2D Motion Analysis	Place tape marker on subject's ankle center, shin center (6 in. below kneecap), patella center, and thigh center (8 in. above kneecap) *Subject is still wearing UA HOVR shoe	NONE	7 min
		Set up iPhone video camera in front of test subject and begin recording	NONE	2 min

		Have subject perform "Depth Jump Test"	Frontal plane video footage of subject knee alignment during jump and landing wearing UA HOVR Shoe	1 min
		Have subject put on personal basketball shoes	NONE	2 min
		Subject performs "Depth Jump Test"	Frontal plane video footage of subject knee alignment during jump and landing wearing men's basketball shoe	1 min
		Have subject put on personal running shoes	NONE	2 min
		Subject performs "Depth Jump Test"	Frontal plane video footage of subject knee alignment during jump and landing wearing women's running shoe	1 min
	Post-Test Questionnaire #1	- Subject fills out Consumer Research questionnaire on UA HOVR Breakthru shoe	Subjective data on UA HOVR Breakthru aesthetic, fit, and comfort level	7 min
	Post-Test Questionnaire #2	Subject fills out female-specific basketball questionnaire	Subject data on preferred colors, patterns, and shoe fits	7 min

TESTING DOCUMENTS

Research Testing Flyer (Provided to test subjects)

University of Oregon
Sports Product Design
Nicole Demby
1/13/2021

SENIOR THESIS PROJECT – BENCHMARK RESEARCH TESTING

Have you ever wondered why there are no women's basketball shoes? Have you ever wondered why female athletes are **8 times** more likely to tear their ACL while playing than male athletes? Would you like to contribute to the future of women's basketball? Be a part of my research testing on Friday!

What Is The Testing For:
I am a graduate student at the University of Oregon studying Sports Product Design. For my final thesis project in the program, I am designing female-specific basketball shoes with the intent to optimize player performance and reduce likelihood of ACL tears in female basketball players.

Testing Goal:
This research will observe the effects of arch support and female-specific fit on plantar loading, knee alignment, and muscle recruitment in female athletes while doing basketball movement.

Test Plan:
In each of the following tests, the athlete will perform movements in their personal basketball shoes, personal running shoes, and Under Armour HOVR Breakthru women's basketball shoes (provided)

Test 1: Plantar Loading (Ground Reaction Forces) – Using Pressure Insoles
The athletes will perform 3 movements in in each pair of shoes for a total of 9 movements.
The movements being performed are:

- Depth Jump Test – to simulate rebounding
- Reactive Shuttle Run – to simulate lateral cutting movement
- Half Court Sprint – to simulate longitudinal court movement

Test 2: Knee Alignment (Knee Valgus Angle) – Using 2D Motion Capture
The athletes will perform the Depth Jump Test in each pair of shoes for a total of 3 movements.

THANK YOU FOR CHOOSING TO BE A PART OF MY STUDY AND **PLEASE** BRING YOUR BASKETBALL SHOES AND RUNNING SHOES TO OPEN GYM ON FRIDAY!

UNIVERSITY OF OREGON

Photo Release Form (Provided to Test Subjects)

University of Oregon
Sports Product Design
Senior Thesis Project
Nicole Demby
1/13/2021

Photographic Release Form

As part of this research project, I will be taking photographs and video footage. Please initial in the spaces below what uses of these photographs you consent to, and sign at the end of the release form. Photos will only be used in the ways you consent to. Your name will not be identified in these photos.

1. ________ Photographs and video can be reviewed by the researcher.

2. ________ Photographs can be used for project illustration.

3. ________ Photographs can be used for academic presentations.

____
Name

____
Signature

____
Date

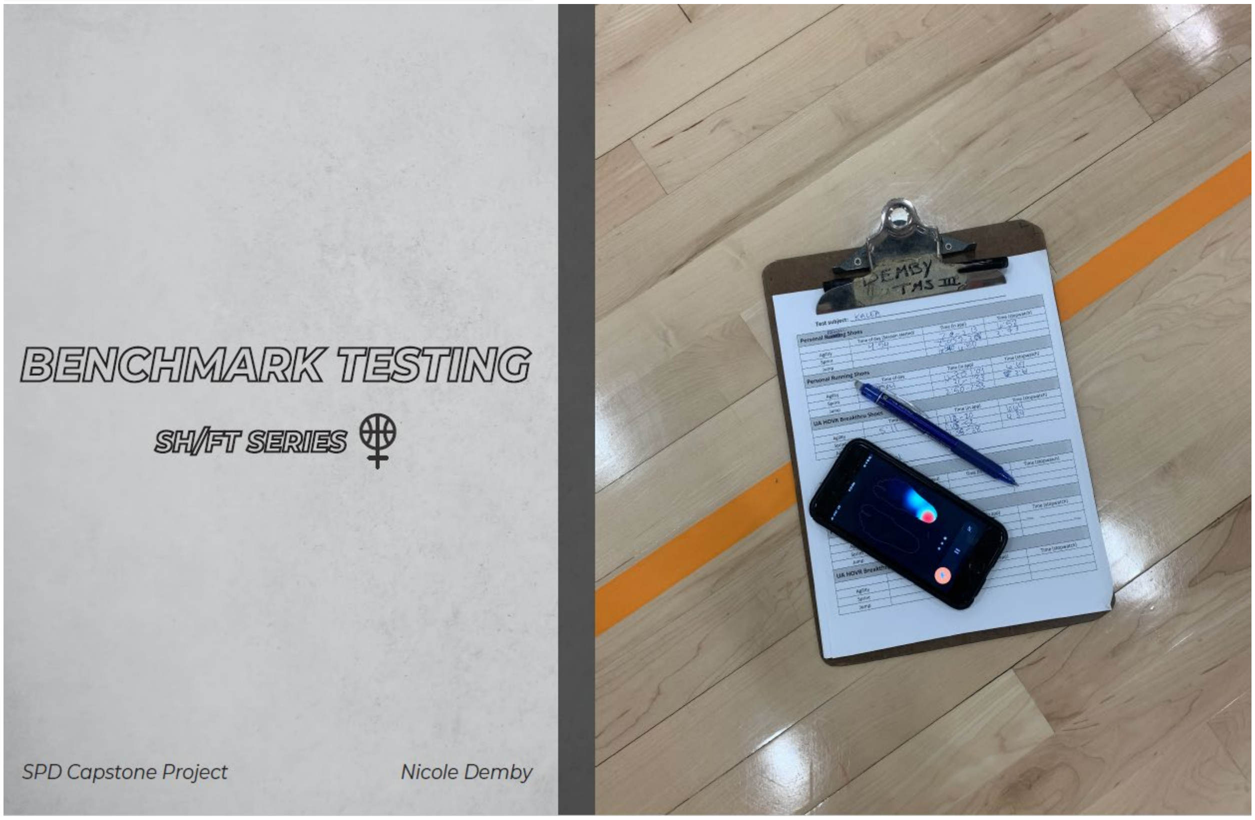
UNIVERSITY OF OREGON

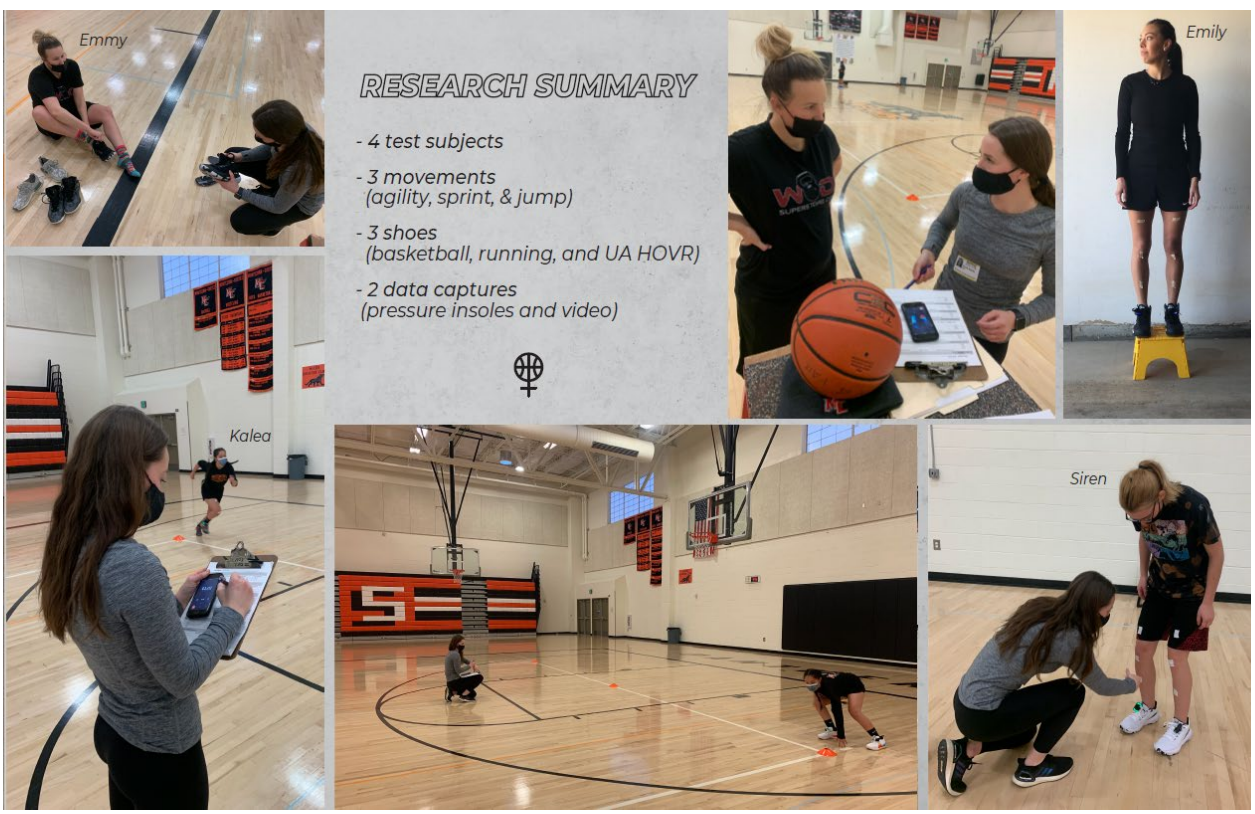
Testing Checklist

Test subject: ____

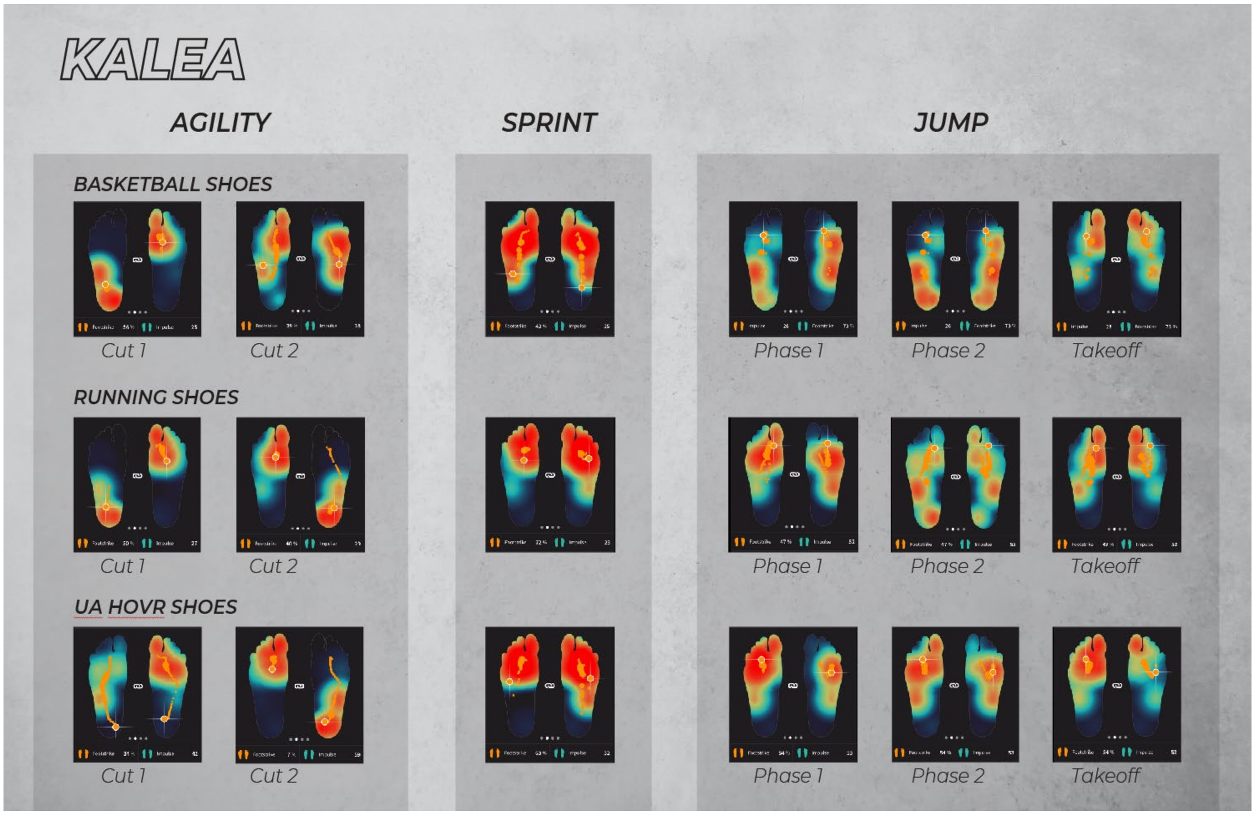
Personal Basketball Shoes			
	Time of day (Session started)	Time (in app)	Time (stopwatch)
Agility			
Sprint			
Jump			
Personal Running Shoes			
	Time of day	Time (in app)	Time (stopwatch)
Agility			
Sprint			
Jump			
UA HOVR Breakthru Shoes			
	Time of day	Time (in app)	Time (stopwatch)
Agility			
Sprint			
Jump			

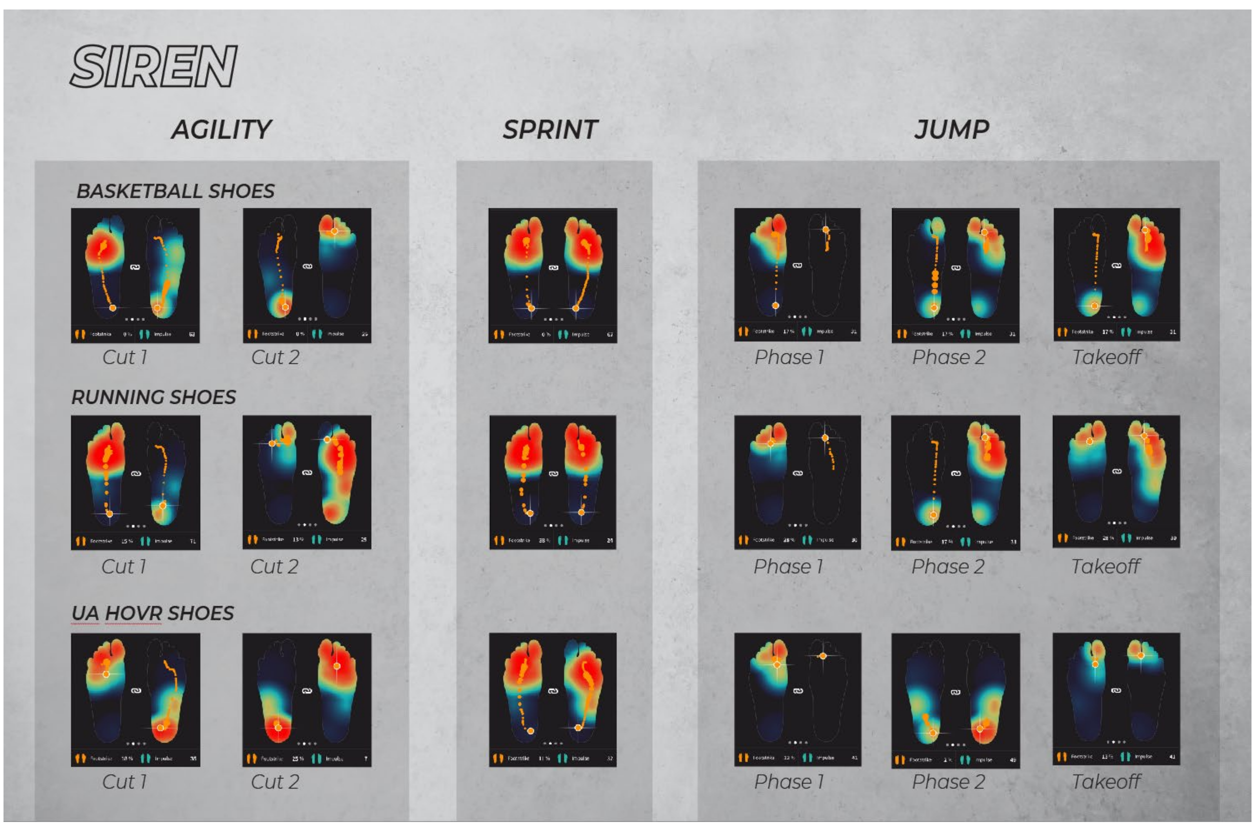
BENCHMARK TESTING FINDINGS

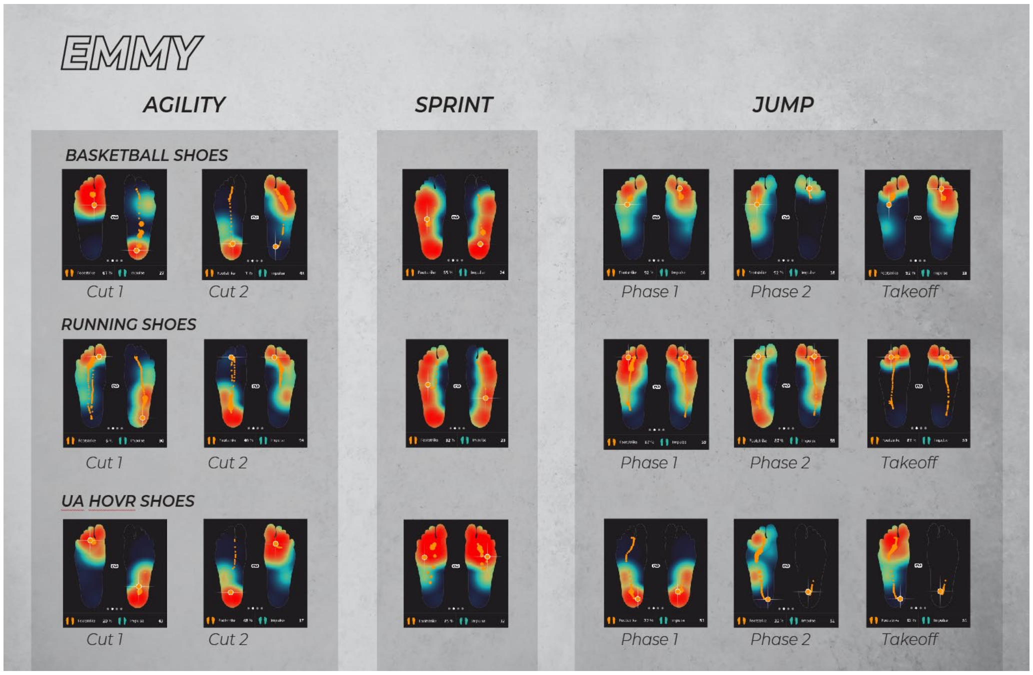




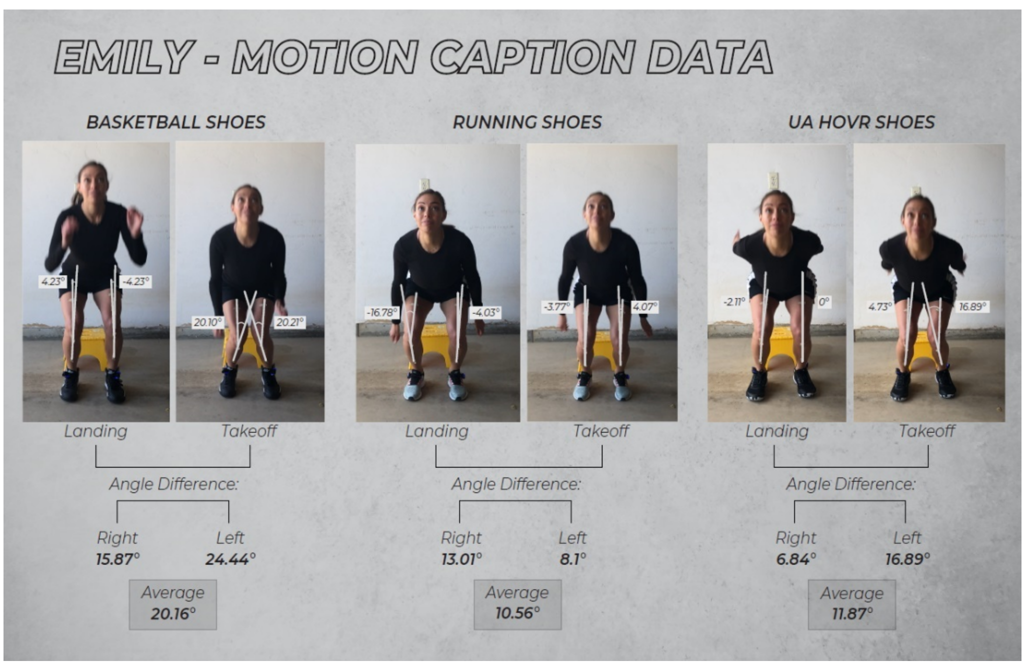
Plantar Loading Pressure Insole Findings







Knee Alignment 2D Motion Capture Data



JUMP TEST KNEE VALGUS ANGLES

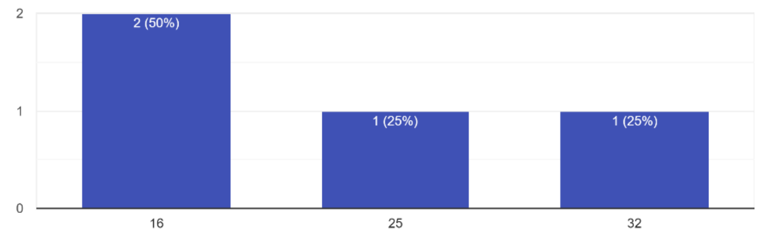
	BASKETBALL SHOES						RUNNING SHOES						UA HOVR SHOES					
	Phase 1		Phase 2		ABS DIFFERENCE		Phase 1		Phase 2		ABS DIFFERENCE		Phase 1		Phase 2		ABS DIFFERENCE	
TEST SUBJECT	Right Leg	Left Leg	Right Leg	Left Leg	Right Leg	Left Leg	Right Leg	Left Leg	Right Leg	Left Leg	Right Leg	Left Leg	Right Leg	Left Leg	Right Leg	Left Leg	Right Leg	Left Leg
EMILY	4.23	-4.23	20.1	20.21	15.87	24.44	-16.78	-4.03	-3.77	4.07	13.01	8.1	-2.11	0	4.73	16.89	6.84	16.89
KALEA	-14.92	2.75	-14.97	-3.12	0.05	5.87	-6.42	0	-2.49	3.83	3.93	3.83	-14.12	0	-9.04	4.16	5.08	4.16
SIREN	4.85	6.03	9.69	8.9	4.84	2.87	1.92	-7.85	7.07	-4.01	5.15	3.84	-1.85	1.95	10.79	11.58	12.64	9.63
EMMY	-8.36	-15.7	-6.75	-8.4	1.61	7.3	-18.33	-8.47	-11.9	-1.43	6.43	7.04	-20.91	-22.5	-13.09	-17.74	7.82	4.76
					5.59	10.12					7.13	5.70					8.10	8.86
					7.86						6.42						8.48	

Under Armour HOVR Breakthru Test Questionnaire & Findings

Name
4 responses

- Kalea Hunt
- Siren Utecht
- Emmy
- Emily Walck

Age
4 responses



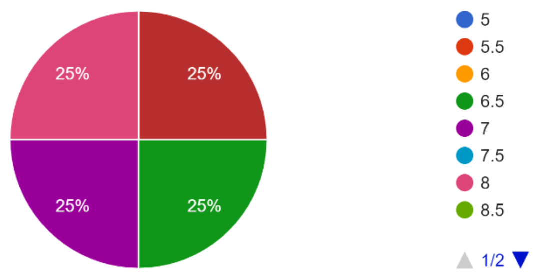
Height
4 responses

- 5'0"
- 5'2
- 5'9"
- 5'5"

Weight
3 responses

- 110 lbs
- 175
- 130

Shoe Size (women's)
4 responses



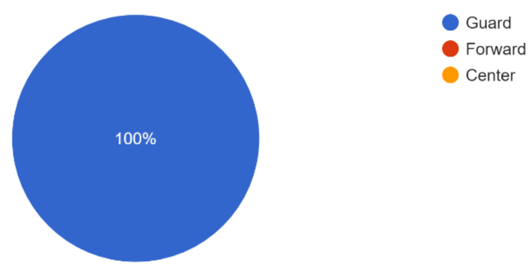
List any previous or current injuries
3 responses

- Sprain ACL
- Pulled muscle
- ACL

What basketball shoes do you currently wear?
3 responses

- Under Armour
- Jordans
- Under Armor (little boys high top shoe)

Basketball Playing Position
4 responses



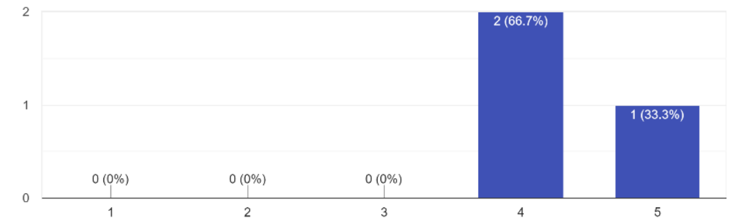
Did you notice any differences in how the shoes fit compared to your current basketball shoes? If so, what are the differences?

4 responses

- The arches are higher
- The arch was higher than my shoes
- They were more snug with much better arch support.
- More arch support and didn't feel as stiff.

How did these shoes fit and feel compared to your current basketball shoes?

3 responses



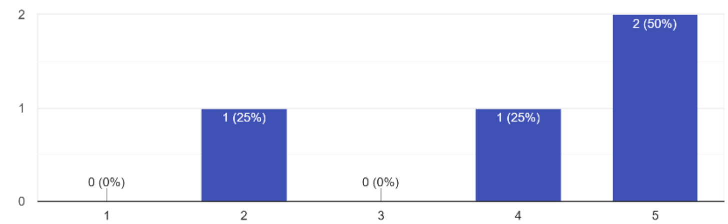
Did you notice any differences in how the shoes fit compared to your current running shoes? If so, what are the differences?

4 responses

- More snug.
- The same thing was the arch
- Being a low top shoe, it still felt like it gave plenty of ankle support. I felt that there were more space in the toe section of the shoe as well.
- A bit looser than my running shoes, I like having my running shoes fit very snug to the top of my foot.

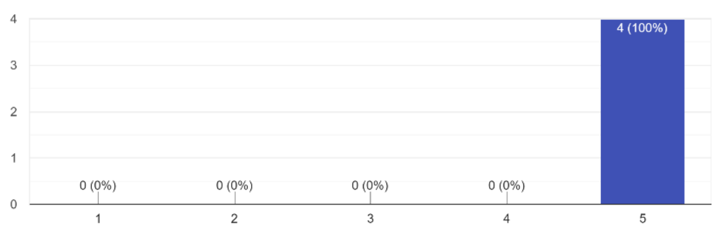
How did these shoes fit and feel compared to your current running shoes?

4 responses



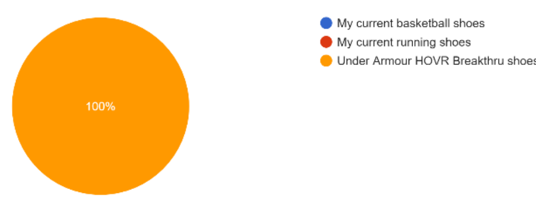
Did you like the added arch support?

4 responses



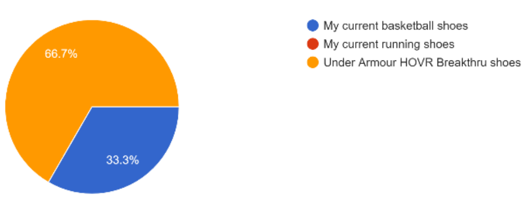
Which shoe felt like it had the most cushioning during the jump test?

3 responses



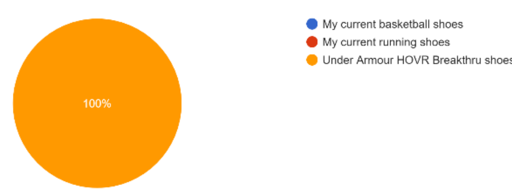
Which shoe felt the most stable during the agility test?

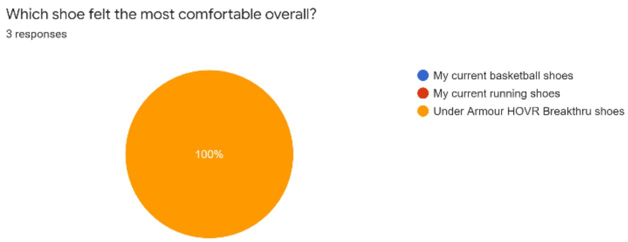
3 responses



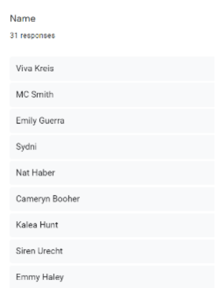
Which shoe felt the most lightweight during the sprint test?

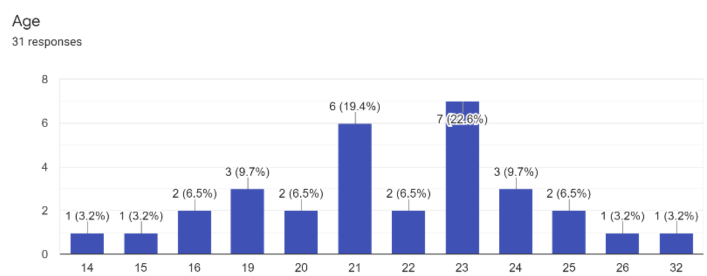
3 responses

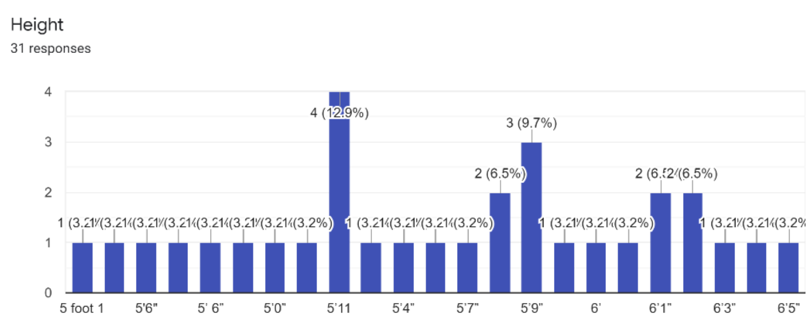


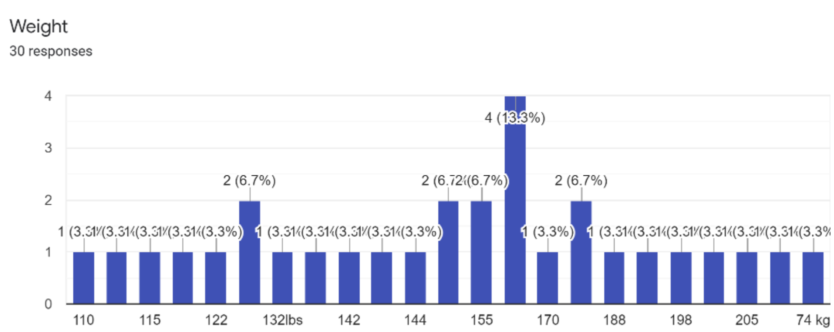


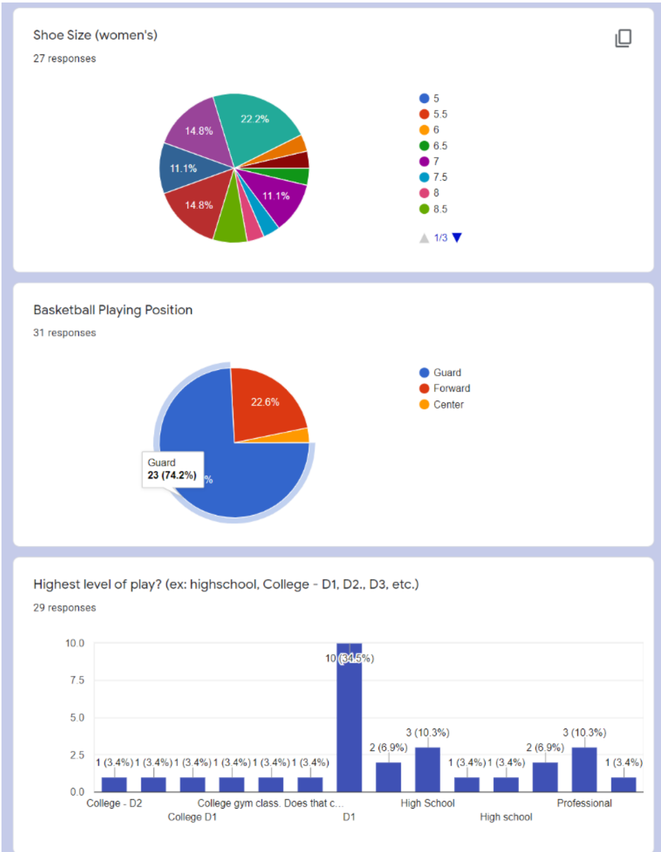
CONSUMER RESEARCH QUESTIONNAIRE & FINDINGS



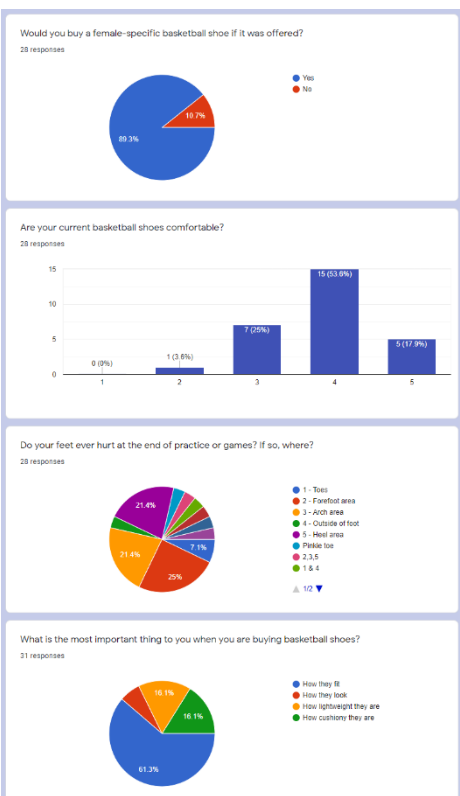


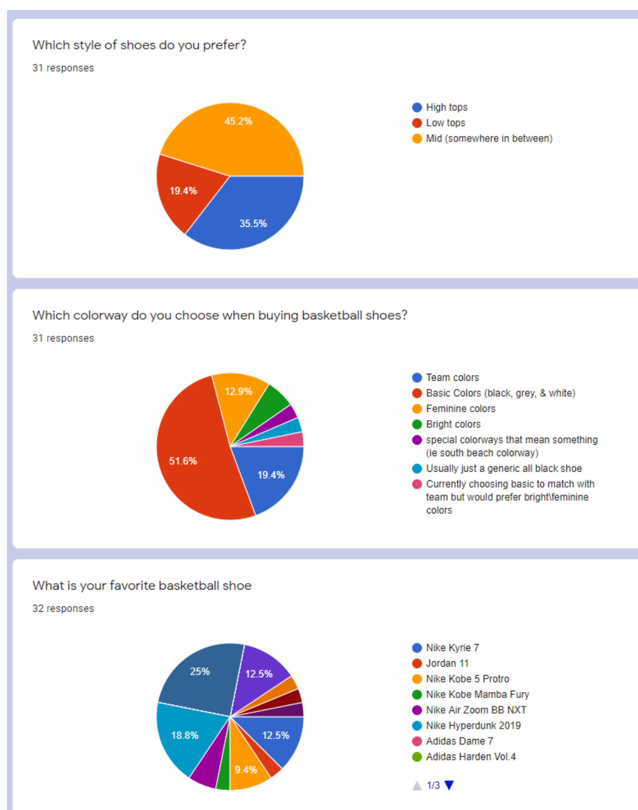


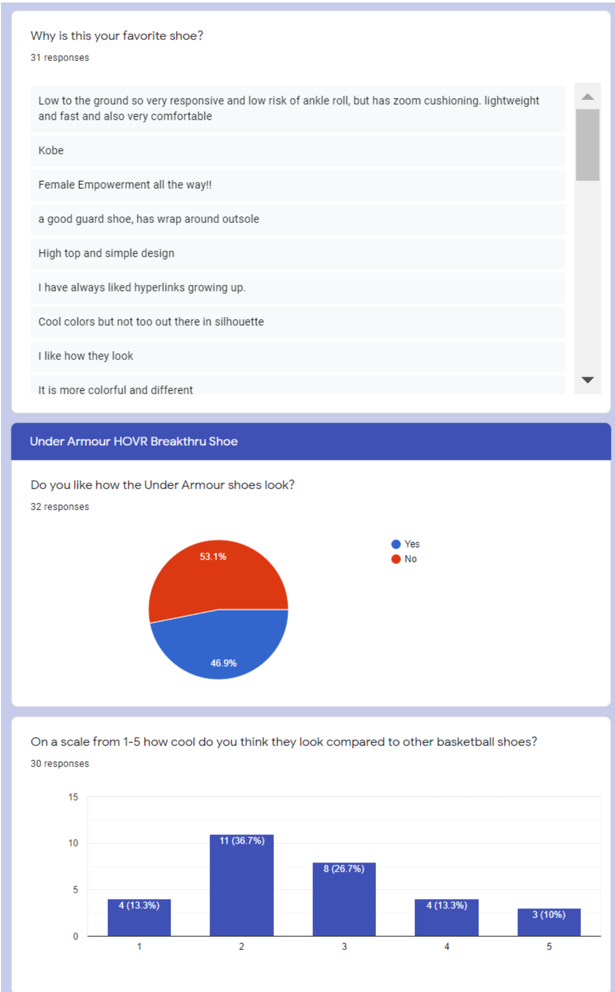


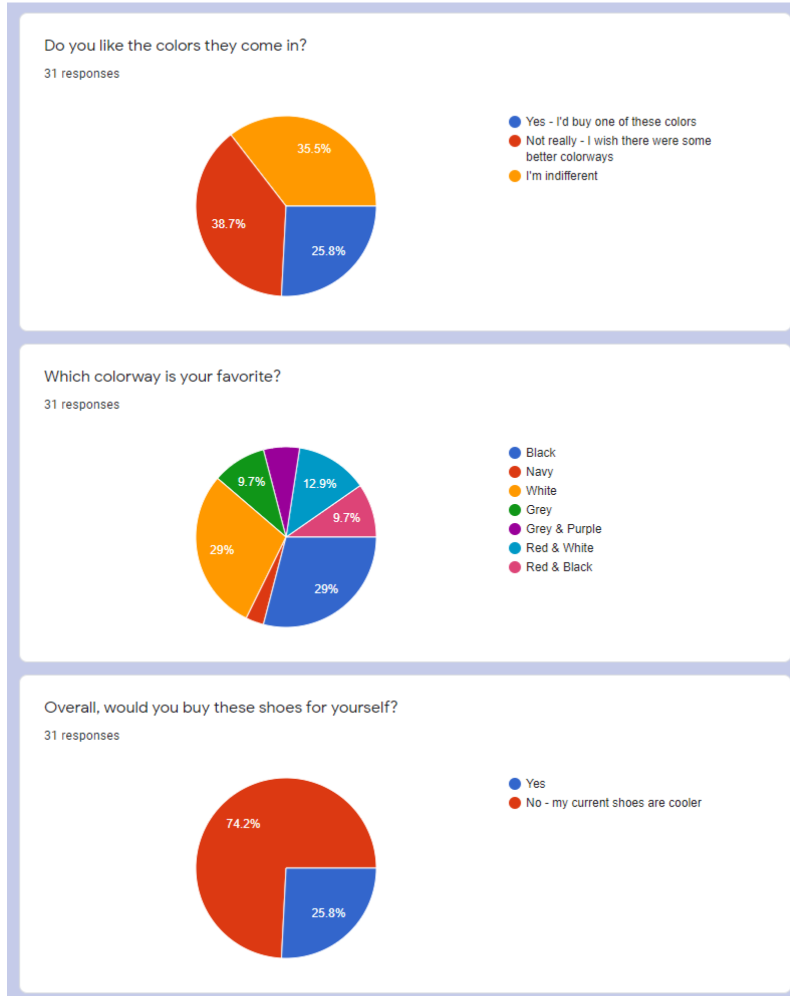

Shoe Size (women's)
27 responses
22.2%
14.8%
11.1%
14.8%
11.1%
5
5.5
6
6.5
7
7.5
8
8.5
1/3
Basketball Playing Position
31 responses
22.6%
Guard
23 (74.2%)
Guard
Forward
Center
Highest level of play? (ex: highschool, College - D1, D2., D3, etc.)
29 responses
10.0
7.5
5.0
2.5
0.0
10 (34.5%)
3 (10.3%)
3 (10.3%)
2 (6.9%)
2 (6.9%)
1 (3.4%)
College - D2
College gym class. Does that c...
High School
Professional
College D1
D1
High school


List any previous or current injuries
28 responses
2
1
0
2 (7.1%)
ACL
Broken hand
PCL tear and meniscus...
Sprained ankle (grade...
sprained ankle, pate...
Achilles Tendinitis, Hip...
Knee surgery on my ca...
Shoulder labrum surgery
Torn meniscus in both...
What basketball shoes do you currently wear?
31 responses
2
1
0
2 (6.5%)
Air Zoom
Kevin Durant
Kyries.
Nike Kybrid S2 (Gra...
Under Armour (little...
KD Trey 5— size 12...
Kyrie 2 Lows (size 1...
Nike Adapt
Nike hyper dunks
lebron soldier, kd13
Basketball Shoe Opinions
Do you have a difficult time finding basketball shoes for yourself?
31 responses
51.6%
48.4%
Yes, it is very hard to find shoes that fit me
No, it is not hard to find shoes that fit me


Would you buy a female-specific basketball shoe if it was offered?
28 responses
10.7%
89.3%
Yes
No
Are your current basketball shoes comfortable?
28 responses
15
10
5
0
0 (0%)
1 (3.6%)
7 (25%)
15 (53.6%)
5 (17.9%)
1
2
3
4
5
Do your feet ever hurt at the end of practice or games? If so, where?
28 responses
21.4%
21.4%
25%
7.1%
1 - Toes
2 - Forefoot area
3 - Arch area
4 - Outside of foot
5 - Heel area
Pinkie toe
2,3,5
1 & 4
1/2
What is the most important thing to you when you are buying basketball shoes?
31 responses
16.1%
16.1%
61.3%
How they fit
How they look
How lightweight they are
How cushiony they are


Which style of shoes do you prefer?
31 responses
45.2%
19.4%
35.5%
High tops
Low tops
Mid (somewhere in between)
Which colorway do you choose when buying basketball shoes?
31 responses
12.9%
51.6%
19.4%
Team colors
Basic Colors (black, grey, & white)
Feminine colors
Bright colors
special colorways that mean something (ie south beach colorway)
Usually just a generic all black shoe
Currently choosing basic to match with team but would prefer bright\feminine colors
What is your favorite basketball shoe
32 responses
25%
12.5%
18.8%
12.5%
9.4%
Nike Kyrie 7
Jordan 11
Nike Kobe 5 Protro
Nike Kobe Mamba Fury
Nike Air Zoom BB NXT
Nike Hyperdunk 2019
Adidas Dame 7
Adidas Harden Vol.4
1/3

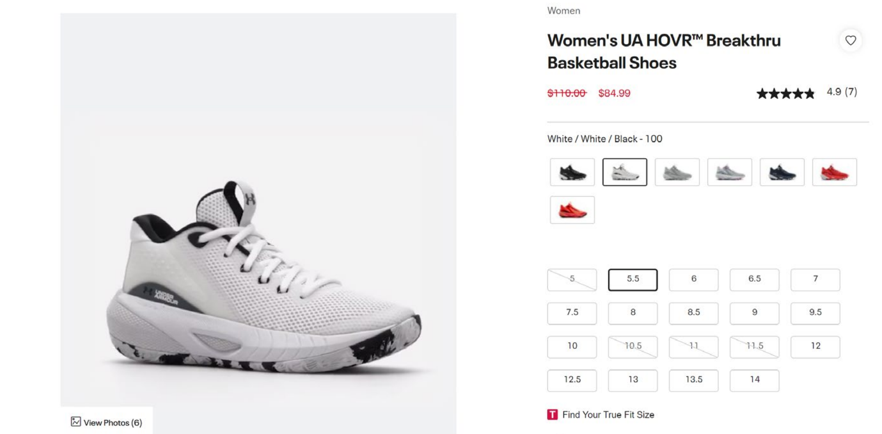

Why is this your favorite shoe?
31 responses
Low to the ground so very responsive and low risk of ankle roll, but has zoom cushioning. lightweight and fast and also very comfortable
Kobe
Female Empowerment all the way!!
a good guard shoe, has wrap around outsole
High top and simple design
I have always liked hyperlinks growing up.
Cool colors but not too out there in silhouette
I like how they look
It is more colorful and different
Under Armour HOVR Breakthru Shoe
Do you like how the Under Armour shoes look?
32 responses
53.1%
46.9%
Yes
No
On a scale from 1-5 how cool do you think they look compared to other basketball shoes?
30 responses
15
10
5
0
4 (13.3%)
11 (36.7%)
8 (26.7%)
4 (13.3%)
3 (10%)
1
2
3
4
5


Do you like the colors they come in?
31 responses
35.5%
38.7%
25.8%
Yes - I'd buy one of these colors
Not really - I wish there were some better colorways
I'm indifferent
Which colorway is your favorite?
31 responses
9.7%
12.9%
9.7%
29%
29%
Black
Navy
White
Grey
Grey & Purple
Red & White
Red & Black
Overall, would you buy these shoes for yourself?
31 responses
74.2%
25.8%
Yes
No - my current shoes are cooler

IDEATION PLANNING

DETAILED SWOT

1. Benchmark Product: Under Armour HOVR Breakthru Women's Basketball Shoe



2. How can we implement female-specific support, stability, and cushioning within basketball footwear to optimize player performance and decrease ACL injury risk?

3. Parts to be improved: shoe upper, sock liner, midsole, outsole

4. "How could we" areas of improvement: support, stability, and cushioning

   More specifically: arch support, specific fit for stability, and lighter cushioning

5. Query paths: Arch support, stability, and cushioning

1. Arch Support Query Paths

A. Shoe Upper / Arch Support
   i. What are the **strengths** of the shoe upper and arch support?
      Shoe upper is flexible and has "strategic support films" that hug the arch

   ii. What are the **weaknesses** of the shoe upper and arch support?
      Shoe upper connects directly into midsole and does not provide any dynamic arch support

   iii. What are the **opportunities** of the shoe upper and arch support?
      Integrate an arch activation system within the interface between the upper and midsole that helps arch rebound from impact and provides proprioceptive properties

      Create a tightening/lacing system that allows the user to adjust their level of arch support/pressure

Utilize a more tapered silhouette around arch area

iv. What are the **threats** of the shoe upper and arch support?
The HOVR model is basic and provides no dynamic arch support properties, making it less technically advanced than other shoes

B. Sock liner / Arch Support
i. What are the **strengths** of the sock liner and arch support?
"3D molded sock liner for underfoot cushioning & support" (UA, n.d.)
Has female-specific fit and arch support

ii. What are the **weaknesses** of the sock liner and arch support?
The sock liner provides arch support in the form of an insole (from the bottom up) rather than an activation system (From the top down).

iii. What are the **opportunities** of the sock liner and arch support?
Create a design that utilizes both the upper and sock liner to provide a dynamic arch rebound activation system. Also provide

iv. What are the **threats** of the sock liner and arch support?
Store-bought or orthopedic insoles that provide arch support
Athletes with flat feet that find arch support uncomfortable

C. Midsole / Arch Support
i. What are the **strengths** of the midsole and arch support?
Additional arch support shank within midsole

ii. What are the **weaknesses** of the midsole and arch support?
Shank is stiff and does not provide dynamic arch support. May be uncomfortable to users with flat feet

iii. What are the **opportunities** of the midsole and arch support?
Add additional cushioning specifically around the midsole region of some sort of more flexible foam/cushioning technology that caters to the movement of the arch

iv. What are the **threats** of the midsole and arch support?
Adding too much arch support can cause the shoe to lose stability. Need to find the best balance between arch support and stability. Streamlined design with minimal vertical bulk

D. Outsole / Arch Support
i. What are the **strengths** of the outsole and arch support?
Outsole is slightly tapered around arch region

ii. What are the **weaknesses** of the outsole and arch support?
There is outsole material under the arch region that potentially goes unused and might be adding extraneous weight to the shoe

iii. What are the **opportunities** of the outsole and arch support?
Subtract the arch region of the outsole from the shoe if it does not provide extra traction to the wearer. Study wear tests on basketball shoes to analyze if this traction region is necessary

iv. What are the **threats** of the outsole and arch support?
This outsole design adds unnecessary weight to the shoe and potentially makes it heavier than competitors on the market

2. Stability Query Paths

A. Shoe Upper / Stability

i. What are the **strengths** of the shoe upper and stability?
The shoe upper is a "breathable mesh upper with strategic support films, designed specific to the anatomy of the female hooper"
The upper provides lightweight support for lateral movements

ii. What are the **weaknesses** of the shoe upper and stability?
The shoe upper is slightly bulky and has little reinforcement to the interface with the midsole with presents tear out risk during lateral cutting movements

iii. What are the **opportunities** of the shoe upper and stability?
Create a system like flywire that provides extremely lightweight lateral reinforcement. Another option is to add TPU film near the upper/midsole interface to create a stronger bond for better lateral stability

Change silhouette/ ankle collar to provide better lateral stability

iv. What are the **threats** of the shoe upper and stability?
The shoe upper is basic and provides an average amount of stability but does not stand out among other products in the market

B. Sock liner / Stability

i. What are the **strengths** of the sock liner and stability?
Sock liner is 3D molded to enhance fit and reduce foot slip within the shoe

ii. What are the **weaknesses** of the sock liner and stability?
The sock liner construction is smooth and doesn't provide lateral stability

iii. What are the **opportunities** of the sock liner and stability?
Add some form of texture or molding up the sidewalls to provide lateral stability and prevent the foot from slipping within the shoe

iv. What are the **threats** of the sock liner and stability?
Store-bought insoles can be bought to provide texture within the footbed

C. Midsole / Stability

i. What are the **strengths** of the midsole and stability?

"Internal shank for extra midfoot stability" (UA, n.d.)

ii. What are the **weaknesses** of the midsole and stability?
Midsole is thick and does not provide a "close to ground feel" that is generally in guard-specific shoes to promote stability during lateral movements

iii. What are the **opportunities** of the midsole and stability?
Utilize a thinner midsole with a different cushioning strategy that places the user closer to the ground

iv. What are the **threats** of the midsole and stability?
Nike technologies such as the KD's "Nike Air Zoom" that are stitched directly into the upper or the Kyrie's curved "Air Zoom Turbo" unit that allow more responsive court feel and heightened banking ability

D. Outsole / Stability

i. What are the **strengths** of the outsole and stability?
"Rubber outsole uses herringbone traction pattern to provide maximum floor control & grip" (UA, n.d.)
The modified herringbone pattern provides superior traction

ii. What are the **weaknesses** of the outsole and stability?
The outsole has the same constant padding throughout the entire length of the foot and provides no specific zoning

iii. What are the **opportunities** of the outsole and stability?
Analyze outsole shoe wear among various shoes to determine the optimal traction zoning patter – add a circular pivot point under the forefoot and extended sidewalls

iv. What are the **threats** of the outsole and stability?
The HOVR Breakthru outsole is incredibly basic and lacks the individuality of other shoes found in the market

3. Cushioning Query Paths

A. Shoe Upper / Cushioning

i. What are the **strengths** of the shoe upper and cushioning?
The shoe upper is mesh with a "half bootie construction with molded collar for a comfortable fit & anatomically correct support"
Shoe upper does not pertain to underfoot cushioning

ii. What are the **weaknesses** of the shoe upper and cushioning?
Shoe upper does not pertain to underfoot cushioning

iii. What are the **opportunities** of the shoe upper and cushioning?
Shoe upper does not pertain to underfoot cushioning

iv. What are the **threats** of the shoe upper and cushioning?

Shoe upper does not pertain to underfoot cushioning

B. Sock liner / Cushioning
   i. What are the **strengths** of the sock liner and cushioning?
      The sock liner provides an extra layer of cushioning to the shoe

   ii. What are the **weaknesses** of the sock liner and cushioning?
      Providing cushioning within the sock liner may be an inefficient way to provide cushioning and could potentially be adding extraneous bulk & weight

   iii. What are the **opportunities** of the sock liner and cushioning?
      Scrap the idea of a cushioned sock liner and instead add that weight and technology to the shoe's midsole. Focus on the sock liner fitting the foot anatomically and providing arch proprioception instead

   iv. What are the **threats** of the sock liner and cushioning?
      This cushioned sock liner might make the shoe heavier but also less comfortable than other products on the market

C. Midsole / Cushioning
   i. What are the **strengths** of the midsole and cushioning?
      "UA HOVR™ technology provides 'zero gravity feel' to maintain energy return that helps eliminate impact"
      "Compression mesh Energy Web contains & molds UA HOVR™ foam to give back the energy you put in"
      Superior energy return and impact elimination for explosive movement

   ii. What are the **weaknesses** of the midsole and cushioning?
      Cushioning is stacked slightly higher than most basketball shoes which makes the shoe a little unstable

   iii. What are the **opportunities** of the midsole and cushioning?
      Utilize a super lightweight and flexible foam for female athletes who are an average of ~60 lbs lighter than male athletes to optimize speed and flexibility and prevent undue strain on lower limb (knee) joints

   iv. What are the **threats** of the midsole and cushioning?
      Proprietary technologies such as Nike Air Zoom units which are incredibly lightweight and responsive

D. Outsole / Cushioning
   i. What are the **strengths** of the outsole and cushioning?
      The outsole is made of a soft rubber compound that promotes flexibility

   ii. What are the **weaknesses** of the outsole and cushioning?
      The outsole does not cover enough of the midsole sidewalls for agile players who spend time on the sides of their feet

iii. What are the **opportunities** of the outsole and cushioning?
Explore traction patterns and rubber compounds that provide the optimal amount of traction and flexibility to the foot

iv. What are the **threats** of the outsole and cushioning?
Other shoe models such as the Nike Kyrie and Nike KD have more elevated outsole/midsole integrated systems than this shoe

FUNCTIONAL IDEATION PLAN

PRODUCT - Guard Shoe	
UPPER	
Problem Identification from research	Ideation Path
SWOT Opportunity: More Lightweight / Less bulky	- Engineered knit - Sock-like feel - Reduce use of foam in ankle-collar - TPU films
SWOT Opportunity: Lateral Stability	- Flywire system - minimal structure - TPU membranes - Straps - Lacing system - Material Layering
SWOT Opportunity: Female Fit	- 3D foot scanning - Wide forefoot area - Female sport last - Stretchy upper material across forefoot
Benchmark and SWOT Opportunity: Arch Support	- Integrate “arch activation system” within upper/midsole interface to promote arch activation and rebounding - Dynamic lacing system specifically for arch - Dynamic tightening system specifically for arch: straps, Velcro, “burton speed pulls” - Boa-type tightening system - Rubber band suspension arch bridge

Benchmark Opportunity: Less bulky upper	- Different lacing system to allow more room - Utilize thinner tongue material - Eliminate tongue – sock-like fit - Engineered knit
Consumer Opportunity: Comfortable arch support	- Dynamic arch rebounding system rather than static molded sockliner
Consumer Opportunity: “We don’t like mid-cuts”	- Make guard shoe a low top - Design shoe specifically to female ankle anatomy to avoid unnecessary rubbing/pressure on medial malleolous - 3D foot scanning
	- Make forward shoe a low top*
	- Make center shoe a high top ** - Use 3D foot scanning to ensure shoe cuts above medial malleolus - Lacing system for extra ankle stability

PRODUCT - Guard Shoe	
SOCK LINER	
Problem Identification from research	Ideation Path
Benchmark Opportunity: Cushioning System	- Utilize cushioning system within sock liner to reduce midsole size (Nike Kobe zoom insoles) - Air zoom units - Foam cushioning (3D molded)
Consumer Opportunity: Enhance Comfort	- 3D molded sock liner in UA HOVR Breaktrhu is uncomfortable for many wearers - Reduce arch support within sock liner

<table>
<tr><th colspan="2">PRODUCT - Guard Shoe</th></tr>
<tr><th colspan="2">MIDSOLE</th></tr>
<tr><th>Problem Identification from research</th><th>Ideation Path</th></tr>
<tr><td>SWOT Opportunity: Flexibility</td><td>- Flexible midsole shank
- Lightweight foam
- Less dense foam</td></tr>
<tr><td>SWOT Opportunity: More Lightweight / Less bulky</td><td>- Utilize lightweight foam
- Zoom units in sockliner
- Streamline midsole cushioning design
- Cutout under arch region – Lebron 15
</td></tr>
<tr><td>Benchmark Opportunity: Stability</td><td>- Reallocate cushioning assets to reduce midsole thickness
- Lower shoe closer to ground
- Use thinner midsole foam</td></tr>
<tr><td>Benchmark Opportunity: Less bulky</td><td>- Streamline midsole cushioning
- Reallocate cushioning assets into sock liner to provide ‘closer to ground’ feel</td></tr>
<tr><td rowspan="3">Benchmark Opportunity: Make position specific</td><td>- Create more responsive feel
- Use firmer foam</td></tr>
<tr><td>- Use thinner amount of foam of same density</td></tr>
<tr><td>- Add slight heel flare</td></tr>
</table>

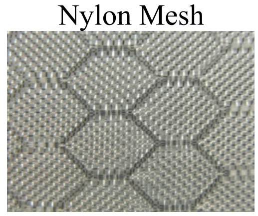
PRODUCT - Guard Shoe	
OUTSOLE	
Problem Identification from research	Ideation Path
SWOT Opportunity: Traction	- Increase surface area of outsole - Add lateral and medial extended outrigger (Nike Kyrie series)
SWOT Opportunity: Female specific	- Female loading patterns - Traction zoning under lateral column and midfoot
Benchmark Opportunity: Make Position Specific	- Add traction patterns specific to lateral movement - Traction zoning under foot - Different herringbone patterns
	- Have general traction zoning - Pivot points under forefoot
	- Utilize aggressive herringbone traction - Large pivot point under forefoot

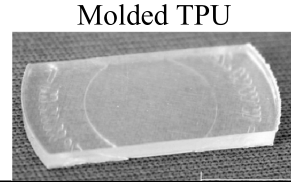
* green cells refer to forward-specific shoe

** blue cells refer to center-specific shoe

AESTHETIC IDEATION PLAN

MATERIAL RESOURCING PLAN

GUARD SHOE			
PART	PERFORMANCE GOALS	MATERIAL THAT WILL SOLVE THIS	IDEAS OF WHERE TO SOURCE THE MATERIAL
Upper	Breathability	Nylon Mesh 	-Look in bins -Look under tables in studios -Buy online (Amazon) -Buy at Mill End -Call local material vendors -Contact suppliers through NW show -Mock up via laser cutting -Take mesh from existing shoes/products
Toe Cap	Strength and stability	TPU Film 	-Look in bins -Look under tables in studios -Buy online (Amazon) -Buy at Mill End -Call local material vendors -Contact suppliers through NW show

Heel Counter	Foot Lockdown	TPU Film	Same as above
Heel Collar	Comfort	KFF PU Foam and polyester jersey 	-Look in bins for foam, die or laser cut -Buy online (Amazon) -Call local material vendors -Contact suppliers through NW show -Source from existing pair of shoes -Source from existing sports product (padding)
Upper – Arch Activation System	Arch Activation - stretch	Polyester Latex Elastic Band 	-Look in bins -Look under tables in studios -Look in hallway near 3D room -Look in Nucleus -Buy at Mill End -Buy online (Amazon) -Take off of existing product -Ace wrap bandages? -Sew multiple elastic pieces together -Mock it using spandex material
Shank	Flexible Support	Molded TPU 	-Mock it with 3D printing -Cast it with 3D part -Contact composite scrapper -Buy existing shank plate online (Amazon)
Sock liner	Comfort	EVA Foam 	-Look in Bins -Look under tables in studios -Buy online (Amazon) -Buy at Mill End -Call local material vendors -Laser cut and vacuum form -Use existing sockliners -Create my own foam layering multiple foam pieces
Sockliner Cushioning Elements	Cushioning	Foam Composites Gel Nike Air unit 	-Create my own foam layering systems -Source from existing products (Nike zoom air unit in Kobe shoe insoles) -Create my own "gel units" -Source Gel units from existing shoes -Laser cut pockets within sockliner foam for cushioning elements -Buy cushioning element online
Midsole	Cushioning	Compression Molded EVA Foam	-Laser cut foam found in bins or elsewhere in studio

FORWARD SHOE			
PART	PERFORMANCE GOALS	MATERIAL THAT WILL SOLVE THIS	IDEAS OF WHERE TO SOURCE THE MATERIAL
Upper	Breathability	Nylon Mesh	Same as guard shoe
Toe Cap	Strength and stability	TPU Film	Same as guard shoe
Heel Counter	Foot Lockdown	TPU Film	Same as guard shoe
Heel Collar	Comfort	KFF PU Foam and polyester jersey	Same as guard shoe
Shank	Flexible Support	Molded TPU	Same as guard shoe
Sock liner	Comfort	EVA Foam	Same as guard shoe
Midsole	Cushioning	Compression molded EVA Foam	Same as guard shoe
Midsole Cushioning Elements	Cushioning	Foam Composites Gel Nike Air Unit 	-Create my own foam layering systems -Source from existing products (Nike zoom air unit in Kobe shoe insoles) -Create my own "gel units" -Source Gel units from existing shoes -Laser cut pockets within sockliner foam for cushioning elements -Buy cushioning element online
Outsole	Traction	Molded Rubber	Same as guard shoe
			-Die cut foam -Could mock it with 3D printing -Could mock it by casting from a 3D part -Could mock it by making my own foam cast -Could source from existing shoe -Could buy online (Amazon)
Outsole	Traction	Molded Rubber 	-Could source from existing pair of shoes -Could buy online (Amazon, AliExpress) -Could mock it with 3D printing -Could mock it by laser cutting traction pattern into foam

CENTER SHOE			
PART	PERFORMANCE GOALS	MATERIAL THAT WILL SOLVE THIS	IDEAS OF WHERE TO SOURCE THE MATERIAL
Upper	Breathability	Nylon Mesh	Same as guard shoe
Toe Cap	Strength and stability	TPU Film	Same as guard shoe
Heel Counter	Foot Lockdown	TPU Film	Same as guard shoe
Heel Collar	Comfort	KFF PU Foam and polyester jersey	Same as guard shoe
Shank	Stability	Carbon Fiber 	-Contact composite scrapper -Could mock it with 3D printing -Could cast it from 3D part -Could lay-up carbon part
Sock liner	Comfort	EVA Foam	Same as guard shoe
Midsole	Cushioning	Compression molded EVA Foam	Same as guard shoe
Midsole Cushioning Elements	Cushioning	Foam Composites Gel Nike Air Unit	-Create my own foam layering systems -Source from existing products (Nike zoom air unit in Kobe shoe insoles) -Create my own “gel units” -Source Gel units from existing shoes -Laser cut pockets within sockliner foam for cushioning elements -Buy cushioning element online
Outsole	Traction	Molded Rubber	Same as guard shoe

IDEATION PLAN TIMELINE

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
2/7	2/8	2/9	2/10	2/11	2/12	2/13
	MIDTERM PREVIEW	**MIDTERM PREP**	**MIDTERM PREP**	**MIDTERM (11-11:15)**	**BREAK**	-Material selection *~1 hour* -Upper sketching (30 ideas) *~3 hours*
2/14	2/15	2/16	2/17	2/18	2/19	2/20
-Upper making (15 ideas) *~3 hours* -Midsole sketching (25 ideas) -Insole sketching (25 ideas) *~2 hours*	**-Class (2-5)** -Midsole sketching (25 ideas) -Insole sketching (25 ideas) *~2 hours*	-Outsole sketching (50 ideas) -Draw ideas on last (5 ideas) *~3 hours*	**-CLASS (2-5)** -3D drafting (best ideas) *~4 hours*	**-Ind. Study (1-2)** -3D drafting (best ideas) *~4 hours*	-3D drafting (best ideas) *~4 hours*	-Material selection *~1 hour* -Upper sketching (30 ideas) *~3 hours*
2/21	2/22	2/23	2/24	2/25	2/26	2/27
-Upper making (15 ideas) *~3 hours* -Midsole sketching (25 ideas) -Insole sketching (25 ideas) *~2 hours*	**-Class (2-5)** -Midsole sketching (25 ideas) -Insole sketching (25 ideas) *~2 hours*	-Outsole sketching (50 ideas) -Draw ideas on last (5 ideas) *~3 hours*	**-CLASS (2-5)** -3D drafting (best ideas) *~4 hours*	**-Ind. Study (1-2)** -3D drafting (best ideas) *~4 hours*	-3D drafting (best ideas) *~4 hours*	-Material selection *~1 hour* -Upper sketching (30 ideas) *~3 hours*
2/28	3/1	3/2	3/3	3/4	3/5	3/6
-Upper making (15 ideas) *~3 hours* -Midsole sketching (25 ideas) -Insole sketching (25 ideas) *~2 hours*	**-Class (2-5)** -Midsole sketching (25 ideas) -Insole sketching (25 ideas) *~2 hours*	-Outsole sketching (50 ideas) -Draw ideas on last (5 ideas) *~3 hours*	**-CLASS (2-5)** -3D drafting (best ideas) *~4 hours*	**-Ind. Study (1-2)** -3D drafting (best ideas) *~4 hours*	-3D drafting (best ideas) *~4 hours*	**FINAL REVIEW PREP**
3/7	3/8	3/9	3/10			
FINAL REVIEW PREP	**FINAL REVIEW**		**FINAL REVIEW**			

IDEATION

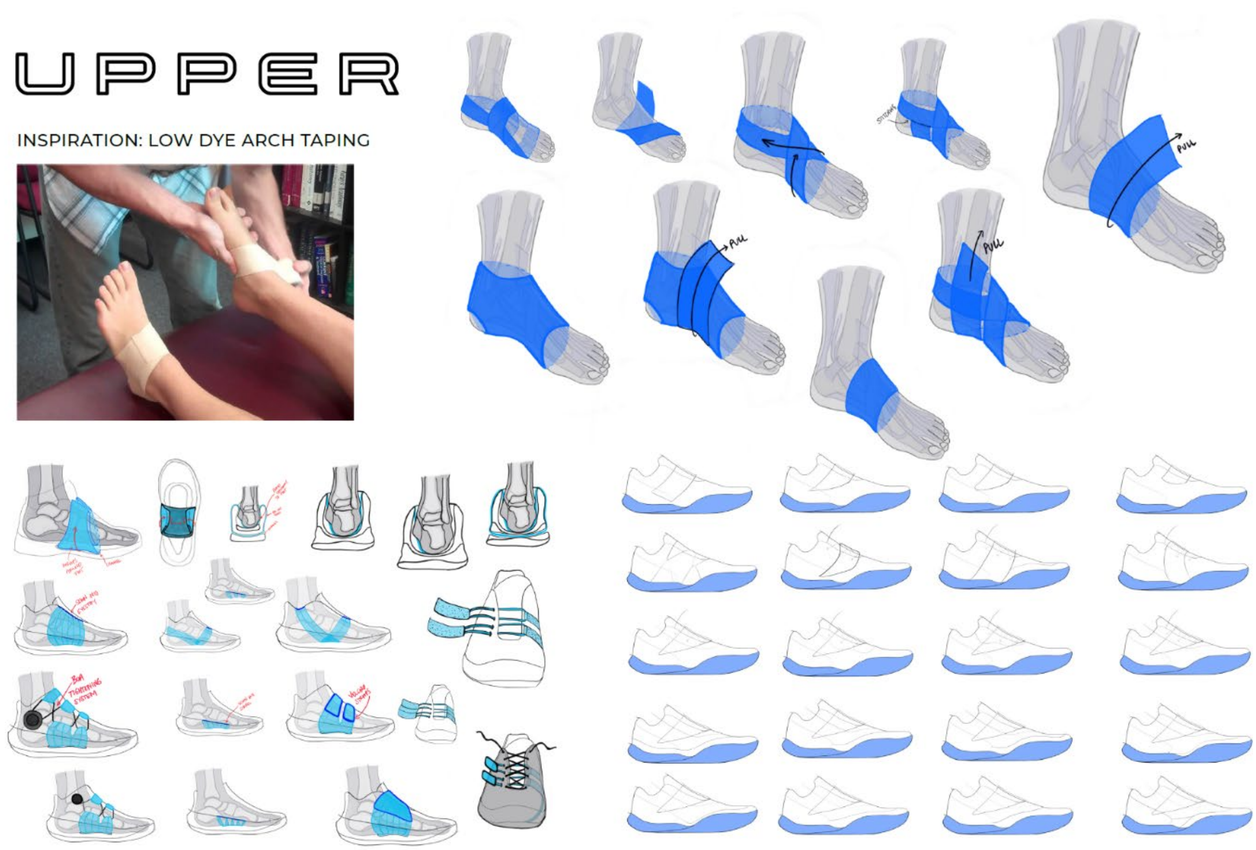
LAST SPECIFICATIONS

1. Female Last
2. Women's size 8
3. Offset: 6 mm
4. Forefoot net: 94 mm		Rearfoot net: 75 mm
5. Last performance attributes: Female specific fit, higher arch

SKETCHING IDEATION

Upper

The research findings from both the pressure insoles and 2D motion capture indicated that adequate arch support in a shoe had a positive effect on knee alignment and plantar loading. Consumer research also suggested a need for arch support within basketball shoes. As a result, the main goals for the upper were: 1. how to implement arch taping into a shoe and 2., how to make that arch support adjustable for the user. Sketching was therefore used to ideate several arch activation systems.



Midsole

The research findings also indicated a strong correlation between the cushioning systems within the women's running and HOVR basketball shoe and correct knee alignment and plantar loading. Pressure insole and consumer feedback data were used to map out the cushioning zones of each shoe. The guard shoe features a drop-in midsole to create an agility-focused, close-to-ground feel whereas the forward and center shoes feature a classic midsole with imbedded cushioning units

BACKGROUND:
Female players are ~27% lighter than male players → Midsole cushioning needs to be 27% more flexible → Female running shoe was softest + encouraged best landing technique

GOAL:
Comine soft running cushion with basketball stability + responsiveness → IMPLEMENTATION:
Utilize insole pressure maps to create a mix of firm and soft cushioning

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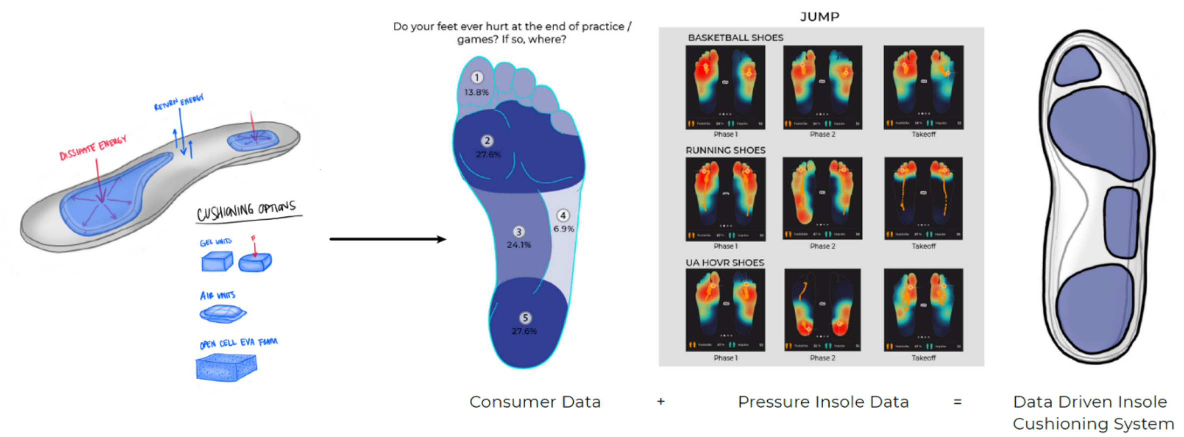
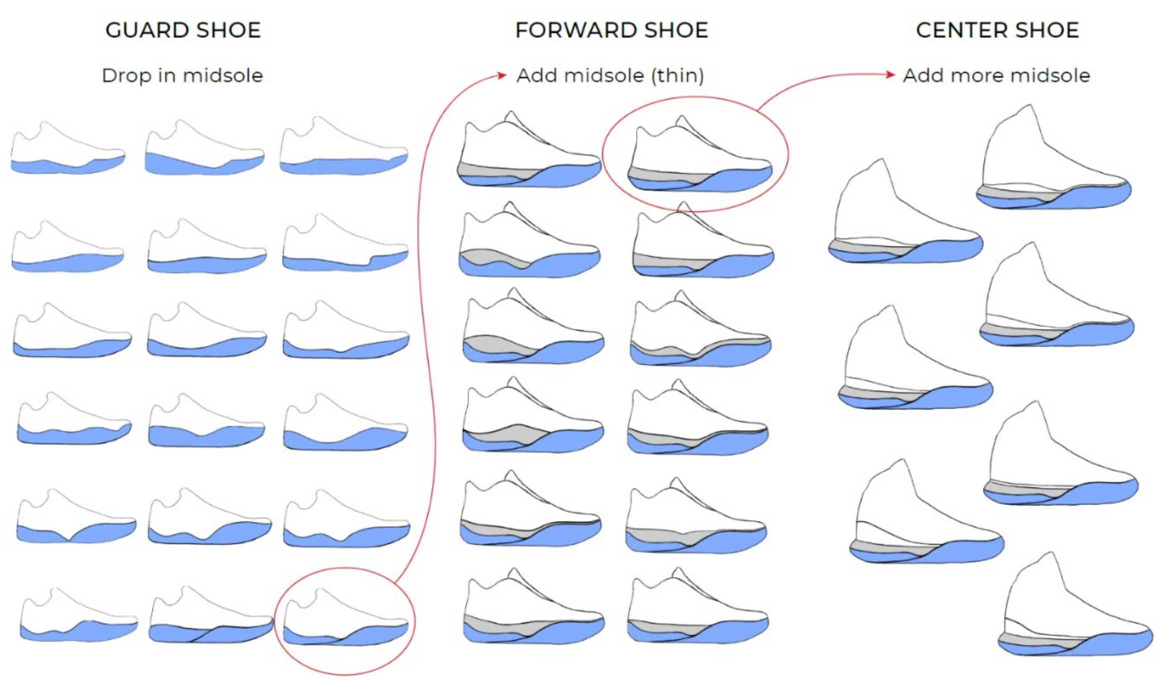
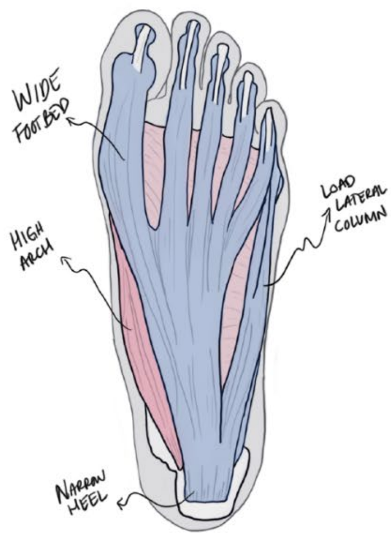
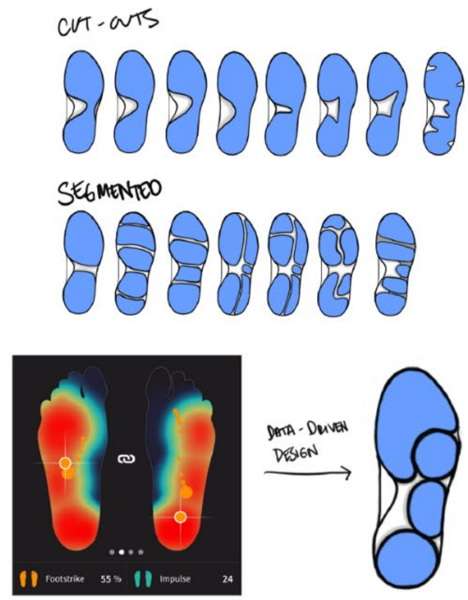




Outsole

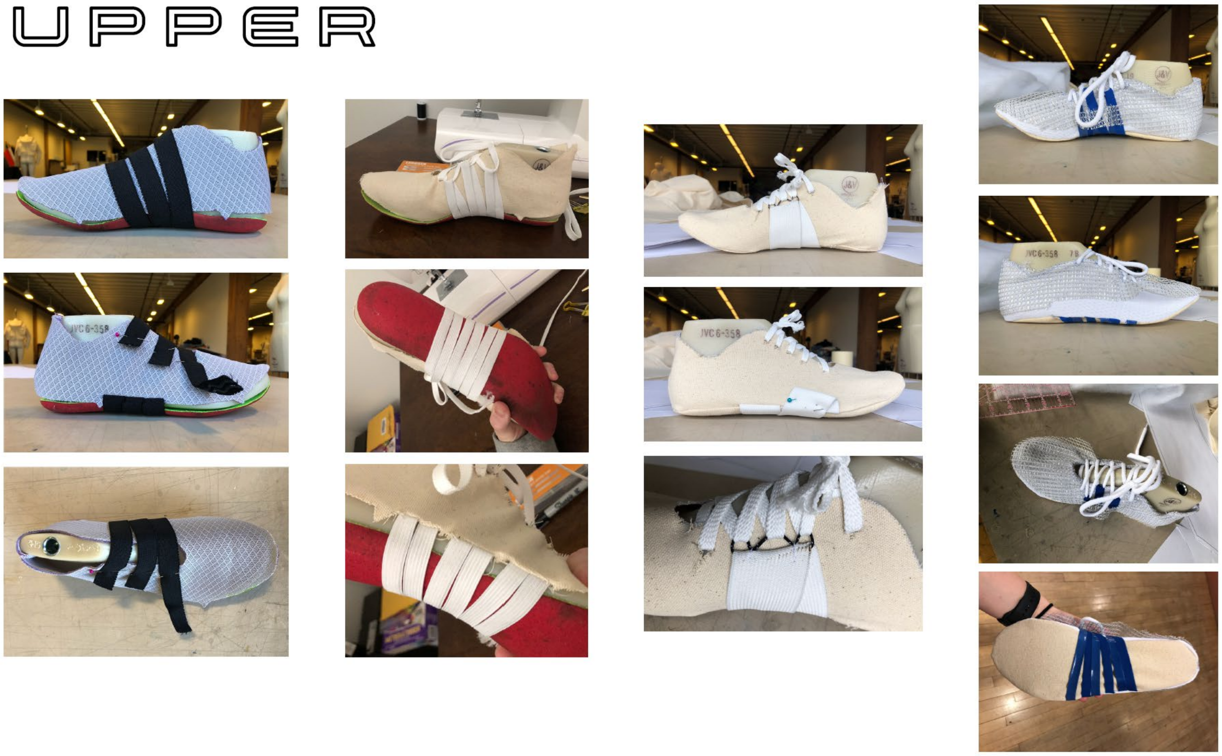
Findings from the pressure insoles were again used to drive the zoning out the outsole traction pattern.



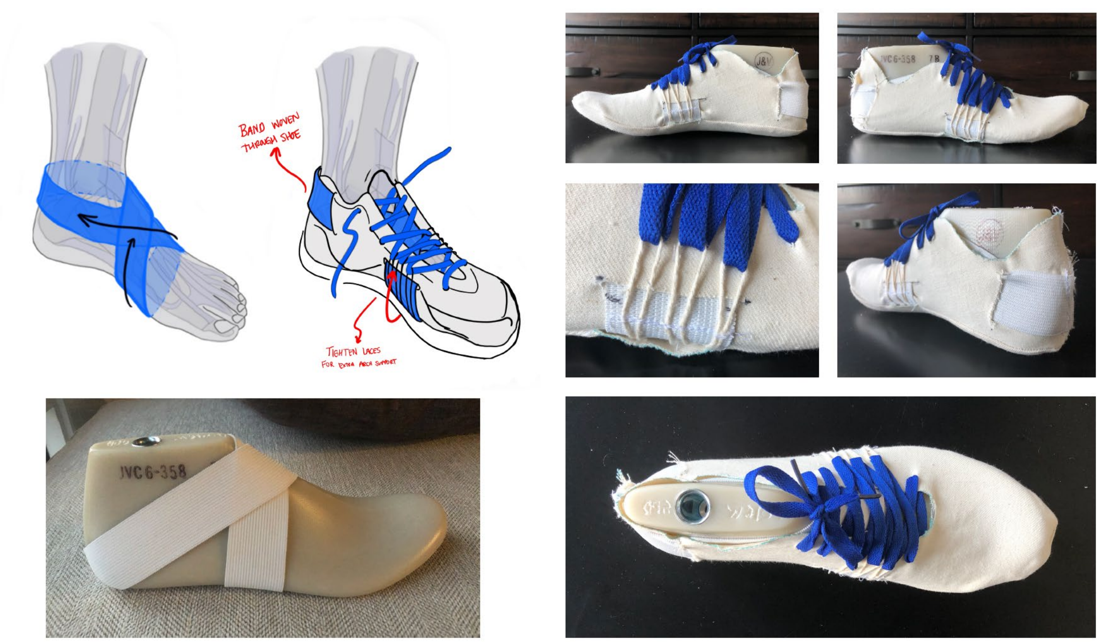


PROTOTYPING

UPPER



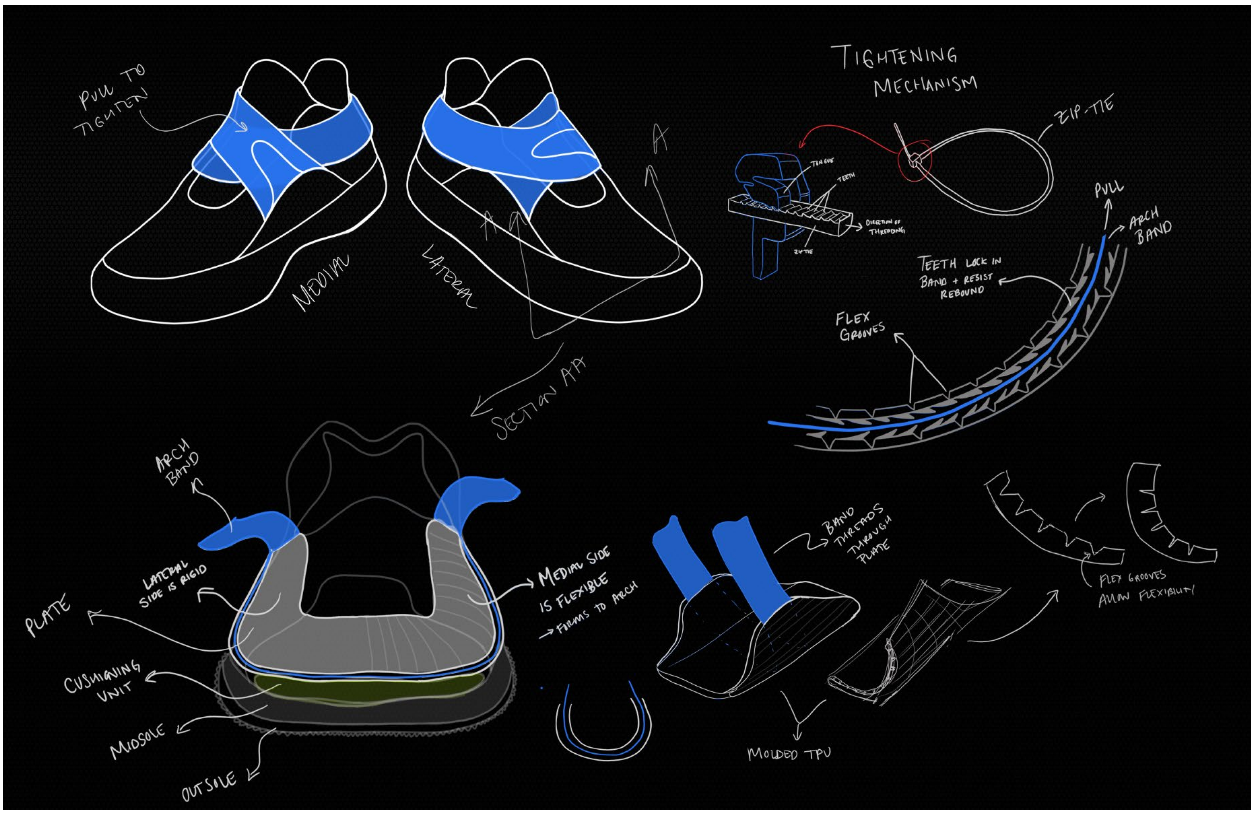
UPPER

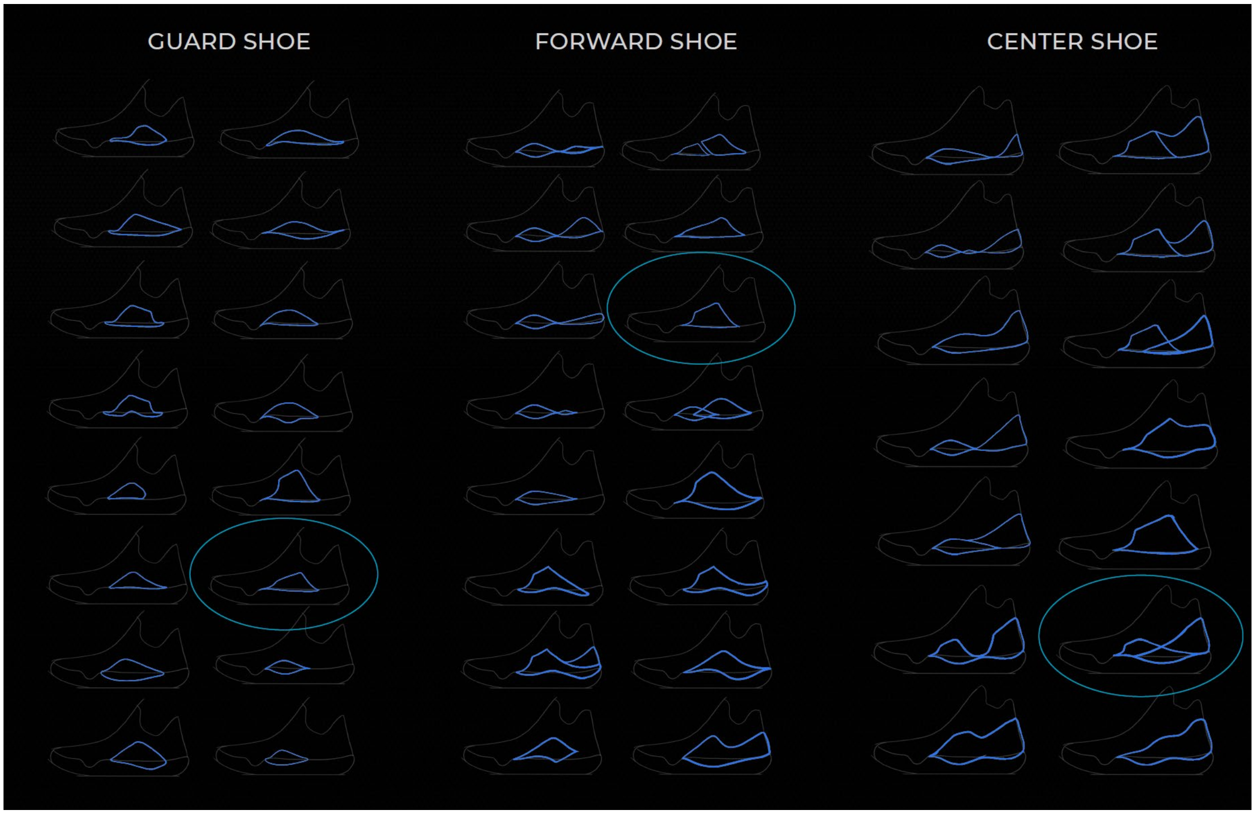

BAND WOVEN THROUGH SHOE
TIGHTEN LACES FOR EXTRA ARCH SUPPORT

TECHNOLOGY INTEGRATION

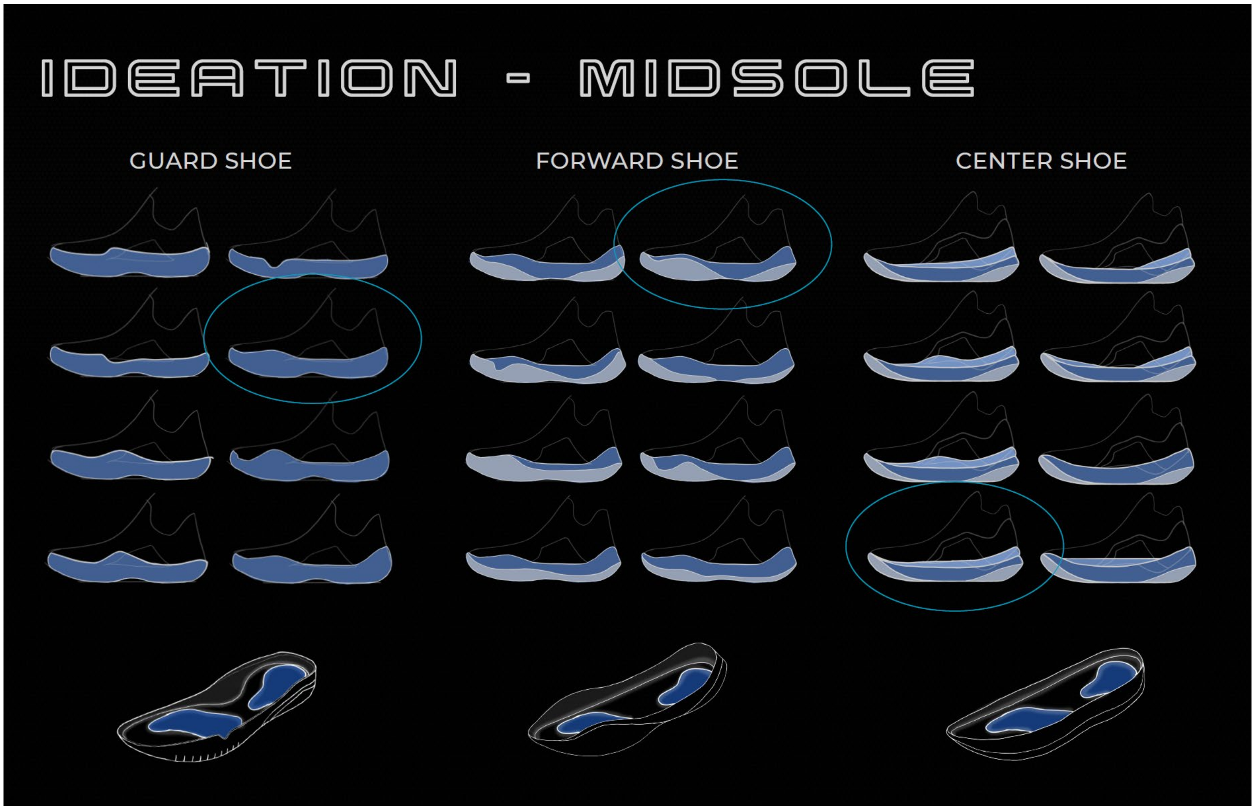
Arch Activation System

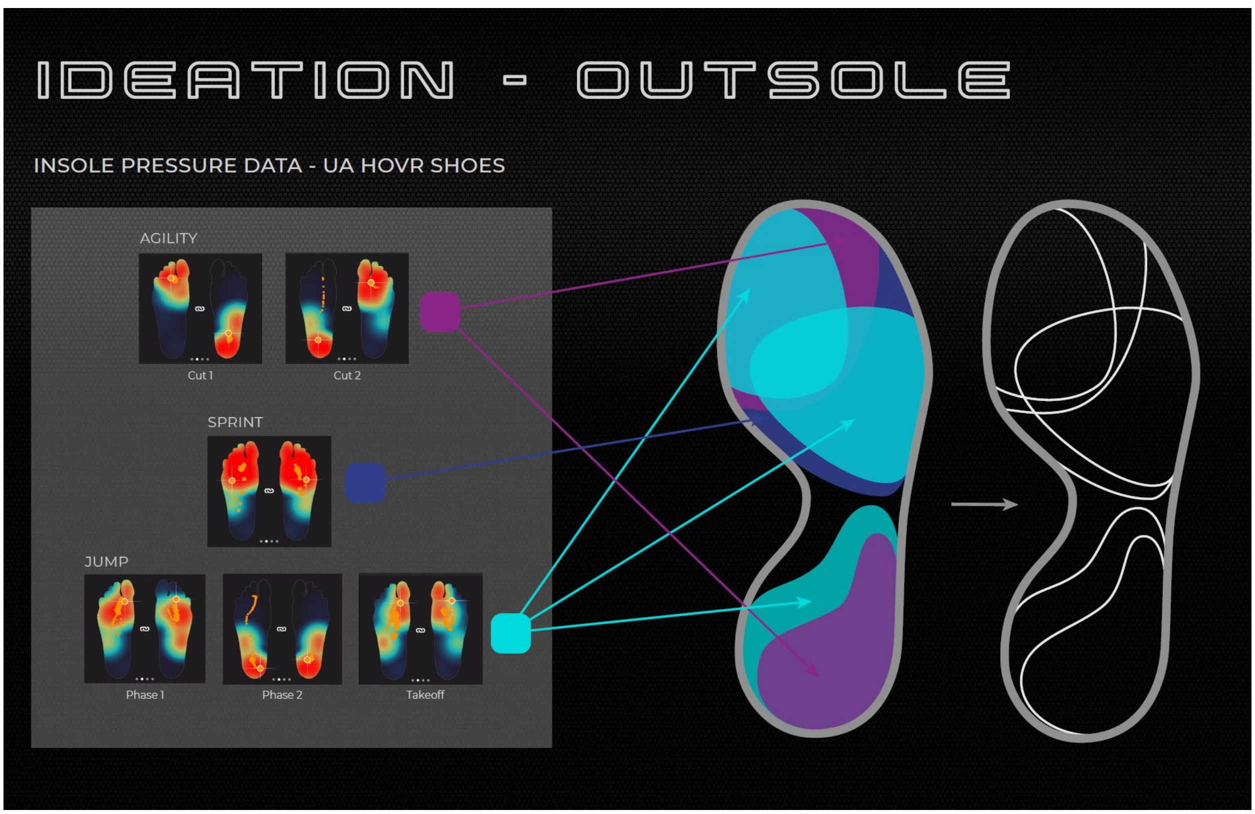
The arch activation system features a continuous elastic band that wraps around the food to support the arch during movement. The band is stretchy and can be pulled to tighten. There is a molded TPU plate that sits between the insole and midsole that acts as a channel for the band to run through, allowing the band to be continuous. Within the plate are flex grooves that provide the plate the ability to bend as the band is pulled, which creates the activation of the arch. Inside the plate are small teeth which mimic the function of a zip-tie system by allowing the band to flow through but resisting its rebound back. These teeth allow the system to be tightened in specific areas.

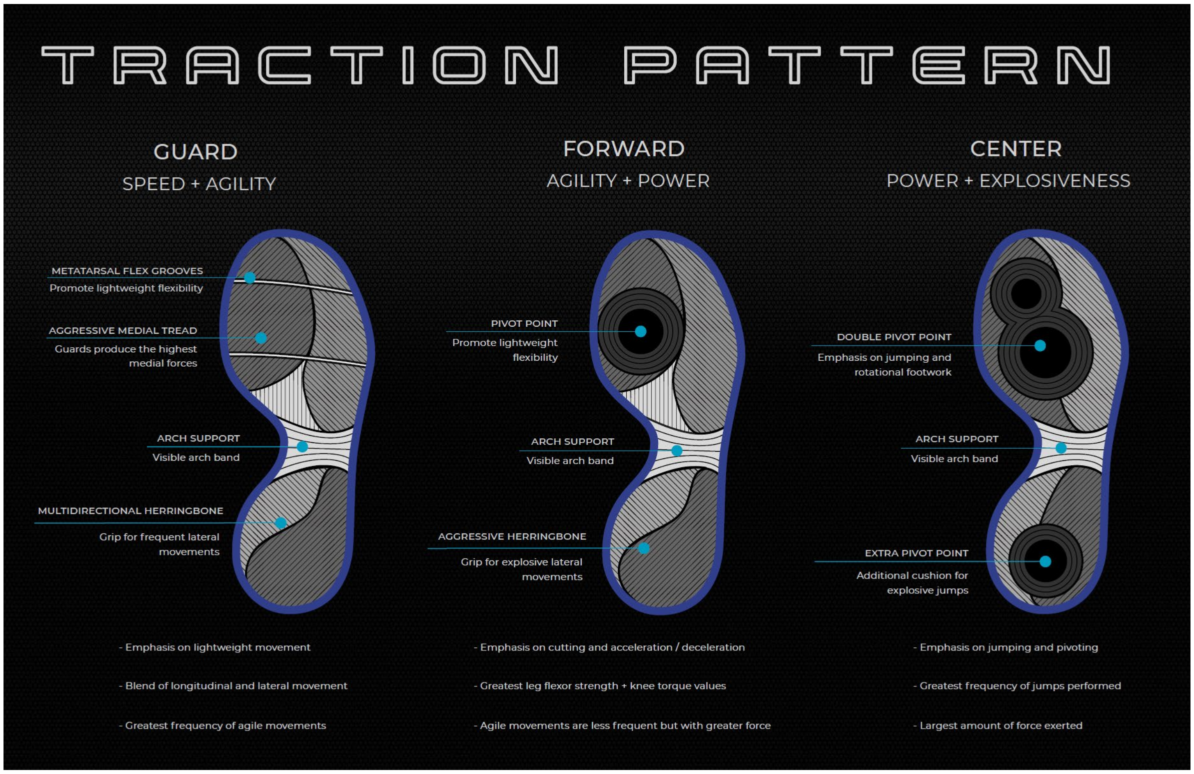



GUARD SHOE
FORWARD SHOE
CENTER SHOE


CUSHIONING MAP
INSOLE PRESSURE MAP - DROP JUMP
FOOT PAIN MAP
CUSHIONING MAP
Phase 1
Phase 2
Takeoff
Phase 1
Phase 2
Takeoff
Phase 1
Phase 2
Takeoff
1
13.8%
2
27.6%
3
24.1%
4
6.9%
5
27.6%


IDEATION - MIDSOLE
GUARD SHOE
FORWARD SHOE
CENTER SHOE


IDEATION - OUTSOLE
INSOLE PRESSURE DATA - UA HOVR SHOES
AGILITY
Cut 1
Cut 2
SPRINT
JUMP
Phase 1
Phase 2
Takeoff



FINAL CONCEPTS


FORWARD SHOE
MID TOP UPPER
Flexibility and support for all around movement
ACTIVATION BANDS
Elastic bands create customizable pressure on arch
MOLDED TPU HEEL CUP
Hugs heel and keeps foot in place
INSOLE
Additional cushion
ACTIVATION PLATE
Slightly larger arch activation plate provides more feedback and stability
CUSHIONING UNITS
Extra soft open-cell foam cushioning units absorb impact forces
MIDSOLE
EVA foam midsole is lightweight, flexible, and responsive to agile movement
EXTENDED OUTRIGGER
Outsole provides extra traction during explosive lateral movement
ROCKER
Very slight rocker for all-around court movement


CENTER SHOE
HIGH TOP UPPER
Maximum stability for frequent jumping
ACTIVATION BANDS
Extra band wrap provides additional ankle support and proprioception
INSOLE
Additional cushion
ACTIVATION PLATE
Combined arch plate and heel cup provide robust stability for explosive movement
CUSHIONING UNITS
Enlarged foam cushioning units absorb repetitive and explosive impact forces
MIDSOLE
Thicker EVA foam midsole absorbs impact from powerful ground reaction forces
OUTSOLE
Jumping-focused traction pattern

TESTING VALIDATION
In addition to weighing each shoe, the same testing protocol performed to the benchmark products will be performed on this footwear collection. These include the 2D Motion Capture test to analyze knee alignment during wear as well as the Pressure Insole test to analyze plantar loading. It is anticipated that the designed shoes will result in straighter knee valgus angles of 2 degrees and promote safer landing technique by reducing the occurrence of flat-footed landing. The shoes will also promote better perceived arch support to the user via higher levels of proprioception.

PHASE III: PROTOTYPE & VALIDATION

SPRING 2021

Women have been underrepresented in basketball since the sport's inception. Although interest in women's basketball has been on the rise over the last decade and females make up over 30% of the sport, less than 1% of basketball shoes are marketed towards women and currently there is only 1 shoe on the market right now that is female specific, which is the Under Armour HOVR Breaktrhu.

When companies do release female basketball shoes, they generally do what is called “shrink it + pink it”, which is taking an existing model, changing the colorway, and scaling it down. So the men’s last and design stay the same. This is unacceptable, because women’s feet are proportioned much differently than men’s feet and are not just scaled down versions. In fact, female feet have a wider forefoot, higher arch, and narrower heel, creating more of a triangular shaped foot as opposed to the rectangular male foot.

On top of that, female basketball players are also 8 TIMES more likely to tear their ACL while playing basketball compared to male players. Interestingly, 70% of these injuries are from non-contact situations.

This fall I did a deep dive into academic and biomechanical research trying to make sense of this huge discrepancy in knee injuries. Although every ACL injury is unique and multifactorial, I was able to pinpoint two major injury mechanisms that could be influenced through footwear, and those were knee alignment, and loading patterns.

Knee alignment is influenced by knee valgus angle, which is when your knees cave in during movement. Females are a lot more likely to have high knee valgus angles during movement, which places their ACL at extreme risk because the misalignment of their leg reduces the ability of surrounding muscles to stabilize the knee, placing greater amounts of stress on the knee ligaments. Moving forward in my experimental research I knew I wanted to monitor this via 2D motion capture of the frontal plane.

Loading patterns are the way we place our weight on our feet which is affected by our landing technique from movements like jumping. This is key because a lot of knee injuries occur when landing from a jump. During my research, I found a few studies that suggested that female athletes are more likely to land jumps flat footed. This again puts their ACLs at higher risk because landing flat footed from a jump creates a higher impulse value because the body has less time to adapt to the change in momentum which again, sends extra load onto the ACL. So for my testing, I used pressure insoles to monitor my test subject's loading patterns.

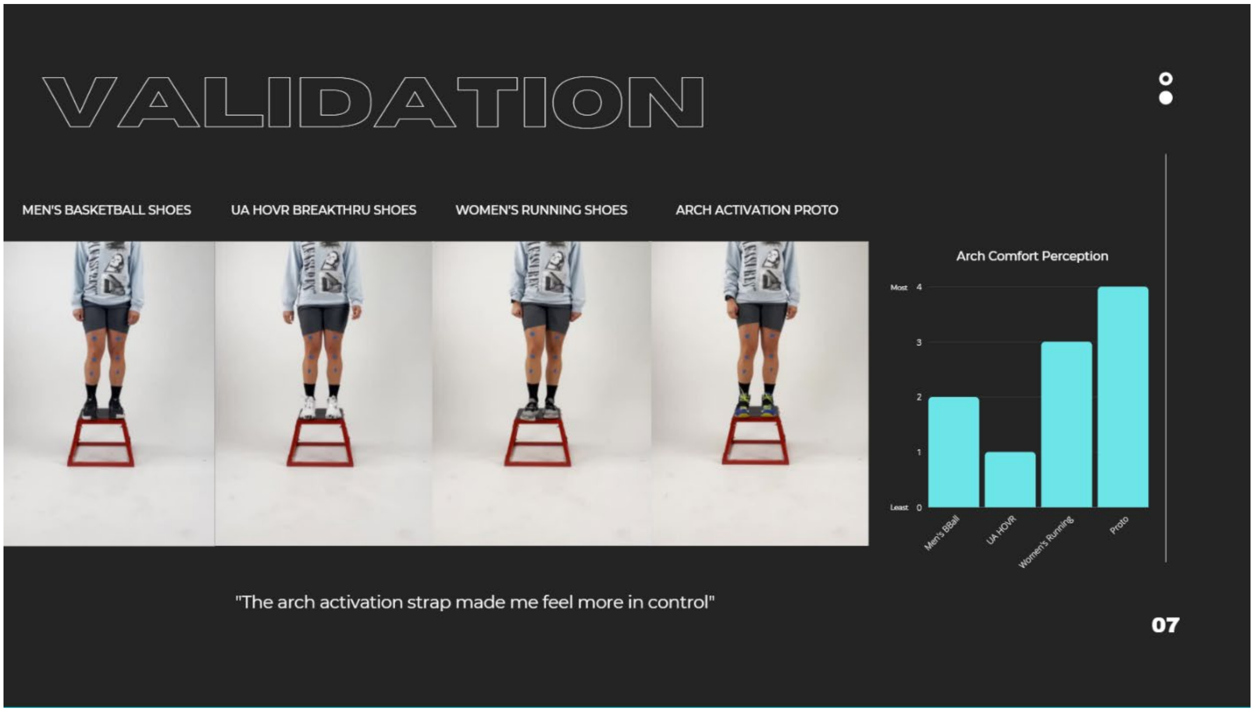
For my testing, I wanted to investigate if female specific fit and arch support in footwear influenced knee valgus angle and landing patterns in female athletes. To test for this, I had test subjects do a drop jump test in 3 different shoes to mimic 3 different conditions:

- the first one being a men's basketball shoe that was obviously male specific and had little to no arch support.
- The second one was my baseline product which was that Under Armour HOVR shoe I mentioned earlier, this one is female specific, basketball specific, and has a really aggressive arch support.
- The condition was a women's running shoe that is female specific and had a moderate arch support.

From the videos you can see that the test subject has really poor knee alignment in both the men's and Under Armor basketball shoes and then it actually straightens out a bit in the running shoes. And then looking at the pressure maps below those, it's harder to see but you can also tell that she begins distributing her weight a bit more along the foot going from the men's shoes to the running shoes. What these two tests showed me was that female-specific fit and arch support positively affected both knee alignment and loading patterns and could potentially reduce risk for ACL injury.

Moving forward from my testing, I knew I wanted to focus on arch support, however I didn't want to go the traditional route of a supportive arch insole, especially because the ones in the Under Armour shoe were so aggressive, they were uncomfortable. Instead, I was inspired by arch taping techniques and the concept of arch activation, which entails lifting the arch from above in a dynamic way rather than holding it up from a rigid support below. In the video you can see some of the prototypes I made exploring which construction would be the most successful for the athlete. These varied from single wide elastic bands to multiple band zones connected to the eyelets. Ultimately, I landed upon the single strap concept because I wanted to keep the arch mechanism independent from the lace tightening system.

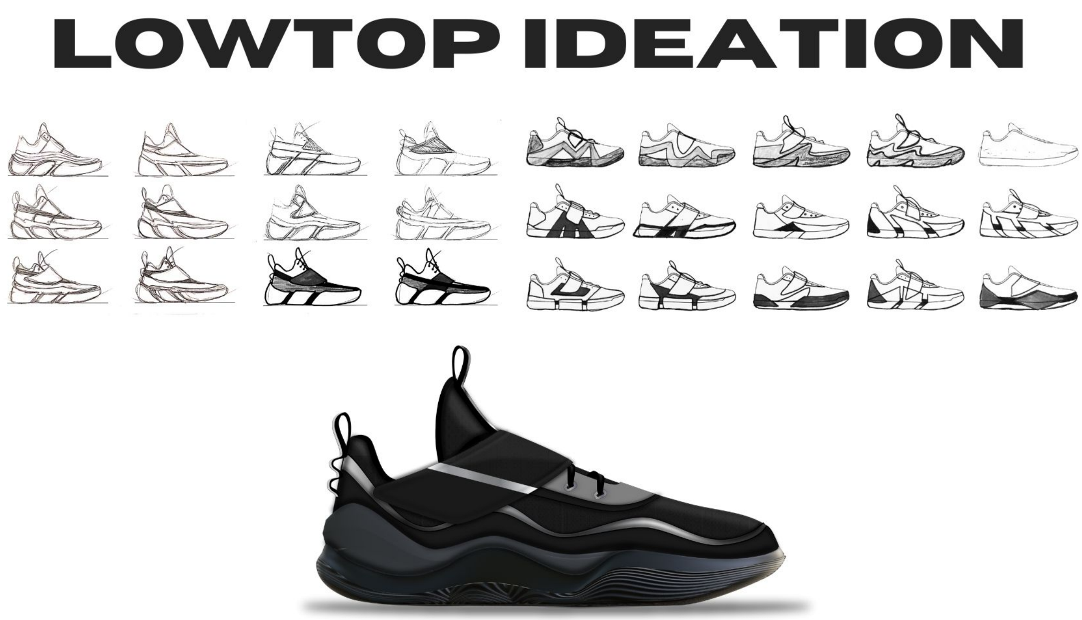
After deciding on the technology construction, I implemented it into a pair of basketball shoes for user testing and validation. As you can see in the videos, I repeated the same 2D motion capture of the drop jump to analyze differences between my prototype and the existing shoes. In a perfect world, I'd have much more robust testing and would have replicated the exact same testing I had done previously with the exact same athletes and footwear samples, however I had done that baseline testing back home in Colorado and was not able to return for this second round. That being said, these videos are pretty inconclusive however the athlete feedback was very positive and in favor of the arch activation technology over the molded insoles. The athlete felt like it provided a lot more control and proprioception than the existing shoes.

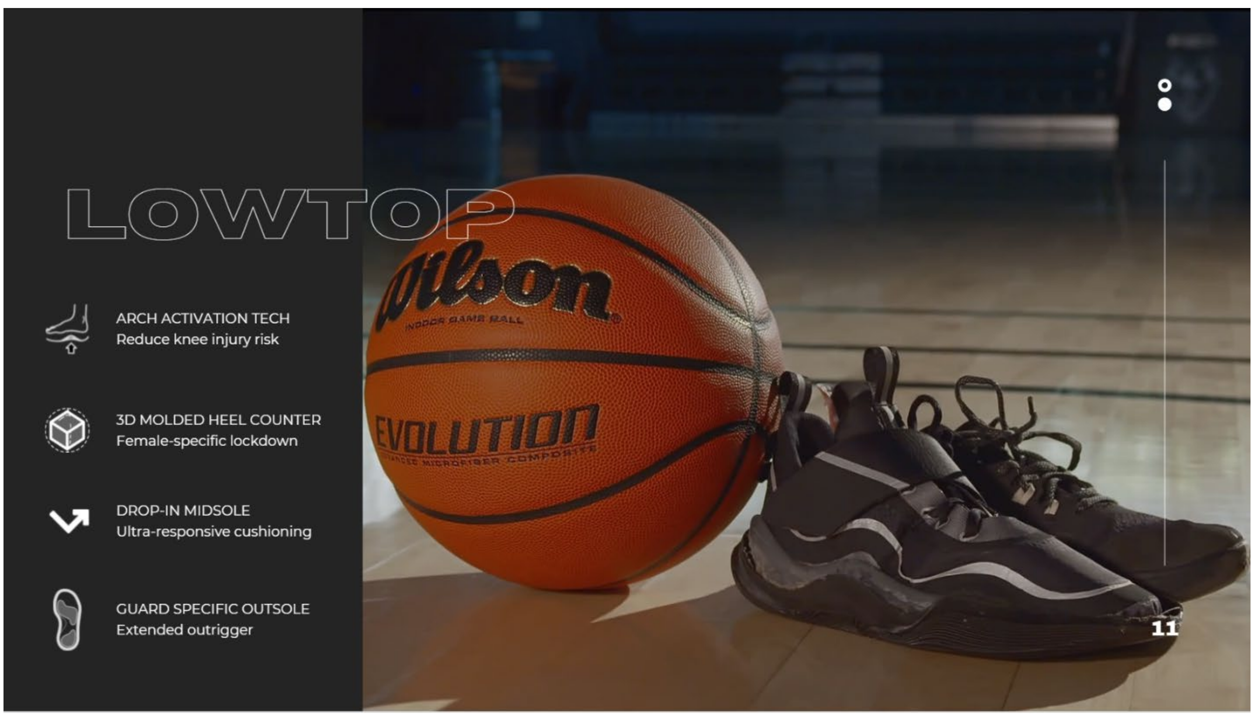


My product line of shoes contains a low top guard specific shoe and a high top post-player specific shoe. There is about a 45 pound and 6 in different between these two positions and each requires a specific skillset:

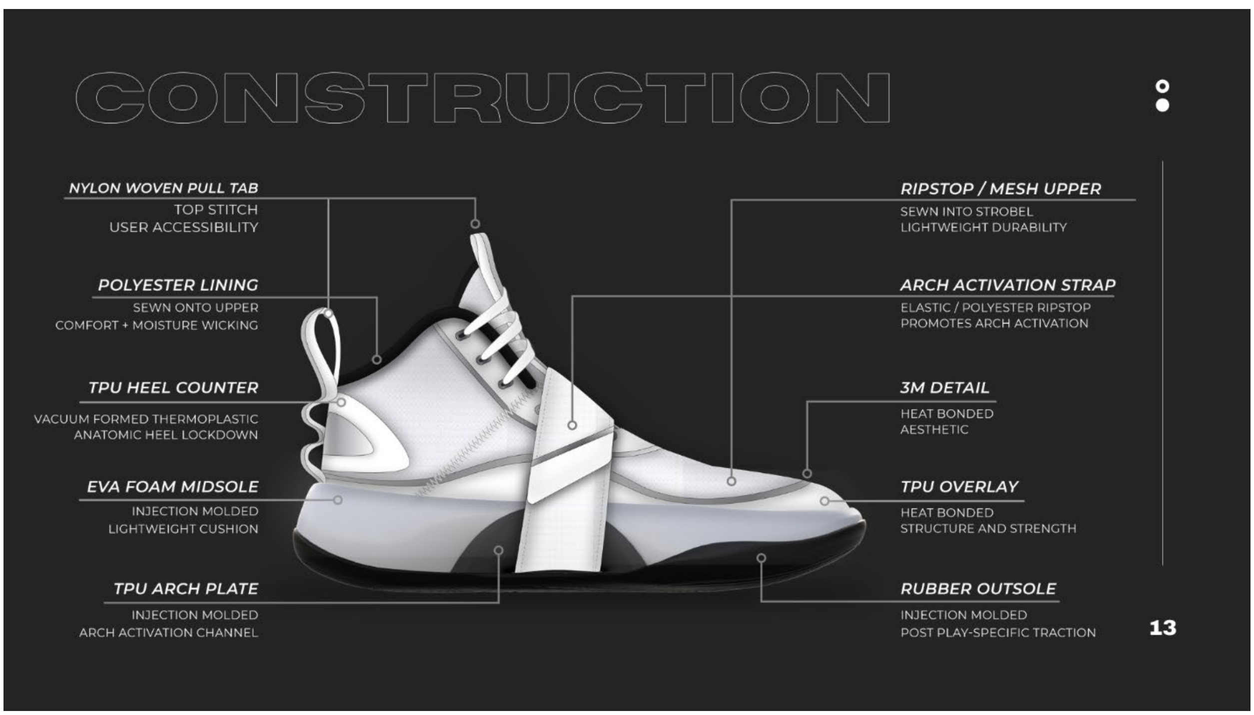
Guards play has an emphasis on agility and speed so a low top delivers that lightweight flexibility. Posts on the other hand, are incredibly powerful and explosive and do a large amount of jumping therefore a high top provides cushion and support for their style of play.

This slide shows some of the aesthetic sketching I did for the guard shoe, just figuring out how to weave in the functional aspects with a fast and agile-looking shoe.



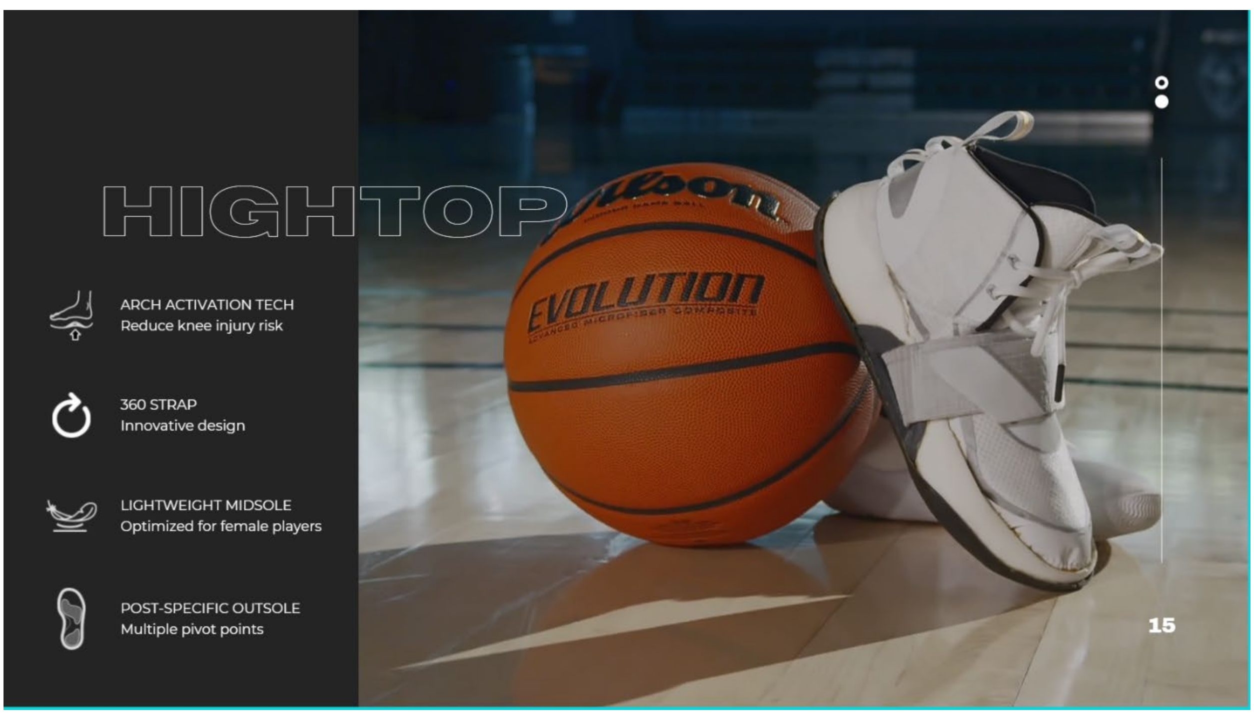


Below are the ideation sketches for the high top post shoe, these had a heavier focus on stability and cushion. And these are my linework samples for the post shoe, which focus more on pivot points in the forefoot and heel.

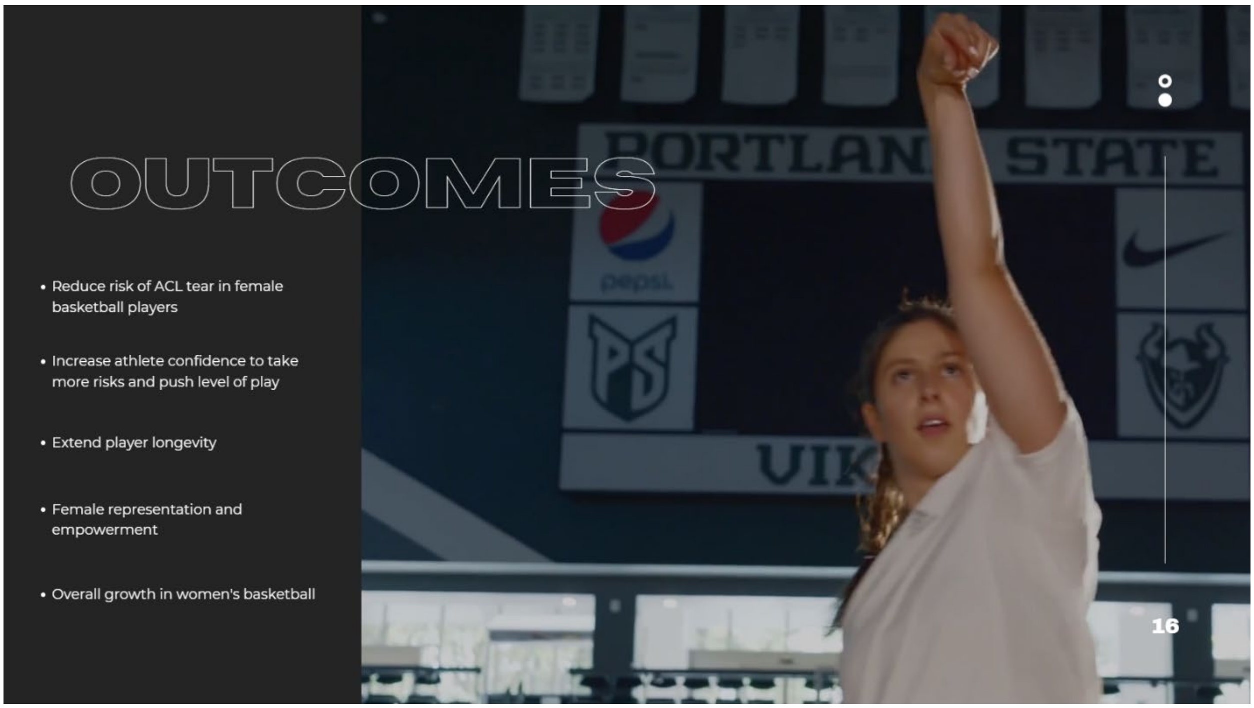


The construction of the upper for this shoe was similar with the same material layering however the strap concept was a bit different, because this shoe has a midsole I wanted to get a little more creative with the strap and had it wrap all the way around the foot. For this shoe there is a foam midsole, a flexible 3D-printed plate that acts as a channel for the strap, and then the rubber outsole.

This video explains the layering system a bit better as I take apart the 3D printed pieces I used to mold my final midsole and outsole which sandwiched the arch plate and the next video shows the midsole system integrated with the upper, showing how the strap weaves through the entire thing and connects back at the top.



Although the glaring outcome of this project was to reduce risk of ACL injury but it goes further than that. With increased athlete confidence, level of play would be pushed, and athletes would be more likely to take risks on the court, having peace of mind that they're less likely to sustain a season-ending injury. This would also extend player longevity. Having shoes like this on the market is an investment in women's sports and would empower female athletes and help grow women's basketball as a whole.



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Shannon Pomeroy (Mentor)

Montezuma Cortez High School (Test Athletes)

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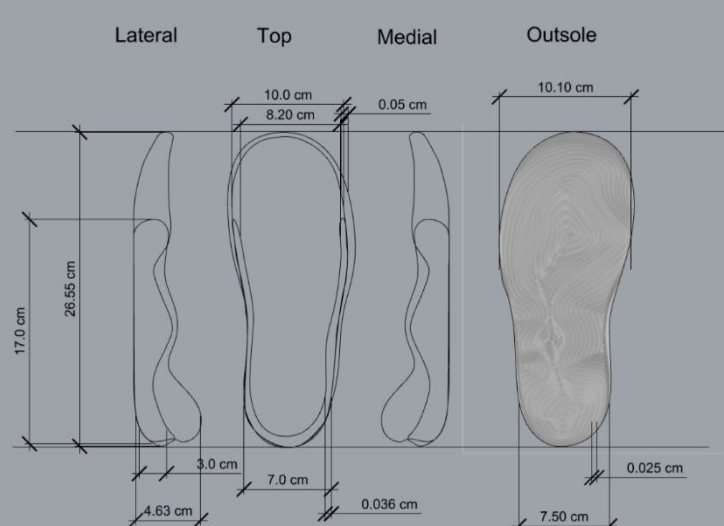
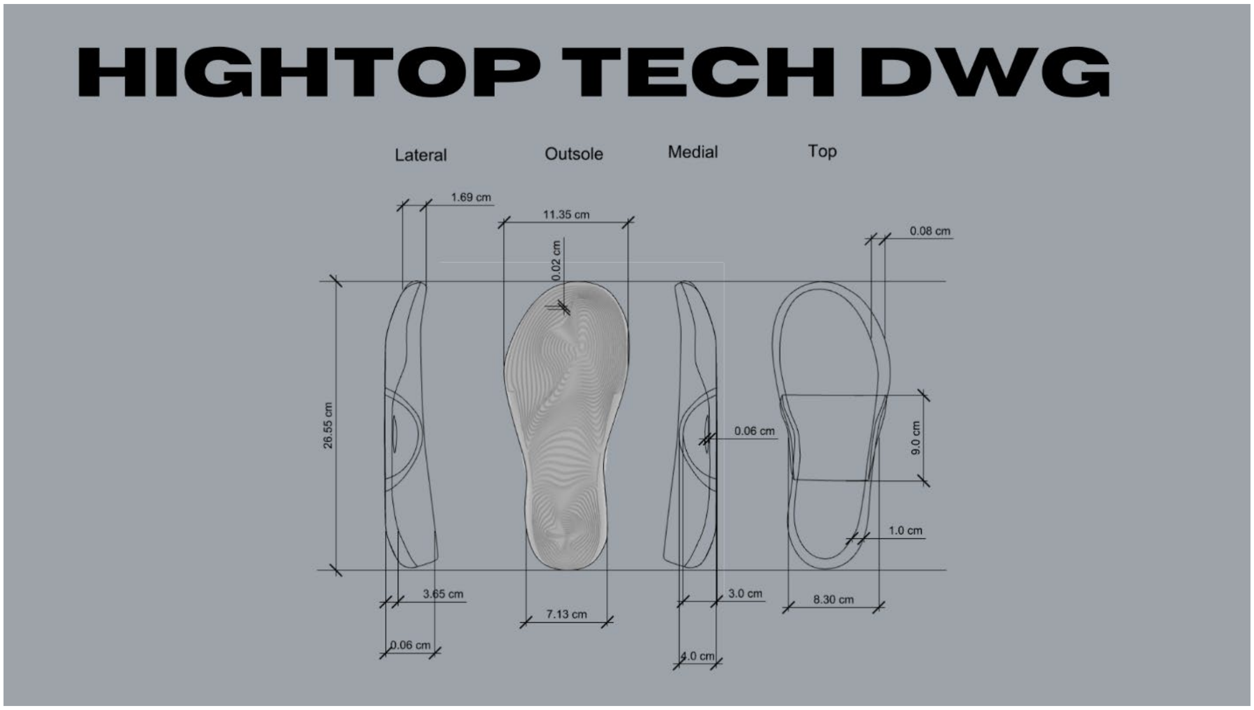
PACKAGING

Polyester drawstring bag for lowtop and hightop

LOWTOP TECH DWG





HIGHTOP TECH DWG
Lateral
Outsole
Medial
Top
1.69 cm
11.35 cm
0.02 cm
0.08 cm
26.55 cm
0.06 cm
9.0 cm
1.0 cm
3.65 cm
7.13 cm
3.0 cm
8.30 cm
0.06 cm
4.0 cm